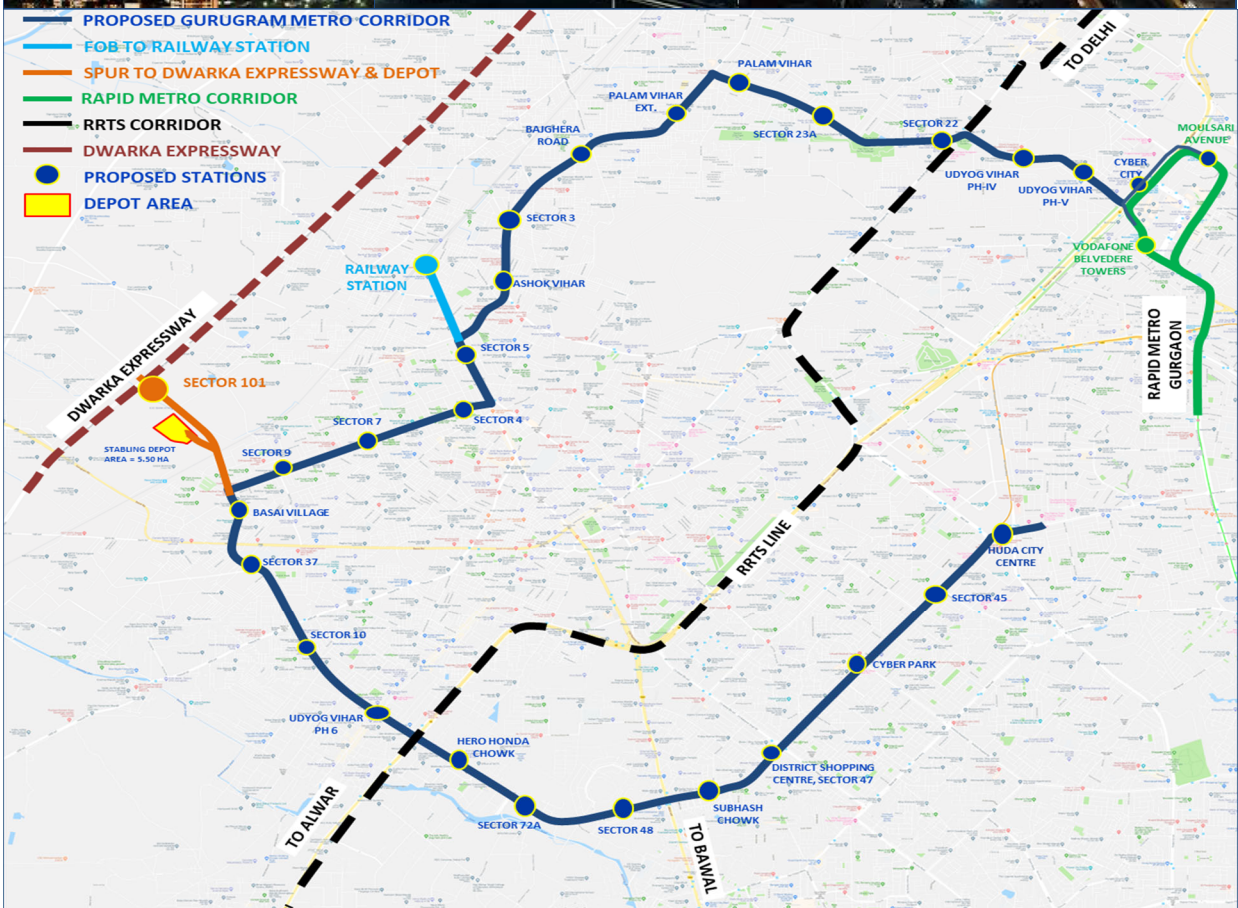




HARYANA MASS RAPID TRANSPORT CORPORATION LIMITED

DETAILED PROJECT REPORT FOR METRO RAIL CONNECTION FROM HUDA CITY CENTRE TO CYBER CITY AND SPUR TO DWARKA EXPRESSWAY, GURGAON



REVISED FINAL REPORT

OCTOBER 2021



TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	i - xxix
-------------------------------	-----------------

1. PROFILE OF THE CITY

1.1	GENERAL/ HISTORICAL BACKGROUND	1-1
1.2	LOCATION, CLIMATE, PHYSICAL SETTING AND REGIONAL LINKAGE.....	1-2
1.3	DEMOGRAPHIC AND SOCIO ECONOMIC PROFILE	1-3
1.4	URBAN LANDUSE STRUCTURE	1-4
1.5	SCOPE OF WORK	1-8
1.6	COMPOSITION OF REPORT	1-12

2. EXISTING TRANSPORTATION SYSTEM IN THE CITY

2.1	INTRODUCTION.....	2-1
2.2	VEHICULAR GROWTH AND COMPOSITION.....	2-1
2.3	ROAD NETWORK CHARACTERISTICS	2-2
2.4	MAJOR TRANSPORT NODES.....	2-3
2.5	PEDESTRIAN AND NON MOTORISED VEHICLE (NMV) FACILITIES	2-3
2.6	TRAFFIC MANAGEMENT INCLUDING PARKING MANAGEMENT.....	2-4
2.7	TRAFFIC CHARACTERISTICS	2-5
2.8	TRAFFIC SAFETY	2-7
2.9	INTERMEDIATE PUBLIC TRANSPORT – COMPOSITION, STATUS AND ROLE	2-7
2.10	PUBLIC TRANSPORT SYSTEM	2-8
2.11	PAST PROPOSALS FROM PREVIOUS STUDIES	2-9
2.12	INTERCONNECTIONS AMONG VARIOUS STUDIES/PROPOSALS.....	2-12
2.13	ISSUES AND PROSPECTS.....	2-13

3. TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

3.1	VARIOUS TRAFFIC AND TRANSPORTATION STUDIES UNDERTAKEN.....	3-1
3.2	SOCIO-ECONOMIC CHARACTERISTICS	3-18
3.3	TRAVEL DEMAND ANALYSIS.....	3-24
3.4	FUTURE TRAVEL DEMAND SCENARIOS.....	3-34
3.5	RIDERSHIP ASSESSMENT FOR HORIZON YEARS	3-40

4. SYSTEM AND TECHNOLOGY SELECTION

4.1	INTRODUCTION.....	4-1
4.2	SYSTEM SPECIFICATIONS ADOPTED FOR THE CORRIDOR.....	4-1

5. CIVIL ENGINEERING

5.1	ALIGNMENT DESCRIPTION OF APPROVED ALIGNMENT, AVAILABILITY OF ROAD SPACE.....	5-1
5.2	ANALYSIS OF CORRIDOR OPTIONS TO BE ELEVATED, UNDERGROUND OR AT GRADE.....	5-48

5.3	DESIGN NORMS	5-59
5.4	GEOMETRIC DESIGN OF CORRIDOR INCLUDING PLAN/PROFILE	5-99
5.5	IDENTIFICATION OF EXISTING SERVICES/ UTILITIES.....	5-110
5.6	LAND REQUIREMENT FOR THE CORRIDOR, DEPOTS STATIONS, PARKING, MULTI MODEL STATIONS	5-125
5.7	OWNERSHIPS DETAILS OF THE LAND REQUIRED FOR THE CORRIDOR	5-126
6.	STATION PLANNING	
6.1.	BACKGROUND.....	6-1
6.2.	STATION AREA CHARACTERISTICS	6-2
6.3.	STATION PLANNING	6-38
6.4.	ACCESSIBILITY FOR DIFFERENTLY ABLED	6-56
6.5.	PARKING ON STATIONS.....	6-58
7.	INTER-MODAL INTEGRATION	
7.1	INTRODUCTION.....	7-1
7.2	PRINCIPLES OF INTEGRATION	7-1
7.3	RECOMMENDATIONS FOR PROPOSED STATIONS	7-2
7.4	FEEDER SERVICES PLANNING AT STATIONS.....	7-3
7.5	RECOMMENDATIONS FOR INSTITUTIONAL, PHYSICAL, FARE, OPERATIONAL AND TECHNOLOGY INTEGRATION.....	7-9
8.	TRAIN OPERATION PLAN	
8.1	TRAIN OPERATION PHILOSOPHY.....	8-1
8.2	SYSTEM FREQUENCY.....	8-5
8.3	ROLLING STOCK REQUIREMENT	8-5
9.	SIGNALING AND TELECOMMUNICATION	
9.1	SIGNALLING SYSTEM.....	9-1
9.2	TELECOMMUNICATION SYSTEM.....	9-6
10.	FARE COLLECTION SYSTEM	
10.1.	TICKETING & ACCESS CONTROL	10-1
10.2.	AUTOMATIC FARE COLLECTION SYSTEM IMPLEMENTAION OPTIONS	10-3
10.3.	FARE SYSTEM INTEGRATION WITH OTHER TRANSPORT OPTIONS	10-6
10.4.	AFC EQUIPMENT STANDARDS	10-7
11.	ROLLING STOCK	
11.1	ROLLING STOCK.....	11-1
11.2	ROLLING STOCK REQUIREMENT	11-5

12. POWER SUPPLY & TRACTION

12.1	CHOICE OF ELECTRIC TRACTION	12-1
12.2	PROJECTED POWER DEMAND.....	12-3
12.3	SOURCES OF POWER SUPPLY OF POWER SUPPLY	12-4
12.4	TRACTION POWER SUPPLY	12-8
12.5	AUXILIARY POWER ARRANGEMENTS.....	12-9
12.6	SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)	12-13
12.7	ELECTROMAGNETIC INTERFERENCE (EMI) & ELECTROMAGNETIC COMPATIBILITY (EMC)	12-14
12.8	STRAY CURRENT CORROSION PROTECTION MEASURES	12-14
12.9	SOLAR ENERGY HARNESSING SYSTEM	12-16
12.10	ENERGY SAVING MEASURES	12-17

13. VENTILATION AND AIR CONDITIONING SYSTEM

13.1	ALIGNMENT ANALYSIS AND NEED FOR VENTILATION	13-1
13.2	DESIGN PARAMETERS	13-1
13.3	STATION VENTILATION AND AIR CONDITIONING OF ANCILLARY SPACES	13-1

14. MAINTENANCE FACILITIES

14.1	DEPOT LOCATION AND APPROACH TO MAINTENANCE	14-1
14.2	DESIGN OF DEPOT FACILITIES AND DEPOT LAYOUT PLANS.....	14-4

15. ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

15.1.	EXISTING SCENARIO	15-1
15.2.	ENVIRONMENTAL NORMS AND REGULATIONS.....	15-21
15.3.	DETAILED ENVIRONMENT IMPACT ASSESSMENT	15-22
15.4.	ENVIRONMENTAL MANAGEMENT PLAN	15-36
15.5.	ENVIRONMENTAL MONITORING PLAN AND ENVIRONMENT MANAGEMENT SYSTEM	15-48
15.6.	SUMMARY OF COST	15-54
15.7.	SOCIAL IMPACT ASSESSMENT.....	15-54

16. DISASTER MANAGEMENT AND SECURITY MEASURES

16.1	DISASTER MANAGEMENT AND IMPERATIVES	16-1
16.2	NEED FOR DISASTER MANAGEMENT.....	16-1
16.3	TYPE OF DISASTERS IN METRO SYSTEM.....	16-1
16.4	OBJECTIVES OF DISASTER MANAGEMENT PLAN	16-2
16.5	PREPAREDNESS OF STAFF FOR DISASTERS	16-2
16.6	PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS.....	16-6
16.7	SECURITY MEASURES, ESSENTIALS OF SECURITY MANAGEMENT, SECURITY SYSTEM DESIGN PARAMETER.....	16-16
16.8	SECURITY SYSTEMS RECOMMENDED FOR GURUGRAM METRO	16-18

17. DETAILED PROJECT COST ESTIMATES

17.1	CAPITAL COST ESTIMATE	17-1
17.2	INNOVATIONS PROPOSE TO REDUCE THE COST.....	17-4
17.3	COSTING OF ENTIRE PROJECT	17-4
17.4	SUMMARY OF CAPITAL COST.....	17-10
17.5	ESTIMATIONS OF OPERATIONS AND MAINTENANCE COST	17-10

18. TRANSIT ORIENTED DEVELOPMENT PLAN

18.1.	NATIONAL TRANSIT ORIENTED DEVELOPMENT (TOD POLICY)	18-1
18.2.	OBJECTIVES OF TOD	18-1
18.3.	TOD POLICY AND GUIDELINES IN HARYANA	18-2
18.4.	VALUE CAPTURE FINANCE (VCF).....	18-4

19. FINANCIAL ANALYSIS & NON FARE BOX REVENUE ASSESSMENT

19.1	INPUT FOR THE ANALYSIS	19-1
19.2	MEANS OF FINANCE.....	19-5
19.3	OPERATIONAL VIABILITY/FIRR	19-8
19.4	SENSITIVITY ANALYSIS.....	19-9
19.5	ALTERNATE MEANS OF FINANCING	19-12

20. ECONOMIC ANALYSIS

20.1	APPROACH AND METHODOLOGY FOR ECONOMIC ANALYSIS.....	20-1
20.2	ESTIMATION OF ECONOMIC COST OF MRTS	20-2
20.3	ECONOMIC BENEFITS OF MRTS	20-3
20.4	EIRR FOR 30 YEARS	20-7
20.5	OUTCOME ON ECONOMIC VIABILITY	20-8

21. IMPLEMENTATION PLAN

21.1	PROJECT IMPLEMENTATION PLAN	21-1
21.2	IMPLEMENTATION STRUCTURE.....	21-1
21.3	LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE PROJECT.....	21-1
21.4	ROLE, RESPONSIBILITY AND INVOLVEMENT OF CITY GOVERNMENT	21-3
21.5	REALISING THE GOAL OF AATMANIRBHAR BHARAT.....	21-4
21.6	WAY FORWARD	21-5

LIST OF FIGURES

FIGURE 1.1: STUDY AREA	1-3
FIGURE 1.2: PROPOSED LANDUSE MAP – GURUGRAM MANESAR URBAN COMPLEX (GMUC) MASTER PLAN 2031.....	1-7
FIGURE 2.1: COMPOSITION OF VEHICLE REGISTERED IN GURUGRAM.....	2-1
FIGURE 2.2: PROPOSED CITY BUS & MASS TRANSIT NETWORK	2-12
FIGURE 3.1: ZONING SYSTEM.....	3-1
FIGURE 3.2: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE.....	3-9
FIGURE 3.3: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE	3-11
FIGURE 3.4: DISTRIBUTION OF METRO PASSENGERS BY TRIP PURPOSE	3-13
FIGURE 3.5: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE.....	3-14
FIGURE 3.6: DISTRIBUTION OF PT/IPT PASSENGER BY TRAVEL FREQUENCY.....	3-17
FIGURE 3.7: DISTRIBUTION OF PT/IPT PASSENGERS BY TRAVEL TIME	3-17
FIGURE 3.8: DISTRIBUTION OF HOUSEHOLDS BY SIZE	3-18
FIGURE 3.9: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL	3-19
FIGURE 3.10: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS/OCCUPATION.....	3-20
FIGURE 3.11: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)	3-23
FIGURE 3.12: DISTRIBUTION OF PASSENGER TRIPS BY PURPOSE	3-23
FIGURE 3.13: DISTRIBUTION OF AVERAGE TRIP LENGTH BY MODE	3-24
FIGURE 3.14: FOUR STAGE TRAVEL DEMAND MODEL.....	3-25
FIGURE 3.15: FOUR STAGE MODEL STRUCTURE.....	3-26
FIGURE 3.16: ATTRACTION MODEL (HBW LINEAR REGRESSION)	3-28
FIGURE 3.17: GRAVITY MODEL FORMULATION	3-29
FIGURE 3.18: MODAL SPLIT MODELS STRUCTURE.....	3-30
FIGURE 3.19 : MULTI-LOGIT FORMULAS (COMBINED SPLIT).....	3-31
FIGURE 3.20: LOGIT MODEL SENSITIVITY.....	3-32
FIGURE 4.1: EXISTING RAPID METRO NETWORK	4-2
FIGURE 5.1: PROPOSED GURGAON METRO CORRIDOR	5-26
FIGURE 5.2: PLAN OF UNDER-CONSTRUCTION FLYOVER & UNDERPASS NEAR EXISTING HUDA CITY CENTRE METRO STATION	5-28
FIGURE 5.3: CROSS-SECTION OF UNDER-CONSTRUCTION FLYOVER NEAR EXISTING HUDA CITY CENTRE METRO STATION	5-29
FIGURE 5.4: LOCATION OF PORTAL NEAR HUDA CITY CENTRE.....	5-30
FIGURE 5.5: LOCATION OF SPECIAL SPAN AT BAKHTAWAR CHOWK.....	5-30
FIGURE 5.6: LOCATION OF PORTAL AT THE START OF SUBHASH CHOWK FLYOVER	5-31
FIGURE 5.7: LOCATION OF PORTAL AT THE END OF SUBHASH CHOWK FLYOVER.....	5-31
FIGURE 5.8: PROPOSED CROSS-SECTION FOR WIDENING OF ROAD	5-32
FIGURE 5.9: LOCATION OF PORTAL AT START OF HERO HONDA CHOWK UNDERPASS	5-33
FIGURE 5.10: LOCATION OF SPECIAL SPAN AT HERO HONDA CHOWK.....	5-33
FIGURE 5.11: LOCATION OF SPECIAL SPAN AT UMANG BHARDWAJ CHOWK	5-34
FIGURE 5.12: MICROMAX MOULSARI AVENUE RAPID METRO STATION.....	5-36
FIGURE 5.13: VODAFONE BELVEDERE TOWERS RAPID METRO STATION.....	5-37

FIGURE 5.14: INTEGRATION/CONNECTIVITY WITH RAPID METRO & METRO MOVEMENT	5-39
FIGURE 5.15: PROPOSED SPUR TO DWARKA EXPRESSWAY.....	5-40
FIGURE 5.16: CONNECTIVITY TO SECTOR 101 STABLING DEPOT.....	5-41
FIGURE 5.17: LOCATION OF SPECIAL SPAN AT RAILWAY TRACKS.....	5-42
FIGURE 5.18: SCHEMATIC DIAGRAM OF GURGAON METRO	5-47
FIGURE 5.19: ALIGNMENT OPTIONS PARAMETERS	5-49
FIGURE 5.20: LOCATION OF PROPOSED HUDA CITY CENTRE STATION - OPTION 1.....	5-50
FIGURE 5.21: LOCATION OF PROPOSED HUDA CITY CENTRE STATION - OPTION 2.....	5-51
FIGURE 5.22: LOCATION OF PROPOSED HUDA CITY CENTRE STATION - OPTION 3.....	5-52
FIGURE 5.23: OPTION 1 – COMPLETELY ELEVATED	5-53
FIGURE 5.24: OPTION 2 – RAILWAY STATION AS UNDERGROUND.....	5-55
FIGURE 5.25: OPTION 3 – COMPLETELY ELEVATED WITH A SPUR TO RAILWAY STATION.....	5-57
FIGURE 5.26: TYPES OF SUPERSTRUCTURE.....	5-66
FIGURE 5.27: LAUNCHING OF BOX GIRDER SEGMENTS.....	5-67
FIGURE 5.28: PRECAST U-CHANNEL SUPERSTRUCTURE	5-68
FIGURE 5.29: LAUNCHING OF U-CHANNEL GIRDER.....	5-69
FIGURE 5.30: LAUNCHING OF I-GIRDER	5-70
FIGURE 5.31: CLC SPAN 75M + 105M + 75M AND STEEL SPAN 60M.....	5-70
FIGURE 5.32: TYPICAL CROSS-SECTIONS OF RAPID METRO VIADUCTS	5-71
FIGURE 5.33: TYPICAL ELEVATED STATION	5-74
FIGURE 5.34: EARTHQUAKE HAZARD MAP	5-78
FIGURE 5.35: LOCATION PLAN OF BOREHOLES UTILIZED FROM HSIIDC METRO (BH 01 – BH 05)	5-83
FIGURE 5.36: LOCATION PLAN OF BOREHOLES UTILIZED FROM HSIIDC METRO (BH 06 – BH 10)	5-84
FIGURE 5.37: LOCATION PLAN OF BOREHOLES DRILLED	5-85
FIGURE 5.38: LITHOLOGICAL SECTION ALONG THE CORRIDOR (UTILIZED FROM HSIIDC METRO).....	5-96
FIGURE 5.39: LITHOLOGICAL SECTION ALONG THE CORRIDOR (DRILLED SECTION)	5-97
FIGURE 5.40: LITHOLOGICAL SECTION ALONG THE CORRIDOR.....	5-97
FIGURE 5.41: LITHOLOGICAL SECTION ALONG THE CORRIDOR.....	5-98
FIGURE 6.1: PRIORITY MRTS CORRIDORS ALONG WITH STATION LOCATIONS	6-2
FIGURE 6.2: ADVERTISEMENTS AT STATIONS& PLATFORM	6-46
FIGURE 6.3: ADVERTISEMENTS ON ROLLING STOCK	6-46
FIGURE 6.4: ISOMETRIC VIEWS OF ELEVATED STATION	6-48
FIGURE 6.5: TYPE A: 130M X 20M.....	6-53
FIGURE 6.6: TYPE B: 130M X 28M.....	6-54
FIGURE 6.7: TYPE C: 130M X 22M.....	6-54
FIGURE 6.8: VARIOUS DIFFERENTLY ABLED FEATURES IN/AROUND METRO STATIONS	6-57
FIGURE 7.1: ACCESS/DISPERSAL MODES FROM TRANSIT MODE.....	7-1
FIGURE 7.2: CONCEPT OF FEEDER SERVICES AT METRO STATIONS.....	7-3
FIGURE 7.3: FEEDER BUS ROUTE PLAN	7-7
FIGURE 8.1: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2026)	8-4
FIGURE 8.2: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2031)	8-4
FIGURE 8.3: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2041)	8-5
FIGURE 9.1: TRAIN CAB RADIO AND COMM. FACILITY FOR MAINTENANCE	9-9
FIGURE 9.2: MASTER CLOCK	9-10

FIGURE 9.3: PASSENGER INFORMATION DISPLAY SYSTEM.....	9-10
FIGURE 9.4: PIDS AT PLATFORM AND CONCOURSE	9-11
FIGURE 10.1: FARE COLLECTION TECHNOLOGY DEVELOPMENT	10-1
FIGURE 10.2: AFC OPERATION PROCESS.....	10-2
FIGURE 10.3: AFC SYSTEM ARCHITECTURE	10-2
FIGURE 10.4: BANKING INTERFACE.....	10-3
FIGURE 10.5: NEAR FIELD COMMUNICATION.....	10-4
FIGURE 10.6: BIOMETRIC SYSTEM FLOW CHART	10-5
FIGURE 10.7: EMV BASED PAYMENT SYSTEM	10-6
FIGURE 10.8: COMMON MOBILITY CARD OVERVIEW.....	10-7
FIGURE 11.1: SIMPLIFIED VELOCITY – TIME OPERATION CURVE.....	11-5
FIGURE 12.1: TYPICAL HIGH VOLTAGE RECEIVING SUB– STATION	12-6
FIGURE 12.2: GAS INSULATED SUB– STATION	12-7
FIGURE 12.3: TYPICAL TRACTION SUBSTATION	12-9
FIGURE 12.2: TYPICAL INDOOR AUXILIARY SUB-STATION	12-10
FIGURE 12.5: SCADA SYSTEM.....	12-14
FIGURE 14.1: RAKE VISITS TO DEPOT AND WORKSHOP	14-5
FIGURE 15.1: TOPOGRAPHICAL MAP OF STUDY AREA	15-3
FIGURE 15.2: MONITORING LOCATION MAP FOR WATER AND SOIL	15-4
FIGURE 15.3: SEISMIC ZONING MAP OF GURUGRAM	15-6
FIGURE 15.4: WIND ROSE DIAGRAM.....	15-12
FIGURE 15.5: MONITORING LOCATION MAP FOR AIR AND NOISE.....	15-13
FIGURE 19.1: MODEL OF IMPLEMENTATION OF MRTS PROJECTS	19-12
FIGURE 19.2 APPROVED FUNDING PATTERN OF DELHI AIRPORT LINE.....	19-14
FIGURE 19.3 FUNDING PATTERN OF HYDERABAD METRO	19-14
FIGURE 19.4 FUNDING PATTERN OF MUMBAI METRO LINE 1	19-15

LIST OF TABLES

TABLE 1.1: POPULATION OF GURUGRAM, 2011.....	1-4
TABLE 1.2: FORECASTED POPULATION OF THE STUDY AREA FOR THE HORIZON YEARS	1-4
TABLE 1.3: PROPOSED LANDUSE – GURUGRAM MANESAR URBAN COMPLEX AREA	1-5
TABLE 1.4: CLASSIFICATION OF LAND RESERVATION FOR MAJOR TRANSPORT CORRIDORS.....	1-6
TABLE 2.1: VEHICLES REGISTRATION IN GURGAON.....	2-1
TABLE 2.2: DISTRIBUTION OF ROAD NETWORK AS PER RIGHT OF WAY.....	2-2
TABLE 2.3: DISTRIBUTION OF ROAD NETWORK AS PER CARRIAGEWAY WIDTH	2-2
TABLE 2.4: DISTRIBUTION OF ROAD NETWORK AS PER ABUTTING LAND USE	2-3
TABLE 2.5: PEDESTRIAN COUNTS ALONG THE ROAD.....	2-3
TABLE 2.6: PEAK HOUR TRAFFIC VOLUME AT MID-BLOCK LOCATIONS.....	2-5
TABLE 2.7: DAILY TRAFFIC COMPOSITION AT MID-BLOCK LOCATIONS	2-6
TABLE 2.8: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED	2-6
TABLE 2.9: DISTRIBUTION OF ROAD LENGTH BY OFF PEAK PERIOD JOURNEY SPEED	2-6
TABLE 2.10: ACCIDENT STATISTICS	2-7
TABLE 2.11: PROPOSED BUS ROUTE HIERARCHY FOR GURUGRAM	2-10
TABLE 2.12: AIR QUALITY INDEX PARAMETERS	2-13
TABLE 2.13: CONTINUOUS AMBIENT AIR QUALITY MONITORING	2-14
TABLE 3.1: DISTRIBUTION OF ABUTTING LANDUSE ALONG MAJOR ROADS	3-2
TABLE 3.2: OUTER CORDON LOCATIONS	3-3
TABLE 3.3: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT MID-BLOCK/SCREEN LINE LOCATIONS.....	3-4
TABLE 3.4: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT OUTER CORDON LOCATIONS	3-4
TABLE 3.5: TURNING MOVEMENT VOLUME COUNT SURVEY LOCATIONS	3-5
TABLE 3.6: TOTAL DAILY APPROACH TRAFFIC (INFLOW) AT INTERSECTIONS.....	3-5
TABLE 3.7: COMPOSITION OF DAILY TRAFFIC AT INTERSECTIONS.....	3-6
TABLE 3.8: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED.....	3-7
TABLE 3.9: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR RUNNING SPEED.....	3-7
TABLE 3.10: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK HOURS	3-8
TABLE 3.11: DISTRIBUTION OF PASSENGERS AT BUS TERMINAL.....	3-8
TABLE 3.12: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE	3-8
TABLE 3.13: DISTRIBUTION OF BUS PASSENGERS BY MODE TO REACH TERMINAL	3-9
TABLE 3.14: DISTRIBUTION OF BUS PASSENGERS BY TRAVEL FREQUENCY	3-9
TABLE 3.15: DISTRIBUTION OF BUS PASSENGERS BY TRAVEL TIME TO REACH BUS TERMINAL.....	3-10
TABLE 3.16: PASSENGER VOLUME AT GURUGRAM RAILWAY STATION	3-10
TABLE 3.17: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE.....	3-10
TABLE 3.18: DISTRIBUTION OF RAIL PASSENGERS BY MODE TO REACH TERMINAL.....	3-11
TABLE 3.19: DISTRIBUTION OF RAIL PASSENGERS BY TRAVEL FREQUENCY	3-11
TABLE 3.20: DISTRIBUTION OF RAIL PASSENGERS BY TRAVEL TIME TO REACH RAIL TERMINAL	3-12
TABLE 3.21: DISTRIBUTION OF PASSENGERS AT RAIL TERMINALS	3-12
TABLE 3.22: DISTRIBUTION OF METRO PASSENGERS BY TRIP PURPOSE	3-12
TABLE 3.23: DISTRIBUTION OF PASSENGERS BY MODE TO REACH TERMINAL.....	3-13
TABLE 3.24: DISTRIBUTION OF METRO PASSENGERS BY TRAVEL FREQUENCY	3-13
TABLE 3.25: DISTRIBUTION OF PASSENGERS BY TRAVEL TIME TO REACH METRO STATION	3-14

TABLE 3.26: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE	3-14
TABLE 3.27: DISTRIBUTION OF PASSENGER AT PT / IPT STOPS	3-15
TABLE 3.28: DISTRIBUTION OF PT/IPT PASSENGERS BY TRAVEL FREQUENCY	3-17
TABLE 3.29: DISTRIBUTION OF PT/IPT PASSENGERS BY TRAVEL TIME	3-17
TABLE 3.30: DISTRIBUTION OF HOUSEHOLDS BY SIZE	3-18
TABLE 3.31: DISTRIBUTION OF HOUSEHOLD MEMBERS BY AGE	3-19
TABLE 3.32: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL	3-19
TABLE 3.33: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS/OCCUPATION.....	3-20
TABLE 3.34: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME	3-21
TABLE 3.35: DISTRIBUTION OF HOUSEHOLDS BY AVERAGE MONTHLY EXPENDITURE ON TRANSPORT ...	3-21
TABLE 3.36: DISTRIBUTION OF HOUSEHOLDS BY VEHICLE OWNERSHIP	3-21
TABLE 3.37: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)	3-22
TABLE 3.38: DISTRIBUTION OF TRIPS BY PURPOSE	3-23
TABLE 3.39 GENERATION MODEL CALIBRATION RESULTS (HOUSEHOLD'S SIZE DISTRIBUTION)	3-27
TABLE 3.40 ZONE WISE DISTRIBUTION OF HOUSEHOLD SIZE	3-28
TABLE 3.41 HIS DATABASE DAILY PERSON TRIPS BY PURPOSE	3-28
TABLE 3.42 ATTRACTION MODEL CALIBRATION RESULTS	3-29
TABLE 3.43 BASE YEAR VALUES OF TIME, VEHICLE OPERATING COSTS AND VEHICLE	3-30
TABLE 3.44 DISTRIBUTION MODELS CALIBRATION RESULTS	3-30
TABLE 3.45 CALIBRATED MODAL CHOICE MODELS PARAMETERS	3-33
TABLE 3.46 MODAL SPLIT MODELS CALIBRATION RESULTS	3-33
TABLE 3.47 MODAL SPLIT MODELS VALIDATION RESULTS	3-33
TABLE 3.48: FORECASTED POPULATION AND EMPLOYMENT IN THE STUDY AREA FOR HORIZON YEARS	3-35
TABLE 3.49: ZONEWISE FORECASTED POPULATION AND EMPLOYMENT FOR HORIZON YEARS.....	3-36
TABLE 3.50: MAXIMUM PEAK HOUR SECTION LOADING ON STUDY CORRIDOR.....	3-40
TABLE 3.51: DAILY RIDERSHIP FOR THE STUDY CORRIDOR.....	3-40
TABLE 3.52: STATION LOADS ON STUDY CORRIDOR IN 2026	3-41
TABLE 3.53: STATION LOADS ON STUDY CORRIDOR IN 2031	3-42
TABLE 3.54: STATION LOADS ON STUDY CORRIDOR IN 2041	3-43
TABLE 3.55: STATION LOADS ON STUDY CORRIDOR IN 2051	3-44
TABLE 3.56: SECTION LOADING FOR 2026, 2031, 2041 & 2051	3-45
 TABLE 4.1: SYSTEM SPECIFICATION PARAMETERS	 4-2
 TABLE 5.1: LIST OF GPS CONTROL POINTS	 5-3
TABLE 5.2: LIST OF TRAVERSE CONTROL POINTS.....	5-7
TABLE 5.3: LIST OF TBM	5-21
TABLE 5.4: MOVEMENT OF METRO TRAIN UP/DOWN LINE	5-38
TABLE 5.5: LIST OF STATIONS FOR CORRIDOR FOR HUDA CITY CENTRE TO SECTOR-56 DIRECTION.....	5-43
TABLE 5.6: LIST OF STATIONS FOR CORRIDOR FOR SECTOR-56 TO HUDA CITY CENTRE DIRECTION.....	5-45
TABLE 5.7: DESIGN CRITERIA.....	5-60
TABLE 5.8: HORIZONTAL CURVE PARAMETERS	5-60
TABLE 5.9: LENGTH OF TRANSITIONS OF HORIZONTAL CURVES	5-61
TABLE 5.10: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION	5-61
TABLE 5.11: GRADIENT PARAMETERS.....	5-62
TABLE 5.12: VERTICAL CURVE PARAMETERS	5-62
TABLE 5.13: RADIUS, CANT AND PERMITTED SPEED	5-63
TABLE 5.14: COMPARATIVE ANALYSIS OF TYPES OF STRUCTURAL ARRANGEMENTS	5-72
TABLE 5.15: GENERALISED GEOLOGICAL SUCCESSION, GURGAON DISTRICT.....	5-77

TABLE 5.16: LABORATORY TESTS	5-79
TABLE 5.17: SUMMARY OF BORE HOLES UTILIZED FROM HSIIDC METRO	5-80
TABLE 5.18: SUMMARY OF BORE HOLES DRILLED ALONG THE CORRIDOR	5-80
TABLE 5.19: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG THE CORRIDOR (UTILIZED FROM HSIIDC)	5-86
TABLE 5.20: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG THE CORRIDOR (DRILLED BOREHOLES).....	5-89
TABLE 5.21: SAFE LOAD CARRYING CAPACITY OF PILES (UTILIZED FROM HSIIDC METRO)	5-92
TABLE 5.22: SAFE LOAD CARRYING CAPACITY OF PILES (DRILLED BOREHOLES).....	5-93
TABLE 5.23: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR	5-100
TABLE 5.24: DETAILS OF HORIZONTAL CURVES OF THE CORRIDOR	5-101
TABLE 5.25: ABSTRACT OF GRADIENTS OF CORRIDOR	5-104
TABLE 5.26: DETAILS OF GRADIENTS FOR CORRIDOR.....	5-104
TABLE 5.27: LOCATION OF PORTALS.....	5-107
TABLE 5.28: LOCATION OF SPECIAL SPAN.....	5-107
TABLE 5.29: ABSTRACT OF HORIZONTAL CURVES OF SPUR TO DWARKA EXPRESSWAY	5-108
TABLE 5.30: ABSTRACT OF GRADIENTS OF SPUR TO DWARKA EXPRESSWAY	5-108
TABLE 5.31: DETAILS OF GRADIENTS FOR SPUR TO DWARKA EXPRESSWAY.....	5-108
TABLE 5.32: LOCATION OF SPECIAL SPAN.....	5-108
TABLE 5.33: DETAILS OF HORIZONTAL CURVES OF SPUR TO DWARKA EXPRESSWAY.....	5-109
TABLE 5.34: UTILITY RESPONSIBILITY DEPARTMENTS	5-110
TABLE 5.35: WATER PIPE LINES OF GMDA.....	5-113
TABLE 5.36: SEWER PIPE LINES OF GMDA	5-113
TABLE 5.37: ELECTRICITY LINES OF HARYANA VIDYUT PRASARAN NIGAM LIMITED (HVPNL).....	5-114
TABLE 5.38: ELECTRICITY LINES OF DAKSHIN HARYANA BIJLI VITRAN NIGAM VIDYUT (DHVBN)	5-115
TABLE 5.39: GAS LINES OF GAS AUTHORITY OF INDIA LTD (GAIL)	5-117
TABLE 5.40: GAS LINES OF HARYANA CITY GAS (HCG).....	5-117
TABLE 5.41: OPTICAL FIBRE CABLE OF POWER GRID CORPORATION OF INDIA LTD (PGCIL).....	5-117
TABLE 5.42: OPTICAL FIBRE CABLE OF BHARAT SANCHAR NIGAM LIMITED (BSNL)	5-118
TABLE 5.43: OPTICAL FIBRE CABLE OF AIRTEL	5-119
TABLE 5.44: OPTICAL FIBRE CABLE OF RELIANCE COMMUNICATION.....	5-120
TABLE 5.45: OPTICAL FIBRE CABLE OF JIO COMMUNICATION	5-121
TABLE 5.46: OPTICAL FIBRE CABLE OF TATA TELE SERVICES COMMUNICATION.....	5-122
TABLE 5.47: OPTICAL FIBRE CABLE OF VODAFONE.....	5-123
TABLE 5.48: OPTICAL FIBRE CABLE OF AIRCEL	5-124
TABLE 5.49: LAND & STRUCTURES REQUIREMENT (IN SQM)	5-126
TABLE 5.50: PERMANENT LAND REQUIREMENT FOR STATIONS	5-128
TABLE 5.51: PERMANENT LAND REQUIREMENT FOR RUNNING SECTION	5-131
TABLE 5.52: LAND TEMPORARILY REQUIRED FOR CONSTRUCTION DEPOT	5-134
TABLE 5.53: TREE LIST WITH GIRTH MORE THAN 30 CM.....	5-134
TABLE 6.1:STATIONS AND INTER-STATION DISTANCE	6-1
TABLE 6.2: STATION FACILITIES ACCOMMODATION	6-40
TABLE 6.3: STATION TYPOLOGIES	6-49
TABLE 6.4: ROOM SCHEDULE FOR STATION TYPE A	6-49
TABLE 6.5: ROOM SCHEDULE FOR STATION TYPE B	6-51
TABLE 6.6: ROOM SCHEDULE FOR STATION TYPE C	6-52
TABLE 6.7: DETAILS OF STATION TYPES	6-56
TABLE 6.8: DETAILS OF PARKING AREAS	6-58

TABLE 7.1: FLEET REQUIREMENT FOR METRO CORRIDOR	7-4
TABLE 7.2: BICYCLE SHARING SCHEME FOR METRO CORRIDOR.....	7-8
TABLE 8.1: YEAR WISE PEAK HOUR PEAK DIRECTION TRAFFIC (PHPDT).....	8-1
TABLE 8.2: CARRYING CAPACITY OF COACHES	8-2
TABLE 8.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED	8-3
TABLE 8.4: HEADWAY AND CAPACITY PROVIDED FOR DIFFERENT SECTIONS	8-3
TABLE 8.5:: ROLLING STOCK REQUIREMENT.....	8-6
TABLE 8.6: VEHICLE KILOMETER FOR HUDA CITY CENTRE TO SECTOR-56.....	8-6
TABLE 8.7: VEHICLE KILOMETER FOR HUDA CITY CENTRE TO SECTOR-101.....	8-6
TABLE 9.1: STANDARDS TO BE ADOPTED FOR SIGNALLING SYSTEM	9-5
TABLE 9.2: TELECOMMUNICATION SYSTEM USED IN DIFFERENT METROS.....	9-6
TABLE 9.3: STANDARDS TO BE ADOPTED FOR TELECOMMUNICATIONS SYSTEM	9-12
TABLE 10.1: STANDARDS PROPOSED FOR AFC SYSTEM.....	10-7
TABLE 11.1: BROAD FEATURES OF ROLLING STOCK	11-3
TABLE 11.2: COACH DIMENSIONS.....	11-4
TABLE 11.3: CARRYING CAPACITY OF METRO RAIL.....	11-4
TABLE 11.4: WEIGHT OF MASS RAIL VEHICLES (TONS)	11-4
TABLE 11.5: ROLLING STOCK REQUIREMENT.....	11-5
TABLE 12.1: POWER DEMAND ESTIMATION (MVA)	12-4
TABLE 12.2 : SOURCES OF POWER SUPPLY	12-5
TABLE 12.3 : POWER DEMAND PROJECTION FOR VARIOUS SOURCES	12-6
TABLE 14.1: RAKE REQUIREMENT FOR DIFFERENT HORIZON YEARS.....	14-2
TABLE 14.2: PROPOSED MAINTENANCE SCHEDULE	14-3
TABLE 14.3: SCHEDULE OF CLEANING.....	14-4
TABLE 14.4: INSPECTION AND WORKSHOP LINES PROVIDED FOR CORRIDOR	14-6
TABLE 15.1: SCOPING MATRIX	15-1
TABLE 15.2: ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING	15-2
TABLE 15.3: SAMPLING LOCATIONS FOR SOIL	15-5
TABLE 15.4: RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLE.....	15-5
TABLE 15.5: DESCRIPTION OF WATER QUALITY MONITORING LOCATIONS.....	15-8
TABLE 15.6: PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES IN PROJECT AREA.....	15-9
TABLE 15.7: METEOROLOGICAL DATA (TEMPERATURE & RELATIVE HUMIDITY)	15-11
TABLE 15.8: AVERAGE RAINFALL (MM).....	15-12
TABLE 15.9: AMBIENT AIR QUALITY MONITORING LOCATION.....	15-13
TABLE 15.10: AIR QUALITY RESULT	15-14
TABLE 15.11: NOISE MONITORING LOCATIONS.....	15-15
TABLE 15.12: AMBIENT NOISE LEVEL MONITORING RESULT.....	15-16
TABLE 15.13: AMBIENT NOISE STANDARDS CRITERIA	15-16
TABLE 15.14: TREE ENUMERATION IN ALIGNMENT, STATIONS & DEPOT	15-17
TABLE 15.15: LIST OF PREDOMINANT TREE OBSERVED IN THE STUDY AREA.....	15-19
TABLE 15.16: DETAILED STATUS OF FAUNA RECORDED IN STUDY AREA	15-19
TABLE 15.17: REDUCTION IN DAILY VEHICLE TRIPS	15-23

TABLE 15.18: FUEL SAVED PER YEAR	15-23
TABLE 15.19: SAVING IN FUEL EXPENDITURE PER YEAR (RS. Lakh)	15-23
TABLE 15.20: POLLUTION REDUCTION (TONS/YEAR)	15-23
TABLE 15.21: LIFE CYCLE SAVINGS FROM EMISSIONS (RS. LAKH)	15-24
TABLE 15.22: CONSTRUCTION EQUIPMENT NOISE EMISSION LEVEL	15-29
TABLE 15.23: DISTANCE AT WHICH $LEQ \leq$ AMBIENT NOISE LEVEL	15-30
TABLE 15.24: VIBRATION SOURCE LEVELS FOR CONSTRUCTION EQUIPMENT	15-30
TABLE 15.25: ESTIMATED VIBRATION LEVELS FOR DIFFERENT CONSTRUCTION EQUIPMENT (PPV in/sec)	15-31
TABLE 15.26: GUIDELINE VIBRATION DAMAGE THRESHOLD CRITERIA	15-31
TABLE 15.27: NOISE LEVELS AT DIFFERENT DISTANCES DURING OPERATION	15-32
TABLE 15.28: NOISE BARRIER	15-33
TABLE 15.29: SCREENING DISTANCES (IN METER) FOR VIBRATION ASSESSMENT	15-34
TABLE 15.30: WATER REQUIREMENT	15-34
TABLE 15.31: LIST OF TREES FOR PLANTATION	15-37
TABLE 15.32: COST FOR TRAINING PROGRAMME	15-46
TABLE 15.33: COST OF ESTABLISHMENT OF ENVIRONMENTAL DIVISION	15-46
TABLE 15.34: CONSTRUCTION STAGE MONITORING SCHEDULE	15-49
TABLE 15.35: OPERATION STAGE MONITORING SCHEDULE	15-50
TABLE 15.36: CLEARANCES/PERMISSIONS FOR PROPOSED METRO CORRIDORS	15-51
TABLE 15.37: ROLES AND RESPONSIBILITIES –PREPARATION AND IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND ENVIRONMENTAL MONITORING PLAN (EMOP)	15-52
TABLE 15.38: SUMMARY OF COST ESTIMATE	15-54
TABLE 15.39: STATION WISE TYPE OF AFFECTED STRUCTURES	15-57
TABLE 15.40: SUMMARY OF AFFECTED PROPERTIES/STRUCTURES	15-57
TABLE 15.41: PARTIALLY AND FULLY AFFECTED STRUCTURES BY TYPE OF STRUCTURES	15-58
TABLE 15.42: IMPACT ON PAFs	15-58
TABLE 15.43: STATION WISE FULLY AND PARTIALLY AFFECTED FAMILIES WITH TYPE OF LOSS	15-59
TABLE 15.44: TITLE HOLDERS AND NON-TITLE HOLDERS AMONG AFFECTED FAMILIES	15-59
TABLE 15.45: DEMOGRAPHIC CHARACTERISTICS OF SAMPLE PAFs	15-60
TABLE 15.46: SOCIAL CHARACTERISTICS OF SAMPLE PAFs	15-61
TABLE 15.47: CORRIDOR WISE OCCUPATIONAL CHARACTERISTICS OF SAMPLE PAFs	15-62
TABLE 15.48: PROJECT AFFECTED TYPE OF COMMERCIAL ACTIVITY	15-63
TABLE 15.49: VULNERABILITY OF PAFs	15-64
TABLE 15.50: AWARENESS AND OPINION OF PAFs ON PROPOSED METRO	15-64
TABLE 15.51: PREFERRED LOCATION AND R&R OPTIONS	15-65
TABLE 15.52: SUMMARY OF PUBLIC PARTICIPATION	15-66
TABLE 15.53: ENTITLEMENT MATRIX	15-68
TABLE 15.54: INDICATORS FOR MONITORING OF RAP PROGRESS	15-74
TABLE 15.55: R&R COST FOR IMPLEMENTATION OF RAP	15-76
TABLE 17.1: LAND & STRUCTURES REQUIREMENT (IN SQM)	17-2
TABLE 17.2: RATES OF ITEMS OTHER THAN LAND	17-2
TABLE 17.3: CAPITAL COST ESTIMATE	17-4
TABLE 17.4: COST COMPONENT UNDER PPP	17-7
TABLE 17.5: TAXES AND DUTIES COMPONENTS	17-7
TABLE 17.6: TAXES AND DUTIES	17-8
TABLE 17.7: ABSTRACT OF COST ESTIMATE	17-10
TABLE 17.8: O&M COST FOR GURUGRAM METRO CORRIDOR	17-12
TABLE 17.9: LAND COST FOR VAIDUCT/RUNNING SECTION	17-13
TABLE 17.10: LAND COST FOR STATIONS	17-15

TABLE 17.11: LAND COST FOR DEPOT.....	17-18
TABLE 18.1: PLANNING PARAMETERS WITHIN TOD ZONE	18-3
TABLE 18.2: REVENUE ASSESSMENT FROM PREMIUM ON ADDITIONAL FAR	18-6
TABLE 18.3: STAMP DUTY COLLECTION IN GURUGRAM CITY.....	18-7
TABLE 18.4: REVENUE FROM ADDITIONAL SURCHARGE ON STAMP DUTY.....	18-7
TABLE 18.5: TOTAL REVENUE SHARE TO GURUGRAM METRO FROM TOD (VCF)	18-9
TABLE 19.1: CAPITAL COSTS (RS. IN CRORE)	19-1
TABLE 19.2: DETAILS OF COMPLETION COSTS (RS IN CRORE)	19-2
TABLE 19.3: COMPLETED COST OF PROJECT.....	19-2
TABLE 19.4: OPERATION AND MAINTENANCE COSTS WITH ESCALATION	19-4
TABLE 19.5: EXPECTED METRO RIDERSHIP IN HORIZON YEARS	19-5
TABLE 19.6: TRIP LENGTH DISTRIBUTION	19-5
TABLE 19.7: FARE STRUCTURE FOR DELHI METRO 2019-2020	19-6
TABLE 19.8: RATES FOR NON FARE BOX REVENUES	19-6
TABLE 19.9: ADVERTISING AREA.....	19-7
TABLE 19.10: NON FARE BOX REVENUE	19-7
TABLE 19.11: TOTAL REVENUE FROM TOD (VCF)	19-7
TABLE 19.12: TOTAL REVENUE FROM TOD & NON FARE BOX SOURCES.....	19-7
TABLE 19.13: TOTAL REVENUE COLLECTION (RS. IN CRORE).....	19-8
TABLE 19.14: COST AND RIDERSHIP SENSITIVITY.....	19-9
TABLE 19.15: COST AND RIDERSHIP SENSITIVITY.....	19-9
TABLE 19.16: GURGAON METRO FIRR WITH ALL TAXES (RS. IN CRORE)	19-10
TABLE 19.17: FUNDING PATTERN UNDER SPV WITH CENTRAL TAXES	19-18
TABLE 19.18: FUNDING PATTERN UNDER PPP – BOT WITH VGF.....	19-19
TABLE 19.19: FUNDING PATTERN UNDER FIXED FEE MODEL.....	19-20
TABLE 19.20: COMPARISON OF THREE IMPLEMENTATION MODELS (RS. CRORE).....	19-20
TABLE 20.1: KEY EVALUATION ASSUMPTIONS.....	20-1
TABLE 20.2: ESTIMATED DEMAND AND MODAL SHARE IN 'WITH' AND 'WITHOUT' SCENARIO	20-2
TABLE 20.3: FACTORS USED FOR CONVERTING PROJECT COSTS TO ECONOMIC COSTS.....	20-2
TABLE 20.4: FINANCIAL COSTS OF MRTS - CAPITAL AND O&M	20-3
TABLE 20.5: ECONOMIC COSTS OF MRTS - CAPITAL AND O&M	20-3
TABLE 20.6: FACTORS USED FOR CONVERTING PROJECT BENEFITS IN TERMS OF ECONOMIC COSTS	20-4
TABLE 20.7: MODE WISE VOC FOR GURUGRAM	20-5
TABLE 20.8: MODE WISE VOT FOR GURUGRAM MRTS	20-5
TABLE 20.9: MODE WISE OPERATIONAL PARAMETERS – METRO	20-5
TABLE 20.10: MODE WISE EMISSION FACTORS (GRAM/KM)	20-6
TABLE 20.11: COST OF ACCIDENTS	20-6
TABLE 20.12: COMPARISONS OF SAVINGS FROM MRTS IN HORIZON YEAR – 2051.....	20-7
TABLE 20.13: ECONOMIC RETURN PARAMETERS OF GURUGRAM METRO.....	20-8
TABLE 20.14: SENSITIVITY ANALYSIS.....	20-8
TABLE 20.15: COST AND BENEFIT STREAM FOR METRO SYSTEM (IN CRORE).....	20-9
TABLE 21.1: PROJECT IMPLEMENTATION SCHEDULE	21-1

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

0.1. PROFILE OF THE CITY

The region of Gurgaon originally fell under the Kuru Kingdom. In the Mahabharata, Gurgaon is described as the village of Guru Dronacharya, Guru of the Kauravas and Pandavas. In late 4th century BCE, the city was absorbed by the Maurya Empire as part of Chandragupta Maurya's earliest expansions of his kingdom.

Gurgaon is a satellite city of Delhi located in the northwestern Indian state of Haryana and is part of the National Capital Region of India. It is 32 km southwest of New Delhi and 268 km (167 mi) south of Chandigarh, the state capital.

Today, it has become a hub of multinational companies, industries giants, call centres, software companies, shopping malls and skyscrapers. Gurgaon's skyline with its many skyscrapers is nationally recognized, and the city has been home to several tall buildings with modern planning. The City has been growing rapidly due to large scale urbanization and economic activities. As a result, city requires an efficient and convenient Mass Rapid Transit System.

A number of initiatives have been taken in recent years to improve the Transport Infrastructure in the City and to provide better public transport facilities to the commuters. However, the growing needs of commuters and city have led city planning agencies to plan and create additional infrastructure facilities to serve the future travel needs.

The Final development plan (2031) for Gurgaon Manesar Urban Complex (GMUC) states a large number of proposals related to improvement in transport network and mass transport facilities for horizon year 2031. The master plan also identified the need of having mass public transit system to cater to the present and future population and mobility requirements.

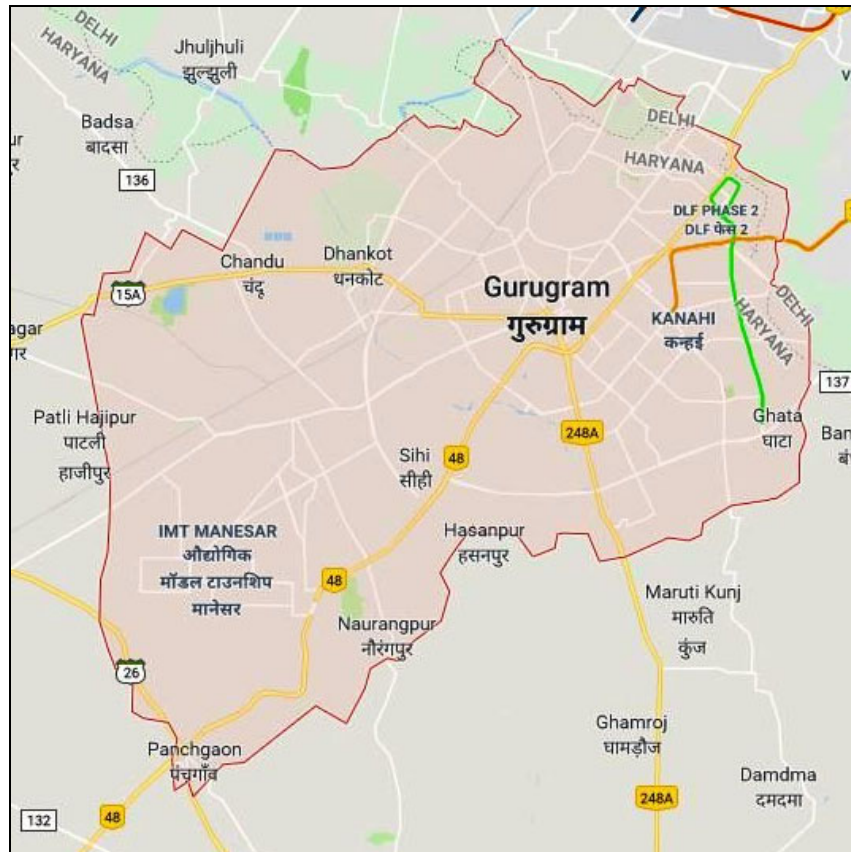
To provide efficient connectivity and ease in the mobility, Haryana Mass Rapid Transport Corporation (HMRTC) had appointed DMRC to prepare 'Techno-Feasibility Study' for Mass Transit Corridor from 'HUDA city centre to Gurgaon Railway Station'. Subsequently, DMRC submitted the Techno-Feasibility report in September 2016.

HMRTC has engaged RITES to prepare the DPR for Metro Rail Connection from HUDA City Centre – Cyber City and Metro Spur to Dwarka Expressway.

The area under the jurisdiction of the Gurgaon Manesar Urban Complex (GMUC) is the Study Area for the present Assignment (**FIGURE 0.1**). The contiguous urban development's abutting the Gurgaon Municipal Corporation area also share significant interactions with it. Gurgaon Municipal Corporation area has 115 sectors which together form 35 wards for municipal operations. Therefore, in order to assess the comprehensive traffic and transport characteristics, GMUC as classified by Census 2011 - comprising of Gurgaon and IMT Manesar is considered.

Population projections is carried out based on the growth trends taken separately for Core, Middle, Outer and special areas collectively forming the Study Area. The population in the study area for Base year 2019 is 16.83 lakh and projected population for the horizon years 2021, 2031 and 2041 is 18.73 lakh, 42.50 lakh and 50.75 lakh respectively.

FIGURE 0.1: STUDY AREA



0.2. EXISTING TRANSPORTATION SYSTEM IN THE CITY

Total vehicles in Gurgaon city have increased tremendously. The share of two-wheelers registration comprises about 60%, while cars comprise about 38%.

It is observed that about 28.2 % of the road network has less than 10 m ROW, 28.7% has 10-20 m ROW, and 17.8 % has 20-30 m ROW while 25.4% has ROW above 30m. It is also observed that about 20% and 28% of the road network has carriageway width less than or equal to 2-lane and 3 to 4 lane respectively and about 26% of roads has carriageway width more than and equals to 6-lane.

The maximum traffic have been observed at Subhash Chowk - Rajiv Chowk section which is about 1,21,403 Vehicle (1,07,242 PCU's) and minimum at Basai Chowk – Gurgaon which is about 38,759 Vehicle (30,559 PCU's).

At present, Gurgaon Bus Terminal is the major terminal for intercity buses which caters to the 18,555 passengers daily and 2024 passengers in peak hour. Gurgaon has a Railway station which is on the line of Delhi – Jaipur. It is one of the major Stations catering to Gurgaon, Delhi and other parts of Gurgaon district. The Gurgaon city is also facilitated with an Airport away from 18km, named Indira Gandhi International Airport which located in New Delhi which is accessible through NH 48.

0.3. TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

A total of 145 internal zones inside GMUC and 4 external zones have been considered for the study. The projected population, employment in the years 2021, 2025, 2031 and 2041 is presented in the **Table 0.1**.

TABLE 0.1: LANDUSE PARAMETERS

Year	Population	Employment	WFPR (%)
2019	16,82,889	6,25,445	37.2%
2021	18,73,097	6,97,842	37.3%
2031	42,50,000	16,99,525	40.0%
2041	50,75,000	20,86,451	41.1%

A four stage travel demand model has been developed for transport demand forecasting. Daily Ridership on the study corridor for the years 2026, 2031, 2041 and 2051 is expected to be 5.34 Lakh passenger trips, 7.26 Lakh passenger trips, 8.81 passenger trips and 10.70 Lakh passenger trips respectively. The maximum peak hour peak direction trips (PHPDT) is shown in the **Table 0.2**.

TABLE 0.2: RIDERSHIP ON GURGAON METRO CORRIDOR

Corridor details	Maximum PHPDT			
	2026	2031	2041	2051
HUDA City Centre – Cyber City and Spur to Dwarka Expressway	19359	27263	34309	43878

0.3.1 Design Ridership

The Metro corridor has maximum PHPDT of 19359, 27263, 34309 and 43878 in years 2026, 2031, 2041 and 2051 respectively. These PHPDT figures will rely on proposed developments as envisaged in Master Plan of Gurgaon, realization of other planned transport infrastructure projects and a number of other issues that could appear during next 20-40 years. Generally, it takes 4-5 years to achieve the estimated ridership on a new mass transit system. Hence, the design ridership has been taken as slightly lower at 70% of the maximum ridership for the commencement year 2026 i.e. 13551 PHPDT and then has been gradually increased every year to stabilize to estimated ridership by the year 2031.

0.4. SYSTEM & TECHNOLOGY SELECTION

Considering the existing rapid metro alignment, city specific characteristics, traffic demand, availability of right of way, Gurgaon metro is planned to be integrated with the Rapid metro network. The system and technology to be adopted for Gurgaon metro will be similar to that of Rapid metro. Metro rail with 3 and 6 car configuration with the ultimate capacity of 30000 PHPDT (with 3 car trains running at 2 minutes headway) and 60000 PHPDT (with 6 car trains at 2 minutes headway) is proposed.

0.5. CIVIL ENGINEERING & ALIGNMENT DETAILS**0.5.1. Geometric Design Parameters****TABLE 0.3: DESIGN CRITERIA**

SN	Criteria	Dimension
1	Gauge	1435 mm
2	Design Speed	80Kmph
3	Maximum Axle Load	15T
4	Electric Power Collection	3rd Rail, 750 V D.C.

TABLE 0.4: HORIZONTAL CURVE PARAMETERS

Description	Elevated Section
Minimum radius on main running lines other than stations	125 m with check rail*
Minimum curve radius at Depot & other lines	100m with check rail
Minimum curve radius at passenger stations	1000 m
Maximum permissible cant (Ca)	110 mm
Maximum cant deficiency (Cd)	85 mm

TABLE 0.5: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.10 m*	7.50 m**
Station	4.10 m	12.50 m
Note: * Track centre in elevated section can be modified as per the choice of girder/super structure. For Double U-girder minimum 4.60 m track centre will be provided. ** For I-girder and Box-girder, Minimum Rail Level above Ground Level shall be 8.50 m		

TABLE 0.6 : GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 2%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

TABLE 0.7: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

0.5.2. Engineering Survey

Topographical Surveys for the corridor and the spur were conducted from April'2018 to April'2019 based on differential GPS.

0.5.3. Geotechnical Investigations

In total, **24 BHs** have been drilled upto a maximum 30.00 m depth each for all along the length of proposed Metro alignment.

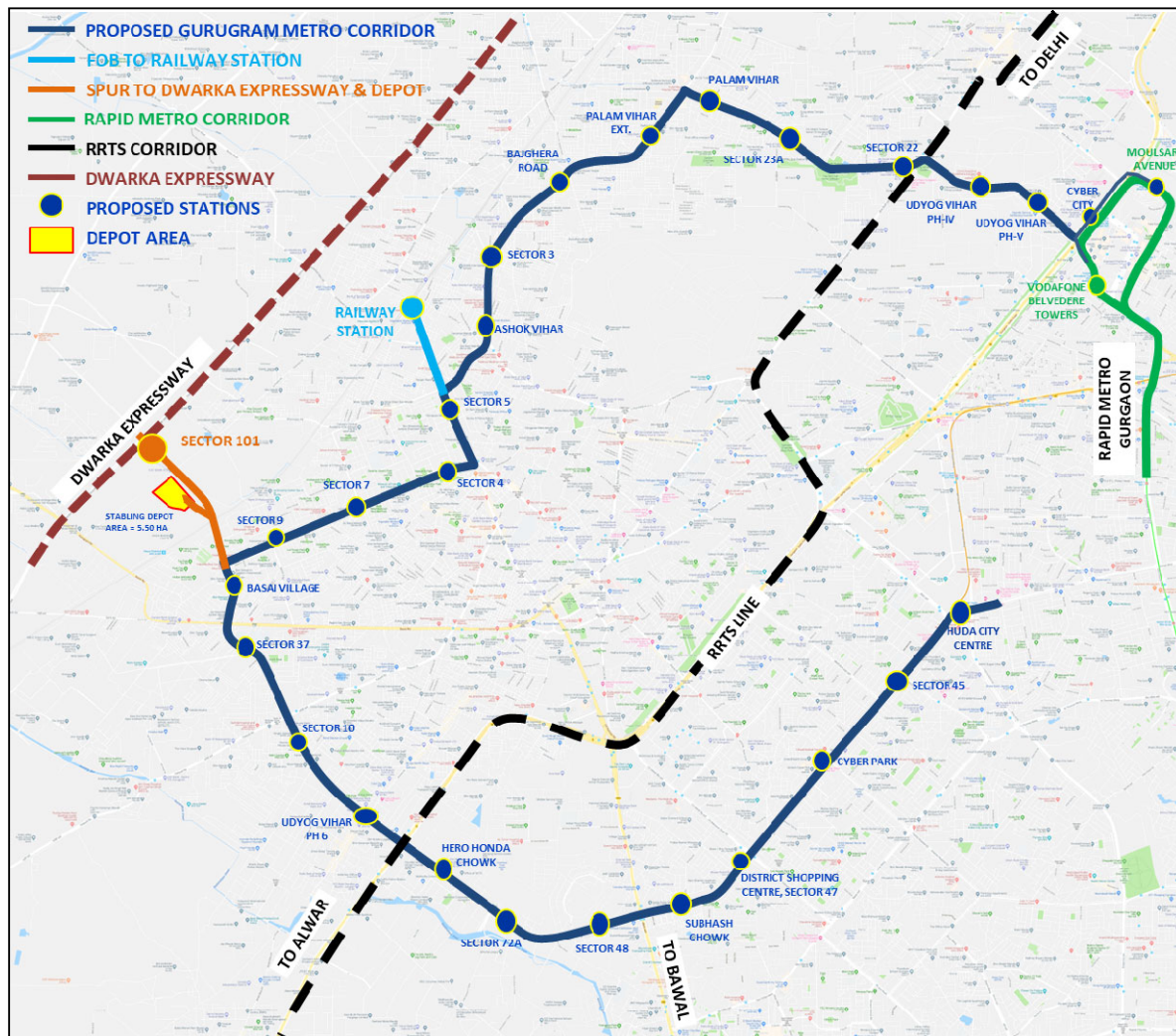
0.5.4. Alignment Description

One corridor along with a spur, has been finalized for implementation in Gurgaon Metro Rail Project network. The total length of the corridor and the spur comes out to be 28.50 km. The details of the corridor are as follows:

- Main Corridor from HUDA City Centre to Cyber City, Gurgaon (26.65 Km).
- Spur from Basai Village to Dwarka Expressway (1.85 Km).

The proposed corridor is planned to have track integration with Rapid Metro at Belvedere Towers and Moulisari Avenue Stations. This will enable optimum utilization of the existing infrastructure and accordingly, the operations have been planned from Huda City Centre – Cyber City – Sector 56 (Terminal Station of Rapid Metro) and vice-versa. Figure 0.2 shows the Gurgaon Metro corridor.

FIGURE 0.2: PROPOSED GURGAON METRO CORRIDOR



Corridor: HUDA City Centre to Cyber City, Gurgaon

For the planning convenience, the zero point of the Corridor is considered at the centre line of the proposed HUDA City Centre station. The chainage along the alignment increases from HUDA City Centre to Cyber City. The total length of the corridor is 26.65 km, consisting of a total of 26 elevated stations. Stabling depot with an area of 5.50 hectare has been proposed in the private land at Sector-101.

TABLE 0.8: ABSTRACT OF HORIZONTAL CURVES – CORRIDOR

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤ 200	24	4135.40	42.42
2	$>200 \leq 300$	5	631.16	6.47
3	$>300 \leq 500$	19	2483.95	25.48
4	$>500 \leq 800$	9	878.66	9.01
5	$>800 \leq 1000$	7	864.95	8.87
6	>1000	13	755.11	7.75
	Total	77	9749.24	100.00

TABLE 0.9: ABSTRACT OF GRADIENTS – CORRIDOR

S. No.	Description	Nos. of Occurrences	Length (m)	% Length
1	Level (0%)	43	9845	36.18
2	$>0\% \leq 1\%$	19	4982	18.31
3	$>1\% \leq 2\%$	39	9234	33.93
4	$>2\% \leq 3\%$	12	2985	10.97
5	$>3\%$	1	165	0.61
	Total	114	27211	100.00

Spur: Basai Village to Dwarka Expressway

The spur takes off from Ch: 11700m after crossing Basai Village station. The spur consists of completely elevated stretch with length of 1.85 Km and one elevated station namely Sector-101 to get its connectivity with Dwarka Expressway. Entry to Stabling Depot has been planned after crossing the railway tracks near Sector 101.

TABLE 0.10: ABSTRACT OF HORIZONTAL CURVES – SPUR

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤ 200	0	0.00	0.00
2	$>200 \leq 300$	1	118.34	19.79
3	$>300 \leq 500$	4	479.75	80.21
4	$>500 \leq 800$	0	0.00	0.00
5	$>800 \leq 1000$	0	0.00	0.00
6	>1000	0	0.00	0.00
	Total	5	598.10	100.00

0.5.6 Land Requirement

Land will be required for the following main components:

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Radio Towers
- Temporary Construction Depots and work sites.

Abstract of land requirements for different components of corridors are given in **TABLE 0.11**.

TABLE 0.11: LAND & STRUCTURES REQUIREMENT

Ownership	Purpose	Permanent Land (Sqm)	Temporary Land (Sqm)	Structures (Floor Area) (Sqm)
Central Govt.	Alignment / Stations, ancillary buildings & Misc.	1047	0	118
	Sub-Total	1047	0	118
State Govt.	Alignment / Stations, ancillary buildings & Misc.	41919	0	1221
	TSS	3000	0	0
	Construction Yards	0	45000	0
	Sub-Total	44919	45000	1221
Private	Alignment / Stations, ancillary buildings & Misc.	10291	0	1767
	Stabling Depot	55000	0	0
	Sub-Total	65291	0	1767
TOTAL		111257	45000	3106

0.6. STATION PLANNING

0.6.1. Station Planning

The stations have been planned based on the basis of following parameters:

- Station planning is dependent on the peak hour traffic load for each station. In the design year, maximum PHPDT of 34309 passengers from 'HUDA City Centre to Cyber City and Spur to Dwarka Expressway' is expected.
- The station is planned for 6 cars train.
- The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the next level does not exceed 5.5 minutes in elevated stations considering that the stations are open and the risk is much less.

- d. The station planning is in compliance to the “Guidelines and space Standards for Barrier Free Built Environment for Disabled and Elderly persons” published by the Ministry of Urban Affairs and Employment India in 1998.
- e. Three typical designs have been suggested for various station (**Table 0.12**) and these will form basis for planning of all the stations (**Table 0.13**).

TABLE 0.12: TYPICAL DESIGNS

Sr. No.	Proposed Type	Elevated/UG	Remarks
1	Type A (Typical Station)	Elevated	130m x 20m
2	Type B (Cyber City)	Elevated	130m x 28m
3	Type C (HUDA City Centre)	Elevated	130m x 22m

TABLE 0.13: STATION TYPOLOGY AND DETAILS

S. No.	Station Name	Chainage (m)	Inter-station Distance (m)	Elevated/ Underground
Corridor: HUDA City Centre to Cyber City				
1	HUDA City Centre	0	-	Elevated
2	Sector 45	1000	1000	Elevated
3	Cyber Park	2200	1200	Elevated
4	District Shopping Centre, Sector 47	3665	1465	Elevated
5	Subhash Chowk	4480	815	Elevated
6	Sector 48	5500	1020	Elevated
7	Sector 72A	6370	870	Elevated
8	Hero Honda Chowk	7400	1030	Elevated
9	Udyog Vihar Phase 6	8659	1259	Elevated
10	Sector 10	9535	876	Elevated
11	Sector 37	10815	1280	Elevated
12	Basai Village	11645	830	Elevated
13	Sector 9	12438	793	Elevated
14	Sector 7	13215	777	Elevated
15	Sector 4	14480	1265	Elevated
16	Sector 5	15465	985	Elevated
17	Ashok Vihar	16510	1045	Elevated
18	Sector 3	17510	1000	Elevated
19	Bajghera Road	18435	925	Elevated
20	Palam Vihar Extension	19591	1156	Elevated
21	Palam Vihar	20400	809	Elevated
22	Sector 23A	21491	1091	Elevated
23	Sector 22	22773	1282	Elevated
24	Udyog Vihar Phase 4	23653	880	Elevated
25	Udyog Vihar Phase 5	24476	823	Elevated
26	Cyber City	25235	759	Elevated

S. No.	Station Name	Chainage (m)	Inter-station Distance (m)	Elevated/ Underground
Spur to Dwarka Expressway				
27	Sector 101	13426	1784 (From Basai Village Station)	Elevated

0.6.2. NMV and Pedestrian Facilities

Pedestrian facilities like continuous footpath of 2m wide, demarcation of pick and drop for PT/IPT, Zebra crossing at intersections, table top crossings, relocation of encroachments, strengthen of ROW have been proposed near the station influence area for ease for pedestrian movement. For non-motorized vehicles facilities like cycle tracks have been planned on the basis of land availability near the station for seamless movement.

0.6.3. Accessibility for Differently-abled

The proposed Metro Rail system should be user-friendly ensuring accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems and the elderly persons. The standards are extracted from 'Guidelines for Pedestrian Facilities' and 'NFA Guidelines', 'Space Standards for Barrier Free Built Environment for differently-abled and Elderly Persons' and other standards. Standard for differently-abled facilities within station areas will be provided for seamless movement around metro stations.

0.7. INTERMODAL INTEGRATION

0.7.1 Principles of Integration

Location of stations for the proposed Metro system has been finalized after extensive stakeholder consultations. Planning principles taken into account for intermodal integration are as follows:

- Seamless connectivity to and from catchment area of the station
- Integration with all possible modes including other mass transport systems
- Priority to pedestrians followed by public transport
- Parking facilities for all modes including non motorized transport (NMT) at important stations
- Minimal land acquisition

0.7.2 Feeder Bus System

The feeder buses shall be of high quality, ultra-modern and customer oriented that

can deliver fast, comfortable and cost-effective urban mobility. Easy-to-board (low floor), attractive and environmentally friendly buses with air conditioning having capacity of 35 (Mini-buses) are proposed for feeder system. The total of 49 buses are required in the year 2026.

Public bicycle sharing will be provided for the passengers for 1 km to 2 km of the metro stations influence area. A bicycle sharing system is the service in which bicycles are made available for free and shared use to metro passengers on a short term basis. The main purpose is to allow passengers to depart or arrive at metro stations.

0.8. TRAIN OPERATIONS PLAN

Gurugram metro is planned to be integrated with the Rapid Metro. Therefore, system similar to Rapid Metro is proposed. Further, the train operations for the Huda City Centre to Cyber City corridor will start from Sector-56 (existing Rapid Metro Station) and for Spur, the operations will be from Huda City Centre to Sector 101.

The Train operation plan for the corridor will be based on the following salient features:

- Operations from Huda City Centre – Cyber City - Sector 56 and Huda City Centre – Sector 101
- Running of services for 17 hours of a day (6:00 hrs to 23:00 hrs) with a station dwell time of 20-30 seconds
- Scheduled speed of 34 kmph
- Make up time of 5% with 8% coasting
- Adequate services to ensure comfortable journey for commuters even during peak periods

The train operation plan is envisaged for Gurgaon Metro corridor with 3 car rake composition during the initial years of operation. With the increase in traffic, combination of 3 and 6 car trains will run to cater to the demand. The infrastructure and train operation plan for the corridor is proposed to be designed for 6 car rake composition for the design year.

It is observed in most urban rail transit systems that ridership materialization in the initial years of operation is less than projected and takes time to reach the expected levels. Therefore, the train operation plan is formulated considering ridership at 70% for the commencement year 2026 i.e. 13551 PHPDT. This will enable to optimize the rolling stock requirement in initial years of operation. The PHPDT for the Year 2031 and 2041 will remain same.

Based on the traffic demand, the details of the proposed train operation plan for Gurgaon Metro corridor are given in **Table 0.14** below:

TABLE 0.14: HEADWAY AND CAPACITY PROVIDED

Items		2026	2031	2041	
Huda City Centre – Cyber City - Sector 56	Cars/ Train	3	3	3	6
	Headway (Sec.)	4.3	2.1	2.1	
	Trains/hr	14	28	21	7
	Capacity @6p/m ²	10598	21196	26929	
	Provided @8p/m ²	13692	27384	34818	
	PHPDT Demand	13551	27263	34309	
Huda City Centre – Dwarka Expressway (Sector 101)	Cars/ Train	3	3	3	
	Headway (Sec.)	20.0	20.0	20.0	
	Trains/hr	3	3	3	
	Capacity	2271	2271	2271	
	Provided	2934	2934	2934	

**70% PHPDT considered for initial year of operation*

The above train operation and headway for different horizon years is proposed to meet the Peak hour peak direction traffic demand (PHPDT) with standees @ 6 passengers/ m² in most of the sections, except in few sections where traffic demand is met with standees @ 8 passengers/ m². This arrangement will optimize the rolling stock requirement. Rolling Stock requirement for different horizon years for Gurgaon corridor is given in **Table 0.15**.

TABLE 0.15: COACH REQUIREMENT FOR DIFFERENT HORIZON YEARS

Year	2026	2031	2041
No. Of Coaches	117*	219	273

*Existing Rapid Metro system has total of 12 rakes i.e. 36 Coaches. Accordingly, in the initial year of operation (2026), additional 81 coaches will be required.

0.9. SIGNALING AND TELECOMMUNICATION

0.9.1. Signaling System

The Communication based Train Control (CBTC) Signaling system provides adequate safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of 90 seconds with continuous automatic train control. The CBTC Technology is suitable for UTO (Unattended Train Operation) / DTO (Driverless Train Operation). Considering the above, CBTC system is recommended for Gurgaon Metro.

0.9.2. Telecommunication System

The telecommunication system acts as communication backbone for signaling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network.

The proposed telecom system and transmission media will have following sub-systems:

- IP, GE based Transmission System
- Telephone Exchange
- Mobile Radio Communication System
- Public Address System (PAS)
- Centralized Clock System
- Passenger Information Display System (PIDS)
- Close Circuit Television (CCTV)
- Central Voice Recording System (CVRS) and
- Supervisory Control and Data Acquisition (SCADA) System

0.10. FARE COLLECTION SYSTEM

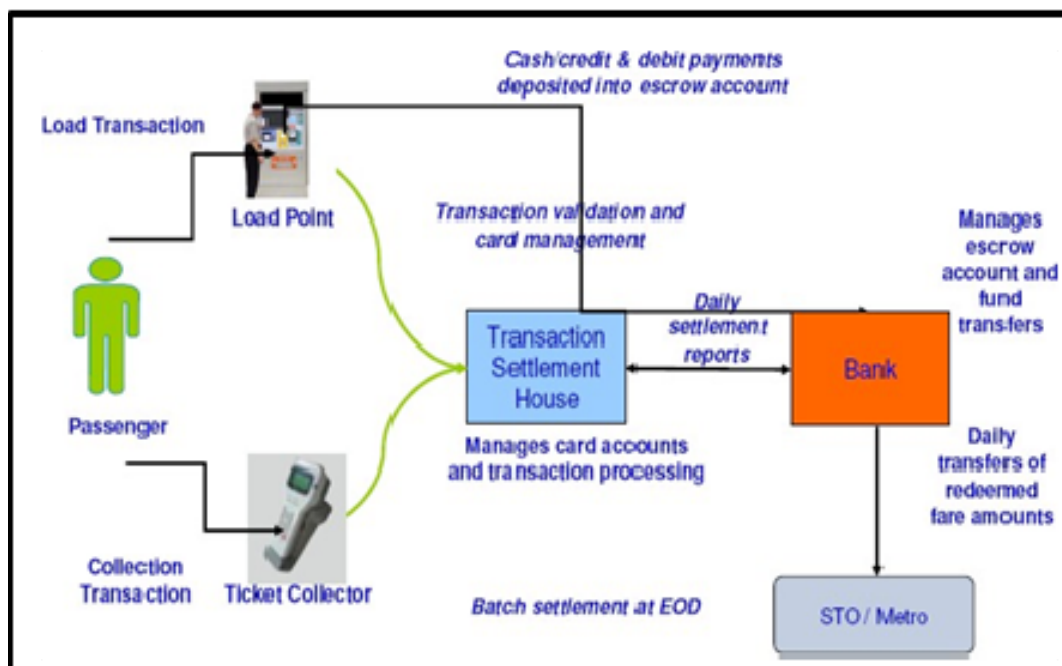
Mass Rapid Transit Systems handle a large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare collection system meets these requirements.

AFC system shall have functionality of interface to CCHS (Central Clearing House System) facility with provision of integration with other transit (MRT, bus etc.) and non-transit (parking, toll etc) which may be planned in future in line with the state / national policy. In Addition, proposed AFC system shall also be NFC (Near Field Communication) enabled so that customers can use their NFC enabled Mobile phones for metro travel. Facility of recharging of Travel Cards using Cash, Debit/Credit Cards and Net banking/web portal shall also be available. AFC system shall also support offsite sales terminals also, wherein cards and tokens can be dispensed at locations outside MRT premises.

Common Mobility Card

Common Mobility Card (CMC) Smart Card will provide Common Fare Collection System across different operators (both Government and Private) and different modes of public transport. Tipped as a nationwide interoperable transport card, the card aims to be a single point of transaction, applicable in state buses, MRT and even parking.

FIGURE 0.3: COMMON MOBILITY CARD OVERVIEW



0.11. ROLLING STOCK

Rolling Stock proposed for the Gurgaon MRTS corridors will be similar to Rapid Metro. The broad features of Rolling Stock are presented in **Table 0.16**.

TABLE 0.16: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Rolling Stock
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC
2	Coach Dimensions	19.9m x 2.8m
3	Train Composition	3 Car: DMC+TC+DMC 6 Car: DMC-TC-MC-MC-TC-DMC
4	Train Capacity	3 car train : 757 @6p/m ² , 978 @8p/m ² 6 car train : 1576 @6p/m ² , 2040 @8 p/m ²
5	Coach construction	Aluminum body
6	Axle load	≤16 T
7	Braking System	Regenerative Braking
8	Propulsion system	3 phase drive system with VVVF control
9	Type of traction supply	750 V DC Third Rail

0.12. POWER SUPPLY AND TRACTION

0.12.1. 750 V DC Third Rail traction system is proposed for Gurgaon Metro corridor. The power requirements of a metro system are determined by peak-hour power demand for traction and auxiliary applications. The ultimate (design) power requirement for this corridor will be conceptualized considering following norms, directives/ guidelines:

- Train operation with combination of 3 car and 6 car trains
- Peak period headway of 2.1 minutes during the design year
- Specific energy consumption of rolling stock – 75 KWh/ 1000 GTKM
- Regeneration @ 20%
- At grade/ Elev. station load – initially 200 kW, ultimate design 250 kW
- Depot auxiliary load – initially 1000 kW, ultimate design 1500 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, power demand estimation for the corridor is given in **Table 0.17**.

TABLE 0.17: POWER DEMAND ESTIMATION (MVA)

Year	2026	2031	2041
Traction	13.65	25.46	31.42
Auxiliary	8.87	10.27	11.67
Total	22.52	35.73	43.09

0.12.2. Sources Of Power Supply

Gurgaon City has 220kV, 66kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridor. Keeping in view of the reliability requirements and considering the complete length of corridors, two receiving Sub-stations are proposed to avail power supply for traction as well as auxiliary services from the Haryana Vidyut Prasaran Nigam Limited (HVPVL) grid sub-stations through cable feeders for the proposed corridor. The Grid Substations which have been identified near the alignment are given in **Table 0.18**.

TABLE 0.18: SOURCES OF POWER SUPPLY

Grid sub-station	RSS of Metro Authority	Approx. Dist. GSS to RSS
Sector 52 GSS (220/66 kV)	Sector 45 RSS (66/33 kV)	03 km
Daulatabad GSS(440/220/66 kV)	Krishna Chowk RSS (66/33 kV)	07 km

0.12.3. Auxiliary Supply Arrangements And Standby Power Supply

Auxiliary sub-stations (ASS) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 200 kW in the initial years and is likely to reach 250 kW in the horizon year.

Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 400 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. Apart from stations, separate ASS is required at each depot with 2x1500 kVA auxiliary transformers to cater to depot cum workshop load.

0.12.4. Solar Energy Harnessing System

Provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations/sheds and buildings is proposed for Gurgaon MRTS. Based on the solar radiation intensity in the city, the peak solar power generation is expected to be about 50 kWp for the elevated stations and about 500 kWp for stabling depot.

0.13. VENTILATION AND AIR-CONDITIONING SYSTEM

The proposed corridor of Gurgaon Metro i.e. Huda City Centre to Cyber City and Spur to Dwarka Expressway has been planned as completely elevated corridor. The air conditioning and ventilation requirement in the elevated stations of the corridors is mainly for the ancillary spaces such as staff room, equipment rooms etc. It is essential to maintain an acceptable environment for the operating and maintenance personnel, to prolong the life of equipment by proper control of temperature, pressure, and humidity, and to mitigate possible gas accumulation.

0.14. MAINTENANCE FACILITIES

The Maintenance facilities for HUDA City Centre to Sector-56 and Spur to Dwarka Expressway is proposed to be undertaken at existing depot of Rapid Metro at Sector 55, Gurgaon and the new stabling depot at Sector-101 for about 91 rakes of 3 cars and for maintenance and repairs of the rolling stock operational on corridor. The depots have the infrastructure to maintain rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor as well as maintenance facilities

for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signaling & Telecomm.; Automatic Fare Collection etc.

The proposed arrangement for stabling and maintenance facilities for Sector 101 Depot is given below in **Table 0.19**.

TABLE 0.19: STABLING DEPOT FOR GURGAON METRO CORRIDOR

Infrastructure	Sector 101 Stabling Depot
Stabling Lines	28 lines of 6 car
Inspection Lines	2 lines
Workshop Lines	2 lines

0.15. ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

0.15.1. Environmental Impact Assessment

The Environmental Impact Assessment identifies and evaluates environmental impacts resulting from the proposed metro corridors during various phases of project cycle and recommends measures to mitigate the negative impacts. For this purpose baseline data has been collected from primary and secondary sources.

The result of water samples analysis indicates that all parameters are within the permissible limit. Coliform was detected, that confirm the human and fecal contamination. Results for location SW1 have been compared with the CPCB surface water quality criteria. Comparing the values of pH, DO, BOD and total coli form with 'Use based classification of surface waters' published by Central Pollution Control Board; it can be seen that the surface water is not fit for any kind of use as specified by CPCB. Particulate matter (PM10 & PM2.5) was found to exceed permissible limit in residential as well as institutional areas at all monitoring locations; while other parameters like SO₂, NO₂ and CO are within permissible limit at all the six monitoring locations. Noise levels were found to exceed permissible noise limit specified for residential and commercial area. About 1008 trees will have to be felled. Proposed metro depot is located in Sector 101 wetland. The state Government has not declared the Sector 101 wetland as wetland so far but due to ecological sensitivity of the area, detailed study is required to prepare a conservation plan for the impact on aquatic flora and fauna and on bird. No archaeological monuments/sites are located on or along the proposed corridors.

Positive impacts include benefits to economy due to saving in cost of fossil fuels, saving in cost of human health from lifecycle emissions of PM_{2.5} and saving in cost of carbon capture from lifecycle emissions of GHG. Negative impacts include air pollution, noise and vibration, water demand during construction of the Metro;

noise and vibration, sewage and effluent during operation of the Metro.

Mitigation measures include pre-construction compensatory afforestation; management during construction of energy, construction material, safety, labour camp, hazardous waste, water pollution, sanitation, air pollution, noise and vibration, C&D waste; management during operation of noise and vibration, water supply and solid waste at stations and depots; training and Disaster Risk Management. Environmental enhancement measures recommended comprise rain water harvesting and green buildings. Estimated cost of implementation of EMP, EMoP and Training for the proposed metro project is about Rs 1557 Lakh.

0.15.2. Social Impact Assessment

As per requirement of Detailed Project Report (DPR) preliminary social impact assessment (SIA) was carried out. SIA identifies and evaluates social impacts resulting from the proposed metro corridor and recommends measures to mitigate the negative impacts. For this purpose, baseline data has been collected through socio-economic survey. The sample socio-economic survey was conducted in November 2018.

The total land required including government and private is 15.94 ha. The project shall require the acquisition of 11.44 ha of land permanently. Out of the total land, 4.73 ha is Government land and 6.71 ha is private land. The project also requires 4.5 ha land for temporary use. Total 33 structures (10 residential, 22 commercial and one residential cum commercial), 52 families are likely to be affected. Out of total affected families, majority of them (27 PAFs) shall be partially affected and remaining 25 families shall be fully affected. Out of the total partially affected families, three are residential and 24 are commercial. Similarly, out of the total fully affected families 10 are residential and 16 are commercial. Compensation for resettlement and rehabilitation shall be considered as per Government of Haryana (GoH) and Government of India policies and guidelines for land acquisition, rehabilitation and resettlement.

The Government of Haryana (GoH) will be the executing agency of the proposed Gurgaon metro rail project. A Special Purpose Vehicle (SPV) shall be set up by the GoH for implementation of the proposed metro rail project. SPV will coordinate with all implementing agencies like PMC, NGO, R&R and Implementation Support Consultant and supervise their work and monitor the progress of the project. Social Management Unit (SMU) of SPV shall look after land acquisition and rehabilitation activities of the project. The responsibility of NGO will be assisting SMU of SPV in implementation of R&R activities. A Social Development Consultant will be appointed by SPV to assist in the R&R implementation process. Grievances of PAPs

will be first brought to the attention of field level staffs of SPV. Grievances not redressed by the staffs (field level) will be brought to the Grievance Redressal Committee (GRC). The period for implementation of RAP has been taken as approx. two and half years. The tentative cost for implementation of Resettlement and Rehabilitation Plan is INR 282 lakh.

0.16. DISASTER MANAGEMENT & SECURITY MEASURES

0.16.1. Disaster Management Measures

An effective system needs to be in place under the provision of 'Disaster Management Act, 2005'. Provisions at metro stations include Fire Detection and Suppression System, Environmental Control System (ECS), Tunnel Ventilation System, Track-way Exhaust System (TES), Power Supply System, DG Sets & UPS, Water Supply and Drainage System, Lights and other facilities which may be deemed necessary. In order to be prepared for any disaster, it is essential to train the concerned staff in situations such as fire, rescue of disabled trains, evacuation, etc. and mock drills need to be conducted.

0.16.2. Security Measures

Security system for metro system plays an important role in helping the system to become the preferred mode choice for commuters. The three phases of security system followed include Prevention, Preparedness and Recovery. Various provisions like CCTV cameras, baggage scanners, metal detectors, bomb detection equipment, wireless sets, snuffer dogs and related facilities will be part of station security system.

0.17. DETAILED PROJECT COST ESTIMATES

0.17.1. Capital Cost Estimate

Cost estimate for Gurgaon Metro corridors has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. at Sept' 2021 price level is presented in **Table 0.20**.

Basic cost is exclusive of taxes and duties. i.e. GST and Custom duty. Taxes and duties mainly comprising of latest prevalent GST & Custom duty are worked out for the corridor. Current rates of Taxes and circular of MoHUA, GOI for Minimum Local Content (MLC) have been taken into consideration.

The rates of items other than land has been finalized on the basis of benchmarking exercise undertaken by MoHUA for similar works. Automatic Fare Collection (AFC)

installations at all stations has been considered through PPP.

TABLE 0.20: ABSTRACT OF COST ESTIMATE

September'21 Price Level

S. No.	Item	Amount (Rs. In Crores)
1	Land	208.52
2	Alignment and Formation	1150.97
3	Station Buildings	918.00
4	Depot	80.00
5	P-Way for main line & depot	212.33
6	Traction & power supply	382.88
7	Signaling and Telecom	393.20
8a	Environment	11.97
8b	R & R incl. Hutments etc.	2.90
9	Misc. Utilities	171.00
10	Capital Expenditure on Security	9.92
11	Capital Expenditure on Inter modal integration	81.00
12	Rolling Stock	648.00
13	Total of all items except Land and R&R	4059.26
14	General Charges including Design charges @ 5% on all items except land and R&R	202.96
15	Total of all items including G. Charges except land and R&R	4262.23
16	Contingencies @ 3 %on all items except land and R&R	127.87
Gross Total including Contingencies (excluding Land and R&R Cost)		4390.09
Gross Total including Contingencies (including Land and R&R Cost)		4601.51
Central GST & Basic Customs duty		311.25
State GST		276.45
Total Cost including Taxes & Duties		5189.21

TABLE 0.21: COST COMPONENT UNDER PPP

September'21 Price Level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. In Crores)
1.0	Automatic fare collection	Per station	3.50	27.00	94.50
2.0	General Charges including Design charges@ 5%				4.73
3.0	Total of all items including G. Charges				99.23
4.0	Contingencies @ 3 % on all items including GC				2.98
5.0	Total including Contingencies & GC				102.20
6.0	Central GST & Basic Customs duty				10.98
7.0	State GST				8.06
8.0	Total Cost including Taxes & Duties				121.24

0.17.2. O&M Estimate

The total O&M cost including additional and replacement cost in the year 2026, 2031, 2041 and 2051 are estimated at Rs. 251.17 Crore, 377.81 Crore, Rs. 792.47 Crore and Rs. 1688.53 Crore respectively.

0.18. TRANSIT ORIENTED DEVELOPMENT PLAN

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. TOD focuses on creation of high density mixed land use development in the influence zone of transit stations, i.e. within the walking distance of (500-800 m) of transit station.

The estimated revenue from TOD has been determined through Value Capture Finance (VCF). Two sources i.e. premium on sale of additional FAR within TOD zone and 0.5% additional surcharge on stamp duty have been proposed for revenue estimation as a part of TOD study. It has been proposed that 35% of yearly projected revenue collection from VCF tools will accrue to Gurgaon Metro (in same lines with Lucknow Metro). Remaining 65% may be used as allied investments in expanding utility capacity to densify areas around the metro stations.

The broad estimation of revenue from TOD is presented in **Table 0.22**.

TABLE 0.22: ESTIMATED REVENUE FROM TOD

S. NO.	Items	Total Revenue (Rs. in crore)		
		2026	2031	2041
1	Premium on Additional FAR	39	52	85
2	0.5% Additional Surcharge on Stamp Duty	71	95	155
	Total	110	147	240

0.19. FINANCIAL ANALYSIS AND NON FARE BOX REVENUE ASSESSMENT

0.19.1. Input for Financial Analysis

The total cost of project including land and R&R cost but excluding taxes and duties is estimated at **Rs. 4601.51 Crore**. The Central GST, Basic Customs Duty and State GST amounts to **Rs. 587.70 Crore**. The capital cost components at Sept '21 prices are given in **Table 0.23**.

TABLE 0.23: CAPITAL COSTS

Cost Component	Amount (Rs. in Crore)
Construction Cost excluding GC, Contingencies, Land and R&R	4059.26
Land Cost	208.52
R & R incl. Hutments	2.90
General Charges and Contingencies	330.83
Construction Cost including land and R&R, GC and contingencies	4601.51
Taxes	587.70
Central GST & Basic Customs Duty	311.25
State GST	276.45
Total Cost including Taxes & Duties	5189.21

With escalation factor of 5 % p.a. (on all costs except Land and R&R), the Completion Cost of the project including Land and R&R (without IDC, Front End Fee and AFC) is estimated to be **Rs. 5758.46 Crore**. It is proposed to start land acquisition and construction work by Year 2022 and commission the system by Year 2026.

The O&M cost of the metro system is another input for the financial analysis. The total O&M cost in the year 2026 is estimated at Rs. 251.17 Crore and Rs. 377.81 Crore in the year 2031. Additional investment of Rs. 994.70 Crore in the Year 2031 and Rs. 641.93 Crore in Year 2041 has been estimated to cater to increased traffic demand. The replacement cost for the corridors is estimated to be Rs. 1910.29 Crore in the year 2045.

0.19.2. Means of Finance

The Revenue for Gurgaon metro will mainly consists of fare box collection and revenue from other non-fare box sources such as property development, advertisement, parking, taxes etc. Estimation of revenue from fare box and non-fare box source has been made. The total annual revenue through the fare box and other sources for the study corridors is given in **TABLE 0.24**.

TABLE 0.24 TOTAL REVENUE COLLECTION (Rs. in Crore)

Source of Revenue	2026	2031	2041	2051
Fare Box Revenue	514	969	1504	2323
Non-Fare Box Revenue	290	418	758	1235
Total Revenue	804	1387	2262	3558

0.19.3. Operational Viability

The FIRR for the project with capital costs including Central taxes and revenue from fare box and non-fare box sources works out to be **13.03%**. The FIRR is found to be more sensitive to ridership than to capital costs. The FIRR of the project is sensitive to revenues, and capital costs. The sensitivity of the project with respect to these factors is given **TABLE 0.25**.

TABLE 0.25 FIRR SENSITIVITY

Parameter	+5%	+10%	-5%	-10%
Capital Cost	12.56%	12.12%	13.54%	14.08%
Ridership	13.57%	14.09%	12.47%	11.89%

FIRR under various scenarios has been computed and shown below **TABLE 0.26**.

TABLE 0.26 FIRR VALUES

Scenario	FIRR
FIRR with Farebox, Advt. revenue and TOD revenue (" base case ")	13.03%
FIRR with Farebox, Advt. revenue but w/o TOD revenue	11.08%
FIRR with only Farebox	6.28%

0.19.4. Alternate Means of Financing

As per Metro Rail Policy '2017, the models considered for financing the Gurgaon metro are:

- Equity Sharing Model (SPV fully under Government Control)
- Built, Operate & Transfer (BOT) or Public Private Partnership (PPP) with VGF
- Grant by the Central Government (Fixed Fee)

The total fund contribution of GoI & GoH under above alternatives excluding land and state taxes is tabulated in **TABLE 0.27**.

TABLE 0.27 COMPARISON OF THREE IMPLEMENTATION MODELS (Rs. Crore)

Particulars	SPV	VGF	Fixed Fee
Contribution by GoI	1047.63	845.21	523.81
Contribution by GoH	1047.63	845.21	3308.27
Sub-Total	2095.26	1690.42	3832.08
Land and R&R by GoH	211.42	211.42	211.42
State Taxes by GoH	308.90	0.00	308.90
IDC by GoH	66.10	0.00	0.00
Total	2681.67	1901.84	4352.40
Present Value @8% of Net Cash Flow to Public Entity	2815.81	65.70	3108.71

It can be seen from the above table that the return in terms of PV of Net cash flows to Government is highest in case of Fixed Fee model, however the contribution of Government under Fixed Fee model is much higher than that under SPV model, contribution of Governments under SPV model is more than that of VGF and less than that of Fixed Fee model. Although under the VGF model, the contribution of Government is lowest, the entire revenues for the Concession Period are accruing to

the Private Partner with no return on Government's contribution. Accordingly, **it is proposed the project may be implemented on SPV Model**. The funding pattern developed under SPV model is placed in **Table 0.28**.

TABLE 0.28 FUNDING PATTERN UNDER SPV MODEL

Source of Funding	Amount (Rs in Crores)	% Of contribution
Equity by GoI	873.74	16.68%
Equity by GoH	873.74	16.68%
SD by GoH for Central Taxes	173.89	3.32%
SD by GoI for Central Taxes	173.89	3.32%
Contribution by Local Bodies	200.00	3.82%
Soft loan from multilateral agencies/Term Loan	2942.89	56.18%
Total	5238.14	100.00%
SD by GoH for Land and R&R	211.42	
SD by GoH for State Taxes	308.90	
Total Cost	5758.46	
SD by GoH for IDC and Front End Fee	66.10	
PPP Component (AFC for Stations)	135.47	
Total Project Cost	5960.03	

As per new Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail. Accordingly, under SPV model for implementation of Gurgaon Metro project following activities have been identified for private participation:

- i) Private participation in Automatic Fare System by completely outsourcing operation of Ticket Operating Machines (TOMs), Ticket Vending Machines (TVMs) and Card Recharge Machines including Smart Cards provisions and Merchant Acquirer functions on similar lines as Lucknow Metro.
- ii) Maintenance contracts with System suppliers for Rolling Stock and Signalling systems in place of in house maintenance.
- iii) Station Civil and E&M maintenance and parking management.
- iv) Exploring long term lease of Elevators at Metro Stations

The cost of the AFC Installations to be borne by a private partner is estimated at **Rs. 121.24 Crore** at September'21 price level which translates to completion cost of **Rs. 138.58 Crore** in the year 2026.

0.20. ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV.

The EIRR works out to **20.36%**, **ENPV@14%** works out to **Rs. 1688 Crores** and **ENPV@8%** works out to **Rs. 6413 Crore**. Sensitivity analysis of the EIRR with 5% to 15% cost overrun and reduction in traffic materialization (separately) has been carried out. The EIRRs under these scenarios are given in **Table 0.29**.

TABLE 0.29: EIRR AND SENSITIVITY ANALYSIS

S. No.	Factor	Range		
		5%	10%	15%
1	Cost overruns due to delay or other factors	19.63	18.96	18.34
2	Increase in Maintenance Cost	20.31	20.11	19.98
3	Reduction in Ridership	20.18	20.01	19.83
4	Reduction in benefits	19.94	19.51	19.08
5	Combination of reduction in benefits and increase in cost	19.23	18.17	17.18

0.21. IMPLEMENTATION PLAN

0.21.1. Project Implementation Plan

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as Revised DPR is approved by Government of Haryana and HMRTC. The possible dates of important milestones are given in **Table 0.30**.

TABLE 0.30: PROJECT IMPLEMENTATION SCHEDULE

S. No.	Tasks	Timelines
1	Final DPR	October, 2019
2	Revised Final DPR	October, 2021
3	State Government Approval of DPR	November, 2021
4	Appointment of Interim Consultant	January, 2022
5	Approval by GoI	March, 2022
6	Appointment of DDC for Civil Works	June, 2022
7	Packaging and Invitation of Bids	September, 2022
8	Appointment of General Consultants	October, 2022
9	Commencement of Civil Works	December, 2022
10	Commencement of Operation	April, 2026

0.21.2. Implementation Structure

Gurgaon metro project will be implemented on SPV model by Haryana Mass Rapid Transport Corporation (HMRTC). However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model. The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

0.21.3. Legal and Institutional Framework for Implementing Project**0.21.3.1 Legal Framework**

Construction of Gurgaon Metro should commence soon. Thus, there is immediate need to have a legislation to provide legal cover to the construction stage of Gurgaon Metro. Implementation of proposed Gurgaon Metro can now be done under “The Metro Railways (Amendment) Act 2009”.

0.21.3.2 Institutional Arrangements

The Government of Haryana created a Special Purpose Vehicle (SPV) for implementing the Gurgaon Metro Rail Project. The SPV, “Haryana Mass Rapid Transport Corporation (HMRTC)” was incorporated on 24.03.2012 under the Companies Act, 1956.

HMRTC shall be responsible for implementation of the proposed Metro rail corridor in Gurgaon.

Metro construction is a very specialized and multi-disciplinary job. It is therefore,

impossible to have a single organizational set up which can be responsible for all aspects of metro implementation, namely investigation, planning, design, drawing up of specifications, preparation of tender documents, fixing of contractors, supervising the contractors' works, ensuring interface fusion between different contractors, ensuring quality and safety during constructions, planning and supervising integration system trials and getting the project commissioned in time.

It is suggested to have a two tier organization with well defined responsibilities for implementation of this project. At the apex will be the HMRTC with full mandate and total power with accountability. The second level will be project management team called the 'General Consultant', who will be engaged by the HMRTC on contract basis. They will be fully responsible for planning, designing and project management. In fact, they will be 'Engineers' for the HMRTC, who will be the 'Client'. The Detailed Design Consultants as required may be engaged by the General Consultants as their sub-consultants within their own contractual responsibilities.

0.21.3.3 High Power Committee

During the implementation of the project, several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Haryana may be set up. Other members of this Committee may be the Secretaries of concerned Departments of State Government and Heads of civic bodies who are connected in one way or the other with the implementation of the project.

0.21.4. Role, Responsibility and Involvement of City Government

0.21.4.1 Unified Metropolitan Transport Authority (UMTA)

For integrated approach in planning and management of urban transport in the city, State Government shall constitute Unified Metropolitan Transport Authority (UMTA) as a statutory body. This Authority would implement various proposals as per CMP for the city, organize investments in urban transport infrastructure, establish effective coordination among various urban transport agencies, manage the Urban Transport Fund (UTF) etc. UMTA will have to play active role in the

implementation of Gurgaon Metro Rail project, being a city government authority.

0.21.4.2 Steering Committee

Apart from a High Power Committee under the chairmanship of Chief Secretary, Haryana, a 'Steering Committee' may be set up under the chairmanship of Commissioner, Gurgaon. Other members of this Committee may be District Magistrate, Municipal Commissioner and other heads of civic bodies who will be connected in one way or the other with the implementation of the project.

0.21.5 Realising the Goal of Aatmanirbhar Bharat

a. Aatmanirbhar Bharat

In the recent times, India has demonstrated how it rises up to challenges and uncovers opportunities therein, as manifested in the re-purposing of various automobile sector industries to collaborate in the making of life-saving ventilators. Atmanirbhar Bharat (self-reliant India) is the vision of the Hon'ble Prime Minister of India of making India a self-reliant nation. The first mention of this came in the form of the 'Atmanirbhar Bharat Abhiyan' or 'Self-Reliant India Mission' during the announcement of the COVID-19 pandemic related special economic package equivalent to 10% of India's GDP in May, 2020 with the aim of making the country independent against the tough competition in the global supply chain and to help in empowering the general public who have been adversely affected by COVID.

Due to the long-lasting lockdown phases, India has come to a very crucial juncture. The Indian culture and tradition have always backed the concept of being Self-Reliant and at the same time not being self-centric but being self sufficient.

The Five pillars of Atmanirbhar Bharat focus on:

- Economy
- Infrastructure
- System
- Vibrant Demography and
- Demand

b. Gurgaon Metro Project - Realising The Goal of Aatmanirbhar Bharat

The project has following major components:

- i) Alignment and Formation
- ii) Station Buildings
- iii) Maintenance Depot
- iv) Traction and Power Supply

- v) Telecommunication
- vi) Utility Diversion, Security & Intermodal Integration
- vii) Rolling Stock

The goods and services or works for which sufficient local capacity and local competition exist, the procurement will be from the indigenous sources.

0.21.6 Way Forward

On acceptance of the Comprehensive Detailed Project Report, following actions may be initiated for implementing the project:

- Approval of State Government (Cabinet Approval) to the Detailed Project Report
- Issue of notifications for the project, alignment and setting up of UMTA
- DPR to be forwarded to the Ministry of Housing and Urban Affairs, Niti Aayog and Finance Ministry with request for approving the Metro project and for financial participation through equity contribution to the SPV
- Approval from Government of India
- Appointment of Detailed Design Consultants (DDC)
- Appointment of General Consultants (GC)
- Packaging and invitation of bids for various contracts
- Land acquisition related issues
- Examination and appraisal of DPR by bilateral/multilateral funding agencies for possible funding
- Stakeholder consultation on environmental and social impact of the project
- Signing of an MOU between Haryana State Government and Government of India giving all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure etc.
- Agreement between the State and Central Government for financing the debt portion of the project along with the setting up of time frame for completing the Project
- Loan approval
- Providing legal cover for construction as well as O&M stages of the Project.
- Memorandum of Understanding between various service providers to provide seamless integration between various transport modes

Chapter – 1

A PROFILE OF THE CITY

1 A PROFILE OF THE CITY

1.1 GENERAL/ HISTORICAL BACKGROUND

The region of Gurugram originally fell under the Kuru Kingdom. In the Mahabharata, Gurugram is described as the village of Guru Dronacharya, Guru of the Kauravas and Pandavas. In late 4th century BCE, the city was absorbed by the Maurya Empire as part of Chandragupta Maurya's earliest expansions of his kingdom. Gurugram is a Yadav (also use title Rao) dominated place which used to hold most of agrarian land and political influence.

Today, it has become a hub of multinational companies, industries giants, call centres, software companies, shopping malls and skyscrapers. Gurugram's skyline with its many skyscrapers is nationally recognized, and the city has been home to several tall buildings with modern planning. The City has been growing rapidly due to large scale urbanization and economic activities. As a result, city requires an efficient and convenient Mass Rapid Transit System.

A number of initiatives have been taken in recent years to improve the Transport Infrastructure in the City and to provide better public transport facilities to the commuters. However, the growing needs of commuters and city have led city planning agencies to plan and create additional infrastructure facilities to serve the future travel needs. The Final development plan (2031) for Gurugram Manesar Urban Complex (GMUC) states a large number of proposals related to improvement in transport network and mass transport facilities for horizon year 2031. The master plan also identified the need of having mass public transit system to cater to the present and future population and mobility requirements.

To provide efficient connectivity and ease in the mobility, Haryana Mass Rapid Transport Corporation (HMRTC) had appointed DMRC to prepare 'Techno-Feasibility Study' for Mass Transit Corridor from 'HUDA City Centre to Gurugram Railway Station'. Subsequently, DMRC submitted the Techno-Feasibility report in September 2016.

HMRTC has engaged RITES to prepare the DPR for Metro Rail Connection from HUDA City Centre – Cyber City and Metro Spur to Dwarka Expressway.

1.2 LOCATION, CLIMATE, PHYSICAL SETTING AND REGIONAL LINKAGE

1.2.1 Location, Climate and Physical Setting

Gurugram is a satellite city of Delhi located in the north western Indian state of Haryana and is part of the National Capital Region of India. It is 32 km southwest of New Delhi and 268 km (167 mi) south of Chandigarh, the state capital.

Under the Koppen climate classification, Gurugram experiences a monsoon-influenced Composite climate. The city experiences four distinct seasons - spring (February - March), summer (April - August), fall/autumn (September - October) and winter (November - January), along with the monsoon season setting in towards the latter half of the summer. Summers, from early April to mid-October, are typically hot and humid, with an average daily June high temperature of 40 °C (104 °F). The season experiences heat indices easily breaking 43 °C (109 °F). Winters are cold and foggy with few sunny days, and with a December daytime average of 3 °C (37 °F). The Western Disturbance brings some rain in winters that further add to the chill. Spring and autumn are mild and pleasant seasons with low humidity. The monsoon season usually starts in the first week of July and continues till August. Thunderstorms are not uncommon during the Monsoon. The average annual rainfall is approximately 714 millimetres (28.1 in).

Major soil type in Gurgaon is loamy sand soil which covers 101 thousand Ha constituting around 84.2 % of total geographical area. The alluvium in the area comprises silt, sand, gravel, clay and kankar.

Sand Dunes Strong winds carry sand and silt, forming dunes, from adjacent Rajasthan to this area with the prevailing wind conditions. These sand dunes are seen in the whole of the area but are more conspicuous in the area between Pataudi, Farukhnagar and Garhi Harsru and attain heights of 3-6m in general. The dune sand is generally well sorted, found fine to medium grained and comprises quartz, ferromagnesian minerals, tiny flakes of mica with small particles of kankar. The sand is loose and dunes keep shifting their positions depending upon the prevailing wind condition.

1.2.2 Regional Linkage

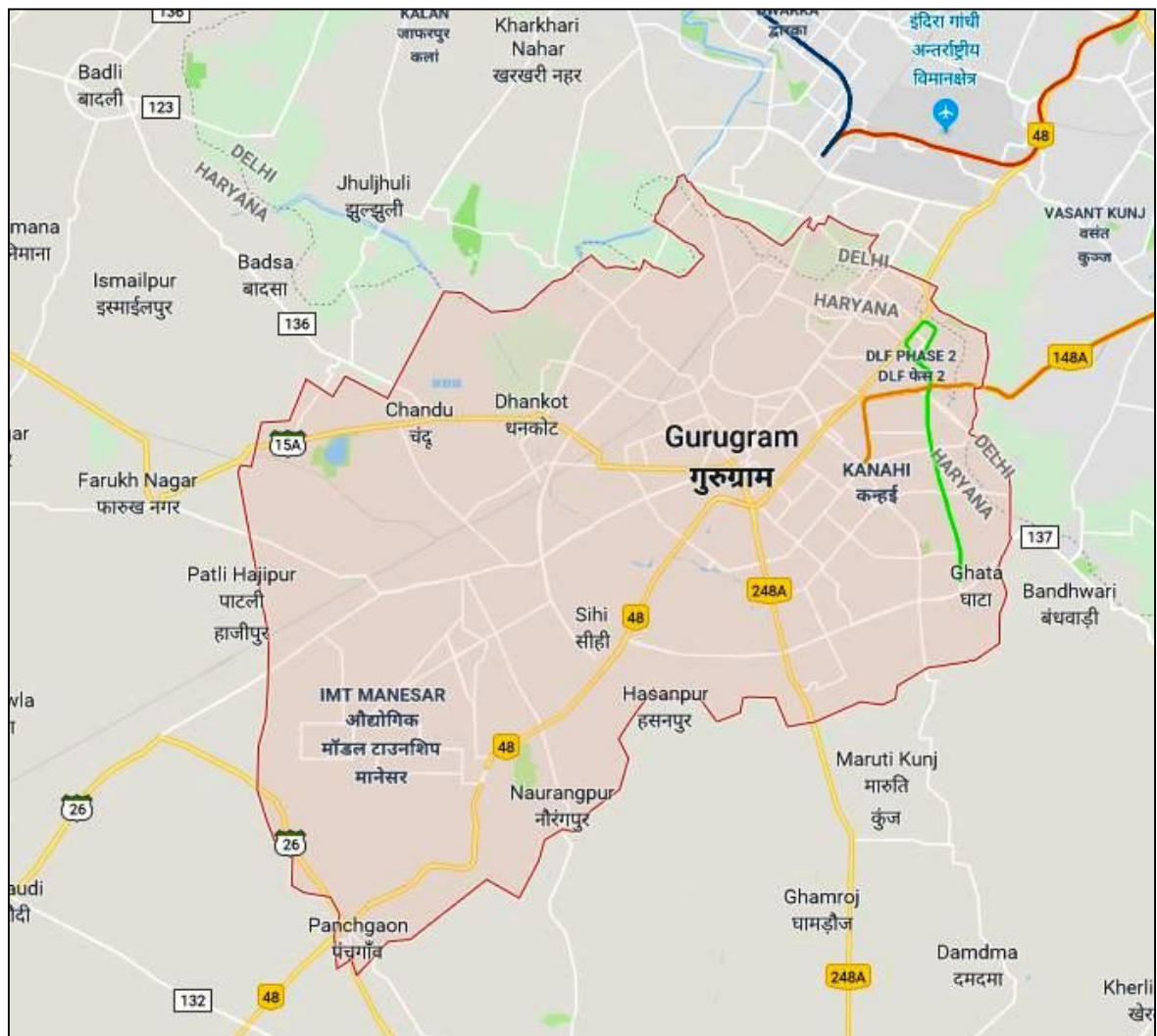
Gurgaon-Manesar Urban Complex (GMUC) is well connected with other major cities by roadways, railways and airways. Broad gauge railway lines directly connect the Gurgaon-Manesar Urban Complex (GMUC) to Delhi and other important cities like Mumbai, Kolkata, Ahmedabad, Jaipur as well as nearby areas. The Indira Gandhi International Airport at Delhi is an international airport 18 Km from Gurugram. Regional road and Railway connectors pass through all the Blocks within Gurugram Manesar Urban Complex (GMUC) resulting in increased road accessibility of sectors to the region.

Consequently, there are potentials for development of regional production, service and distribution centers in all the Blocks with in Manesar Urban Complex (GMUC).

1.3 DEMOGRAPHIC AND SOCIO ECONOMIC PROFILE

The area under the jurisdiction of the Gurugram Manesar Urban Complex (GMUC) is the Study Area for the present Assignment (**Figure 1.1**). The contiguous urban development's abutting the Gurugram Municipal Corporation area also share significant interactions with it. Gurugram Municipal Corporation area has 115 sectors which together form 35 wards for municipal operations. Therefore, in order to assess the comprehensive traffic and transport characteristics, GMUC as classified by Census 2011 - comprising of Gurugram and IMT Manesar is considered.

FIGURE 1.1: STUDY AREA



1.3.1 Population Growth

The city of Gurugram has grown leaps and bounds due to the various developments. These developments have played a crucial role in altering the demographic situation of the city. The demographic changes include the sharp increase in the population numbers in the city. The Gurugram has evolved in a city with the series of changes and dynamics in demography. As per 2011 census, the population of Gurugram is 8,76,969. The Gurugram had a population of 2.11 lakh as per 2001 Census which has increased to 8.77 lakh in 2011 (Table 1.1).

TABLE 1.1: POPULATION OF GURUGRAM

Area	Population (2001)	Population (2011)
Gurugram	2,11,079	8,76,969

Source: Census of India 2011

1.3.2 Population Density, Migration and Spatial Pattern

Population density in GMUC 2031 varies from 250 persons per hectare to 625 persons per hectare. Rapid urbanization and increase in rural-urban migration has resulted in manifold increased in problems associated with urban Infrastructure in developing economies. Population projections is carried out based on the growth trends taken separately for Core, Middle, Outer and special areas collectively forming the Study Area. Accordingly, the population in the study area for Base year 2019 and years 2021, 2031 and 2041 is presented in Table 1.2.

TABLE 1.2: FORECASTED POPULATION OF THE STUDY AREA FOR THE HORIZON YEARS

Year	Forecasted Population
2019	16,82,889
2021	18,73,097
2031	42,50,000
2041	50,75,000

1.4 URBAN LANDUSE STRUCTURE

1.4.1 Landuse Characteristics as per Master Plan 2031– Gurugram Manesar Urban complex

Gurugram is growing and emerging as trade and business center in last ten-fifteen years and witnessing rapid in migration from immediate hinterland and different part of the state of Haryana. It resulted in to rapid urbanization in neighboring areas of Gurugram Manesar Urban Complex (GMUC) become outgrowths of Gurugram City. The proposed land use distribution clearly suggests thrust on the development of residential areas and a continued thrust on industrial development to boost the local economy. Transport continues to occupy a significant share of the land in the city. The proposed land use and respective map is presented in Table 1.3 and Figure 1.2 respectively.

TABLE 1.3: PROPOSED LANDUSE 2031– GURUGRAM MANESAR URBAN COMPLEX AREA

S.No.	Landuse	Area (Hectares)	Percentage (%)
1.	Residential	16021	47.30
2.	Commercial	1616	4.77
3.	Industrial	4613	13.62
4.	Transport and Communication	4428	13.07
5.	Public Utilities	608	1.79
6.	Public and semi public	2027	5.98
7.	Open spaces	2928	8.64
8.	Special zone	114	0.34
9.	Defence land	633	1.87
Total Land		32988	97.39
10.	Existing town	406	1.20
11.	Village abadies	478	1.41
Grand Total		33872	100

Source: Town & Country Planning Department, Haryana

1.4.2 Master Plan Proposals

The proposed road network is planned to increase connectivity within the region, simultaneously helping alleviate traffic problems. For solving the inter-city and intra-city traffic problems of Gurgaon-Manesar Urban Complex, new road links with Delhi Metropolitan City and upcoming Sohna town have been proposed.

- 90 metres wide road link between Vasant Kunj in Delhi to Mehrauli road in Gurgaon.
- 90 metres wide road link from Andheria Mor in Delhi to Gurgaon-Faridabad road in Gurgaon through Mandi and Gual Pahari.
- 150 metres wide road link between Dwarka residential complex of Delhi to Gurgaon at National Highway number 8 before Toll Plaza towards Gurgaon.
- 90 meters wide road link from junction of sector 63A/64 with V3(b) road of Gurgaon-Manesar Urban Complex-2031 AD to sector dividing road of sector 30/31 of Development Plan of Sohna -2031 AD.

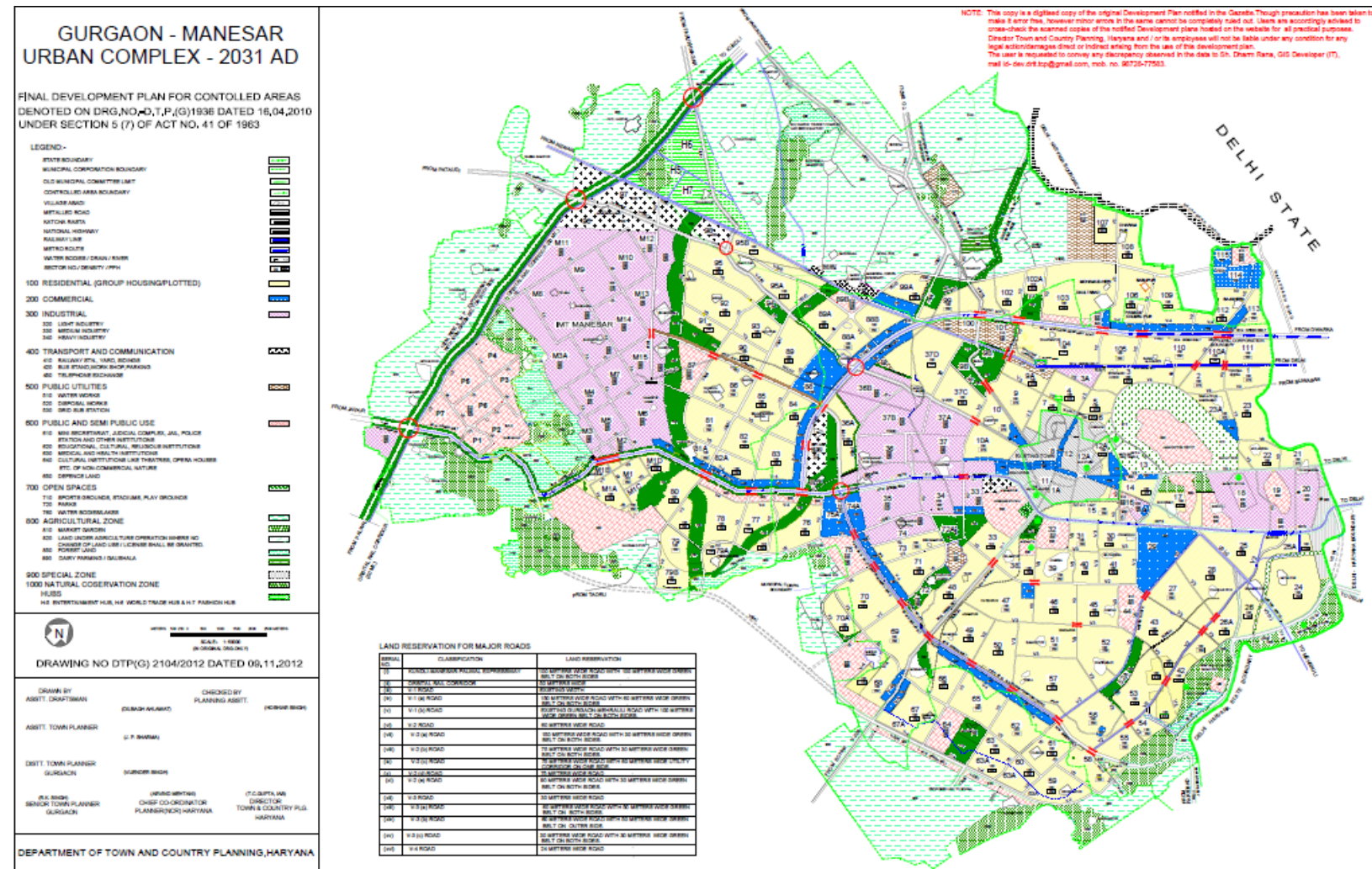
In the new urbanisable area, the widths of sector dividing roads have been proposed as 75 metres and 60 metres. Haryana Urban Development Authority has already developed auto market in sector 10 in an area of 16 hectares. A Transport Nagar has also been developed by Haryana Urban Development Authority in an area of 28 hectares in sector 33. In order to cater to the future demand of the public, the Transport Nagar and Container Depots have been proposed adjoining to Garhi Harsaru Railway Station on Delhi-Rewari Railway line. A pocket of 45 hectares of land has been reserved for idle parking adjoining village Garhi Harsaru along railway line opposite to wholesale market proposed in sector 99A.

Existing Delhi-Gurgaon Metro Link which terminated at HUDA City Centre (Sector 29) is proposed to be extended upto Manesar via Sector 43-44, 52-52A, 56-57, SPR and NH-8. It is proposed that the area shown under Inter State Bus Terminal is approximately 162 hectares which can be very appropriately used for Inter State Bus Terminal-cum-Mass Rapid Transit System Depot. The alignment of Regional Rail Transit System (RRTS) linking Delhi to Alwar via Gurgaon passes along NH-8. Land reservation for major transport corridors marked in the drawing are as under:

TABLE 1.4: CLASSIFICATION OF LAND RESERVATION FOR MAJOR TRANSPORT CORRIDORS

S.No.	Classification	Land reservation
1	Kundli-Manesar-Palwal Expressway	100 metres wide road with 100 metres wide green belt on both sides
2	Orbital Rail Corridor	50 metres wide
3	V-1 road	Existing width
4	V-1(a) road	150 metres wide road with 60 metres wide green belt on both sides
5	V-1(b) road	Existing Gurgaon-Mehrauli road with 100 metres wide green belt on both sides.
6	V-2 road	60 metres wide road
7	V-2 (a) road	150 metres wide road with 30 metres wide green belt on both sides
8	V-2 (b) road	75 metres wide road with 30 metres wide green belt on both sides
9	V-2(c) road	75 metres wide road with 60 metres wide utility corridor on one side
10	V-2(d) road	75 metres wide road
11	V-2(e) road	90 metres wide road with 30 metres wide green belt on both sides
12	V-3 road	30 metres wide road
13	V-3(a) road	60 metres wide road with 50 metres wide green belt on both sides.
14	V-3(b) road	60 metres wide road with 50 metres wide green belt on outer sides
15	V-3(c) road	30 metres wide road with 30 metres wide green belt on both sides
16	V-4 road	24 metres wide road

Source: Town & Country Planning Department, Haryana

FIGURE 1.2: PROPOSED LANDUSE MAP – GURUGRAM MANESAR URBAN COMPLEX (GMUC) MASTER PLAN 2031

1.4.3 Major Activity Centers

The major activity centre in GMUC are HUDA City Centre, Cyber City, IFFCO Chowk, Sadar Bazar, Hero Honda Chowk, Udyog Vihar, IMT Manesar, Golf Course, Technology Park, Udyog Vihar, Sector 29 and MG Road etc.

1.5 SCOPE OF WORK

DPR for the Metro corridor and Metro spur has been prepared as per Metro Rail Policy 2017. The scope covers the following:

1.5.1 Assessment of Existing City Profile with Existing Transport Characteristics

The implementation options should be identified for best suitable alternative. If metro system is identified as the most viable alternative, then implementation options needs to be explored for those projects seeking Central Financial Assistance (CFA) as mentioned in the Metro Rail Policy, 2017.

Task 1: A brief overview of the city in terms of its growth, economy, spatial structure and trends, perspectives on the future growth. Overview of study areas and existing plans with land use distribution, review of zoning Regulations, employment distribution by Traffic Zones, land use plan proposals should be done.

Task 2: Brief review of previous transport studies like City Master Plan, Comprehensive Mobility Plan and proposed Metro Rail plan and other urban transport proposals. A brief showing interconnection among City Master Plan, Comprehensive Mobility Plan and proposed Metro Rail plan should be given.

1.5.2 Travel Characteristics and Demand Estimates

Task 3: Describes the components of urban transport system in terms of status, trends and gaps based on primary survey data, present travel patterns and forecast for the future travel demand.

Task 4: Based on primary survey data and various traffic and transportation studies undertaken for the city, the present travel patterns and forecast for future travel demand should be done.

Task 5: Travel demand analysis, model framework, model calibration, summary of travel demand patterns and ridership assessment for horizon year.

1.5.3 System and Technology Selection

Task 6: Identification of suitable transit technology and the system specification to be adopted for the corridor including the rationale for choosing a particular technology as per the prescribed specification as issued by MoHUA from time to time. The technology chosen should not be a proprietary technology of any vendor.

1.5.4 Corridor Alignment Description

Task 7: Alignment description of approved alignment, with detail about site conditions specifying road geometrics, utilities available along the corridor

Task 8: Detailed analysis of corridor options with grade selection for construction. Design norms for track geometry, fixed structure clearance, geotechnical details with new innovative techniques to be used for implementation in civil works, track system etc

Task 9: Identification of existing services/utilities, if any

Task 10: Detailed estimation regarding land requirement for the corridor, depots, stations, parking, multi modal stations etc. with land ownership

1.5.5 Station Planning

Task 11: Station planning with preparation of general layouts based on type of station and site specific conditions focusing on:

- Station Area planning for non-motorized vehicles and pedestrians' facilities, multi modal integration with existing modes, feeder service planning.
- Accessibility for differently abled persons including specifying parking at stations for private and para transit facilities.
- Platform widths based on Station loadings and the minimum width to be provided.

1.5.6 Intermodal Integration

Task 12: Prepare an Intermodal Integration Plan focusing on how the Metro Rail will integrate with the existing transportation systems/proposed transit system and introduction of a feeder system, integrated with the proposed Metro Rail project for improving last mile connectivity. This will include not only preparation of an operational plan for feeder system but also infrastructure that need to be upgraded/ improved or introduced for improving the intermodal integration with other modes of public transport to improve the viability of the project. Recommendations for institutional integration, physical integration, fare integration, operational integration and technology integration would also need to be elaborated in the report.

1.5.7 Train Operation Plan

Task 13: System operation approach, station yard planning, trains operation plan including system frequency, timetabling, rolling stock requirement, stabling details.

1.5.8 Signaling and Telecommunication

Task 14: Identification of Signaling and System control, Operation Control Centre (OCC), maintenance requirement, technology selection and choice of automation.

Task 15: Identification of Telecommunication System, System Traffic Control, maintenance and emergency communication, Passenger Information System (PIS)

1.5.9 Fare Collection System

Task 16: Detailing the specifications for Automatic fare collection system, Ticketing and pass system, Fare System integrated with other transport Systems including integration of fares of all available modes with the Metro system planned as per the guidelines issued by MoHUA (such as National Common Mobility Card).

1.5.10 Rolling Stock

Task 17: Technology selection, identification of rolling stock adopted as per Guidelines laid by MoHUA. Rationale for deviations, if any in choice of rolling stock parameters from the prescribed specifications and standards prevailing and Rolling stock requirement for various horizon years should be specified.

1.5.11 Power Supply and Traction System

Task 18: Choice of electric traction system. Projected power demand, Source of power supply, Traction and Auxiliary Supply and supervisory control and data acquisition system. No. of tractions and their locations.

1.5.12 Ventilation and Air Conditioning System

Task 19: Need for Ventilation and Air Conditioning, design parameters and design concepts for VAC System with details on tunnel ventilation, station ventilation and air conditioning of ancillary spaces including specifications for control and monitoring facilities.

1.5.13 Depots

Task 20: Identification of Depot locations. Approach to maintenance of depot facilities and workshop along with detailed designs and layout plans.

1.5.14 Environmental and Social Impact Assessment

Task 21: Existing scenario, with analysis on water quality, noise level, land environment, biological environment etc.

Task 22: Environmental norms and Regulations, Detailed Environment Impact Assessment (EIA), Environment Management Plan (EMP), formation of an Environmental Management System (EMS) and costs estimates for Environment Impact mitigation measures.

Task 23: Detailed Social Impact Assessment (SIA) including R&R assessment, Resettlement Impacts, Resettlement Assistance Plan (RAP) and Monitoring and Evaluation Framework.

1.5.15 Disaster Management and Security Measures

Task 24: Disaster Management, Disaster Management imperatives, Objectives of Disaster Management Plan, Systems to cater for disasters and Security Systems recommended for MRTS and Safety and Security Measures.

1.5.16 Cost Estimation

Task 25: Detailed project cost estimates

- Capital cost estimates including taxes and duties
- Innovations proposed to reduce the cost of system
- Estimation of Operations and Maintenance Cost and the assumptions made thereof

1.5.17 Transit Oriented Development Plan

Task 26: The potential for Transit Oriented Development along the metro corridors based on the guidelines issued by MoHUA to be developed including densification of corridor by increasing FSI and land value capture as per the guidelines issued by MoHUA. Guiding list of lands/areas amenable for change in near future e.g. vacant land, low rise development relocation etc., use type.

1.5.18 Financial Analysis and Non Fare Box Revenue Assessment

Task 27: Estimations and inputs for the corridor, estimation for O & M, overheads, phasing of construction and lease of Built up Area (BUA), Operational viability of the project

Task 28: Means of finance, revenue from different sources, fare box revenue, non-fare box revenue, like advertisement, taxes and property development etc, possible ways of funding the project using different approaches. Alternative means of funding the project using different approaches Like PPP, BOT, DBFOT, DFBOT, Developer Finance Model Etc. and need to identify the proposed funding /implementation model in line with the Metro Policy 2017.

Task 29: Financial Returns: FIRR with 30 year time horizon, Sensitivity analysis should be done based on scenario building with variation in ridership estimates scenarios, costs estimates and Time overrun. Alternative scenarios based on the different options for funding /implementation of the project should be evaluated. A project should be able to meet its financial requirement for cost recovery and under a set of plausible assumptions be able to self-finance its activities. The State Governments will have to ensure the financial sustainability of the project through financial assistance.

1.5.19 Economic Analysis

Task 30: The Economic analysis should include economic cost and benefit analysis of the project and estimation of the EIRR for a period of 30 years.

1.5.20 Implementation Plan

Task 31: Project implementation structure, if proposed to be implemented under various alternatives such as public or PPP model, role, responsibility and involvement (including financial stake) of the city government along with other government agencies in metro rail project, needs to be elaborated in the report.

1.5.21 Institutional Arrangement and Stakeholders Consultation

Task 32: Legal and Institutional Framework for implementation of the project based on the identified implementation plan should be included in the report. Stakeholders' consultation should be held at each major stage of the project such as the Draft DPR stage.

1.6 COMPOSITION OF REPORT

This report consists of following chapters covering:

Chapter 1: Profile of the City covering background, demographic characteristics, urban landuse structure

Chapter 2: Existing Transport System in the City covering existing road network, traffic characteristics status of IPT and PT systems.

Chapter 3: Travel Characteristics and Demand Estimates with existing travel characteristics and travel demand estimates

Chapter 4: System and Technology Selection covering traction system etc.

Chapter 5: Civil engineering covering alignment planning, geometric design parameters, geotechnical investigations, utilities and land requirements

Chapter 6: Station planning gives the typical stations planned for metro corridors

Chapter 7: Intermodal integration summarises the interchange possibilities of existing and proposed modes of transport

Chapter 8: Train operation plan for the proposed metro rail system

Chapter 9: Signalling and Telecommunication covering the types of signaling and telecommunication systems and standards

Chapter 10: Fare Collection System covers the proposed ticketing system for passenger fare collection

Chapter 11: Rolling Stock gives the requirement of rolling stock for operation of the proposed metro system

Chapter 12: Power supply requirements, sources of power supply, substations and related infrastructure facilities

Chapter 13: Ventilation and Air Conditioning Systems covers the need for ventilation and standards adopted

Chapter 14: Maintenance depot facilities, rolling stock maintenance and depot layouts

Chapter 15: Environmental & Social Impact Assessment with repair and resettlement plans

Chapter 16: Disaster Management and Security Measures covering types of disaster, preparedness and security measures in metro system

Chapter 17: Detailed Cost Estimates including capital and O&M costs

Chapter 18: Transit Oriented Development along the metro corridors and revenue potential

Chapter 19: Financial Analysis and Non-Fare Box Revenue covering revenue estimates and estimation financial internal rate of return

Chapter 20: Economic Analysis gives economic benefits and estimation of Economic Internal Rate of Return

Chapter 21: Implementation Plan provides the project implementation options

Chapter – 2

EXISTING TRANSPORTATION SYSTEM IN THE CITY

2 EXISTING TRANSPORTATION SYSTEM IN THE CITY

2.1 INTRODUCTION

Recent rapid urban development in Gurugram has resulted in transport problems such as traffic congestion and increase in traffic accidents in all the cities/towns. Although the state governments and the local administrations have been making substantial efforts to improve urban transport, problems have been exacerbated to a large extent by the rapidly increasing number of private vehicles. This necessitates the assessment of existing transportation infrastructure in the city.

2.2 VEHICULAR GROWTH AND COMPOSITION

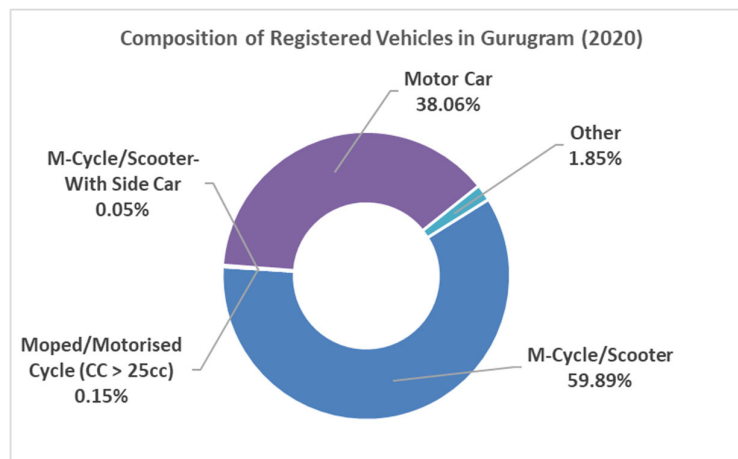
Total vehicles in Gurugram city have increased tremendously. The share of two-wheelers registration comprises about 60%, while cars comprise about 38 %. **Table 2.1** and **Figure 2.1** shows the growth and composition of vehicular traffic in the city.

TABLE 2.1: VEHICLES REGISTRATIONS

S.No	Vehicle Type	Year				
		2020	2019	2018	2017	2016
1	M-Cycle/Scooter	66,519	62,998	57799	50390	42500
2	M-Cycle/Scooter-With Side Car	52	51	47	18	6
3	Moped/ Motorised Cycle (CC > 25cc)	172	171	166	195	236
4	Motor Car	42,270	40,794	39059	38532	30752
5	Other	2054	1689	1296	756	580

Source: MoRTH, Vahan Dash Board (Official Website) for Gurugram-South

FIGURE 2.1: REGISTERED VEHICLE COMPOSITION



2.3 ROAD NETWORK CHARACTERISTICS

2.3.1 Network Inventory

Primary traffic surveys covering road network inventory, speed and delay, traffic and travel characteristics were carried out in the Study Area. The summary of existing road network is appraised in the subsequent sections.

The distribution of the road network as per right of way (ROW) is presented in **Table 2.2**. It can be observed from the table that about 28.2 % of the road network has less than 10 m ROW, 28.7% has 10-20 m ROW, and 17.8 % has 20-30 m ROW while 25.4% has ROW above 30m.

TABLE 2.2: DISTRIBUTION OF ROAD NETWORK AS PER RIGHT OF WAY

S.No.	Right of Way (m)	Length (km)	Percentage (%)
1	< 10	159.7	28.2
2	10 – 20	162.6	28.7
3	20 – 30	100.9	17.8
4	30 – 40	80.3	14.1
5	>40	63.8	11.3
	TOTAL	567.3	100

Source: RITES Primary Surveys

The distribution of the road network as per carriageway width is presented in **Table 2.3**. It can be observed that about 20% and 28% of the road network has carriageway width less than or equal to 2-lane and 3 to 4 lane respectively and about 26% of roads has carriageway width more than and equals to 6-lane. It is also observed that about 50% of the surveyed road network has a central median.

TABLE 2.3: DISTRIBUTION OF ROAD NETWORK AS PER CARRIAGEWAY WIDTH

S.No	Carriage way width	Length (km)	Percentage(%)
1	Intermediate Lane (Upto 6m)	118.4	20.9
2	2 Lane	156.4	27.6
3	4 Lane	141.6	25
4	6 Lane and above	150.9	26.6
	TOTAL	567.3	100

Source: RITES Primary Surveys

The distribution of the road network with respect to abutting land use is presented in **Table 2.4**. It is seen that the road network is abutted by residential land use upto an extent of about 15.2%, commercial 7.9 %, Residential & Commercial 41.4%, industrial 32.7%, educational 0.9% and only about 1.5% by agricultural. About 0.5% of the road network has Transport Infrastructure alongside.

TABLE 2.4: DISTRIBUTION OF ROAD NETWORK AS PER ABUTTING LAND USE

S. No.	Type	Road length (Km)	Percentage (%)
1	Residential	86.1	15.2
2	Commercial	44.95	7.9
3	Residential & Commercial	234.85	41.4
4	Educational & Institutional	4.9	0.9
5	Green/Agricultural/Vacant	8.5	1.5
6	Industrial	185.45	32.7
7	Transport Infrastructure	2.575	0.5
TOTAL		567.3	100

Source: RITES Primary Surveys

2.4 MAJOR TRANSPORT NODES

Terminals are the major transport nodes which attract and produce high number of trips every day. At present, there is one bus terminals in the city. It is Gurgaon Bus Terminal, which is the major terminal for intercity buses and Gurgaon Bus Terminal caters to the 18,555 passengers daily and 2024 passengers in peak hour. Gurgaon has a Railway station which is on the line of Delhi – Jaipur. It is one of the major Stations catering to Gurgaon, Delhi and other parts of Gurgaon district. The Gurgaon city is also facilitated with an Airport 18km away, named Indira Gandhi International Airport located in New Delhi and is accessible through NH 48.

2.5 PEDESTRIAN AND NON MOTORISED VEHICLE (NMV) FACILITIES

As per the Comprehensive Mobility Plan (CMP) 2020 for Gurgaon, Pedestrian counts along/across the road has been carried out at 15 locations in the study area. It has been observed that there is a significant pedestrian movement across road at Bus stand and Mahaveer Chowk. The pedestrian volume count at various locations is presented in the **Table 2.5**.

TABLE 2.5: PEDESTRIAN COUNTS ALONG THE ROAD

S. No	Location	Peak Hour (Across)	Peak Hour (Along)
1	Bhim Nagar Chowk	225	659
2	Bhim Nagar	94	283
3	Bus Stand	534	2681
4	Good Earth City Centre	110	122
5	Haryana Urban Development Authority	282	206
6	Huda Colony	63	173
7	Mahaveer Chowk	547	2020
8	Maruti Suzuki Gate No. 1	318	422
9	Ravi Nagar	52	206

S. No	Location	Peak Hour (Across)	Peak Hour (Along)
10	Sec-4 Laxman Vihar	115	545
11	Sheetla Mata Mandir	172	1338
12	Shukrali	130	346
13	Sikandarpur	63	133
14	Tau Devilal Park	87	107
15	Vimla Society	65	295

Source: CMP, Gurgaon (2020)

The supporting infrastructure for NMV is very negligible and no dedicated/ segregated lanes for bicycle are made. The footpaths are absent on 59% of major road stretches and no safe pedestrian crossing facilities are provided at major intersections in the city. Lack of NMT infrastructure in the city increases levels of accidents and also hinders movement of normal motorized traffic. Other areas of the city have e-rickshaws traversing the narrow lanes of CBD, in other parts of the city these cycle rickshaws are used for short distance trips.

As per CMP Gurugram (2020), the Non-motorized transport strategy comprises of providing footpaths and walkways, safe pedestrian crossing facilities and NMT network for full width, NMT management where there is sufficiently available ROW and the requisite demand. The salient points are as follows:

- Barricading of footpath near every intersection for controlled crossing from an allocated vent.
- Improved pedestrian paths with improved height and barricading.
- Removing encroachments from footpaths - Harding road, Boring canal road, Frazer road.
- Suitable road markings in the form of “zebra crossings” at all intersections.
- Barricading of footpath near every intersection for controlled crossing from an allocated vent.
- Foot over bridges (FOBs) with elevators and ramps for bicycle access are proposed at the identified locations to ease pedestrian mobility.

2.6 TRAFFIC MANAGEMENT INCLUDING PARKING MANAGEMENT

Traffic management proposals in CMP consist of improvement of some important intersections, signalizing plans, pavement marking and signages, creation of Traffic Management Cell with Hi-tech facilities. The existing issues and concerns are as follows:

- Lack of pedestrians facilities like footpath along major roads resulting in pedestrian spill over on right of way
- Chaotic operations of shared auto services

- On-street parking causes reduction in efficient roadway width
- Absence of necessary infrastructure such as bus stop, lighting etc.

2.7 TRAFFIC CHARACTERISTICS

Traffic volume and composition

The traffic counts both in terms of numbers of vehicles and Passenger Car Units (PCUs) have been computed at various mid-block locations as presented in **Table 2.6**. It is observed that the Subhash Chowk - Rajiv Chowk had the maximum traffic i.e. 121403 Vehicle (107242 PCU's) and minimum at Basai Chowk – Gurgaon 38759 Vehicle (30559 PCU's).

TABLE 2.6: PEAK HOUR TRAFFIC VOLUME AT MID-BLOCK LOCATIONS

No.	Location	Total Vehicles	Total PCU's
MB1	Subhash Chowk - Rajiv Chowk	121403	107242
MB2	Rajiv Chowk - Gurgaon	76524	64227
MB3	Hero Honda Chowk - Kadipur Chowk	50533	44979
MB4	Basai Chowk - Gurgaon	38759	30559
MB5	Railway Station - Gurgaon	75178	58718
MB6	India Post Office - Bhagwan Vishwakarma Chowk	68206	53367
MB7	CRPF Camp Chowk - Sector 5 Chowk	72727	62242
MB8	Pataudi Road - Kadipur Chowk	47760	37873

Source: RITES Primary Surveys

Traffic composition of total fast moving passenger, goods and slow moving vehicles at mid-block locations are presented in **Table 2.7**. The composition of traffic observed at various mid-block locations show that the locations exhibit predominance of fast moving passenger traffic varying from 78.42% to 92.65% %. On an average about 86.97% of traffic consists of light fast moving passenger vehicle. The share of slow moving vehicles varies from 1.72% to 12.01% with an average of about 6.405%. The maximum share of bus traffic is observed to be 1.97% at CRPF camp Chowk-Sector 5 Chowk with an average of about 1.39% overall. The share of goods traffic varies from 1.63% to 11.55% and the average goods traffic in study area is about 5.23%.

TABLE 2.7: DAILY TRAFFIC COMPOSITION AT MID-BLOCK LOCATIONS

S N	Location of Mid-Block	Composition (%)							
		Total Fast Moving Passengers						Total Goods	Total Slow
		Car/Jeep /Van	2- whlr	Taxi	Auto	S Auto	Total Buses		
1	Subhash Chowk - Rajiv Chowk	47.13	2.83	33.98	5.06	3.65	1.33	4.3	1.72
2	Rajiv Chowk - Gurgaon	31.04	2.77	41.92	5.69	10.14	1.7	3.78	2.96
3	Hero Honda Chowk - Kadipur Chowk	32.93	2.71	37.27	1.94	3.57	0.97	11.55	9.06
4	Basai Chowk - Gurgaon	19.76	1.4	47.87	2.3	9.94	0.96	5.76	12.01
5	Railway Station - Gurgaon	19.35	2.56	51.01	5.48	10	1.43	4.31	5.86
6	India Post Office - Bhagwan Vishwakarma Chowk	20.71	2.94	49.64	8.44	7.73	1.26	1.63	7.65
7	CRPF Camp Chowk - Sector 5 Chowk	30.13	5	39.7	7.08	5.8	1.97	5.35	4.97
8	Pataudi Road - Kadipur Chowk	24.92	1.95	49.74	2.55	7.09	1.54	5.2	7.01

Source: RITES Primary Surveys

Speed and Delays Characteristics

The journey speed characteristics during peak and off-peak periods are presented in **Table 2.8** and **Table 2.9** respectively. It can be observed that journey speeds are low in the study area – road network having journey speed less than 30 kmph during peak and off-peak periods being only 67.10% and 32.40 % respectively.

TABLE 2.8: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED

S. No.	Journey Speed (Km/hr)	Road Length (Km)	Percentage (%)
1	<=10	89.3	15.7%
2	11-20	120.05	21.2%
3	21-30	171.35	30.2%
4	>30	186.6	32.9%
	Total	567.3	100%

Source: RITES Primary Surveys

TABLE 2.9: DISTRIBUTION OF ROAD LENGTH BY OFF PEAK PERIOD JOURNEY SPEED

S. No.	Journey Speed (Km/hr)	Road Length (Km)	Percentage (%)
1	<=20	83.11	14.7%
2	21-30	100.39	17.7%
3	31-40	167.63	29.5%

S. No.	Journey Speed (Km/hr)	Road Length (Km)	Percentage (%)
4	41-50	216.16	38.1%
	Total	567.3	100

Source: RITES Primary Surveys

2.8 TRAFFIC SAFETY

Traffic safety refers to the methods and measures used to prevent road users from being killed or seriously injured. Typical road users include: pedestrians, cyclists, motorists, vehicle passengers and passengers of on-road public transport. Road accidents are an outcome of various factors like vehicle population, human population and adherence/enforcement of road safety regulations etc. Road accident causes injuries, fatalities, disabilities and hospitalization with severe socio economic costs. Accident statistics at Crash hotspots are presented in **Table 2.10**.

TABLE 2.10: ACCIDENT STATISTICS

Item	2015-16	2016-17	2017-18	2018-19	2019-20
Total No. of Cases of road accidents	1142	1201	1214	1194	1205
No. of Deaths	447	420	481	495	433
No. of Injured Persons	791	1213	1189	844	807

Source: Statistical Abstract Haryana (2015-19)

Special traffic drives for making the public aware of the traffic rules include:

- Imposing 'fines at the spot' procedure for defaulters.
- Organizing road safety programs for:
 - informing the public of new regulations or changes to the traffic regulation system
 - influencing the attitudes towards road safety
 - persuading road users to change their behavior in relation to identified causal factors in road accidents

2.9 INTERMEDIATE PUBLIC TRANSPORT – COMPOSITION, STATUS AND ROLE

Intermediate public transport (IPT) system comprises of shared & private auto-rickshaws, Tata magic and e-rickshaw, which currently cater to a major part of overall trips in the city for estimated route length of 117 km. IPT service is become the life-line of Gurgaon's city transport system, especially in the inner areas. There appears to be an excess supply of IPT modes and there is absence of any system for parking and management for the same. This coupled with haphazard movement of rickshaws creates problems for smooth movement of traffic on the streets.

IPT service used to cater the daily passenger demand at major hubs like metro stations, IFFCO chowk, Gurgaon Bus Stand, Rajiv Chowk, Subhash Chowk and Hero Honda Chowk . The other major stops of IPT locations are as under:

- Basai Chowk (Hero Honda Road)
- Bhagwan Vishwakarma Chowk (Railway station road)
- ESI Hospital (Neki ram marg)
- Hero Honda Chowk (Subash chowk road)
- IFFCO chowk metro station
- Huda City Centre metro station (Gate 1)
- Huda City Centre (Near Taj Vivanta (HUDA CC) bus stop)
- Huda City Centre (near cyber business park)
- Jail Road Near Sohna Chowk
- Prakash Puri Chowk (Old Railway station road)
- Subhash Chowk

2.10 PUBLIC TRANSPORT SYSTEM

Public Transportation Services

Public transportation in Gurugram is provided by Bus and Metro Rail. The city bus service is operated by public and private bus operators in the Gurgaon region to connect at major activity centres. However, the services can neither be relied upon for punctuality nor are they reliable. There is no uniform and a standard schedule of operation. In addition to these, public transport majorly includes shared auto rickshaws.

Existing Bus Routes

At present, bus service is operational on 24 routes by government and 4 route by private in the Gurgaon and the city bus service is provided by Gurgaon Metropolitan City Bus Limited (GMBCL) on 2 routes. However, Transport Department (Haryana) has intended to start intra city bus service on following routes:

- Mahavir To Dhundhera Border and back-DPL To Mahavir
- Mahavir Chowk To Hero Honda
- Huda City Centre To Huda City Centre Metro Station
- Huda City Centre To Sector 29 Station
- Rajiv Chowk To Rajiv Chowk
- IMT Manesar To DaulaKuan
- IFFCO Chowk To Bus Stand Gurgaon

Institutional Framework and Responsive Agency

City transport system generally has several organizations involved that look after various forms and aspects of the transport system and network. Most of these organizations have overlapping functions and areas of work. It is due to this reason that a good institutional arrangement for organizing, regulating and managing urban transport system in cities has become very essential. In case of Gurgaon, Public Transport requirements are catered by Public & Private City Bus Operators.

Constraints

The city bus system needs to be augmented and provided adequate protection in terms of patronage from the other IPT modes and mini-buses to ensure the viability of the system.

The level of bus passenger infrastructure like boarding-alighting bays and passenger information system etc. is very low in the city which required to enhance to support the public transport system.

High growth of private modes over the years has resulted in declining trend of public transport system share. Private auto, shared auto, cycle rickshaw and e-rickshaws supplement these transportation services. There is no control over mushrooming IPT modes in the city, which lead to issues of congestion along with contesting with the buses for passengers. The challenge is to reverse this trend and ensure that public transport system is augmented to cater to the significant daily travel demand.

2.11 PAST PROPOSALS FROM PREVIOUS STUDIES

Various past studies including Implementation of City Bus Service Project, final development plan for Gurgaon Manesar Urban Complex and Comprehensive Mobility Plan (Draft) for Gurgaon Manesar Urban Complex have stressed the need for strategies to have the best transportation modes and infrastructure proposals to address the transportation related issues in the City.

I. Implementation of City Bus Service Project in Gurgaon – Bus Route Planning and Rationalization (March, 2018)

Municipal Corporation of Gurgaon intends to improve the public transport in Gurgaon by developing adequate bus route system and rationalizing of para-transit routes which is run by private operators. The department has engaged Delhi Integrated Multi Modal Transit System (DIMTS) to conduct the bus route planning and rationalization study covering the following services:

- Planning of Bus Routes based on origin destination of users and connectivity of various city nodes

- Rationalize the existing para-transit services/routes and re-organize their operation so that city area is sufficiently covered by public transport network.

The proposed bus route hierarchy is presented in **Table 2.11**.

TABLE 2.11: PROPOSED BUS ROUTE HIERARCHY FOR GURGAON

Route Type	Route Name	Route Length (in km)
Trunk Routes	Gurgaon Bus stand to Bilaspur kalan	30
	Harsaru to Dundahera	11.9
	Huda city centre to Dharampuri	13
	Sector 2 to Ghata Village	19.7
	Basai Chowk to Huda city centre (Via GBS)	11.9
	Sohna to Railway station	21.7
	Manesar to Railway station	26
Primary Routes	Huda city centre to Huda city centre (via Hero honda chowk, Railway station)	25.1
	Gurgaon Bus stand to Farrukh nagar	19.5
	Gurgaon Bus stand to Ansal University (Mayfield Garden)	13.9
	Sikanderpur Metro station to Sector 84	19.6
	Cyber City to Badshahpur*	17.7
	Huda city centre to Palam Vihar*	14.9
	Sec 56 to Dundahera	16.3
	Manaser to Cyber City*	27.6
	Gurgaon Bus stand to Palam Vihar	10.5
Secondary Routes	Huda City Centre to Maruti Kunj (Via Badshahpur)	13.2
	Sector 97 to Badshahpur (Via IMT Manesar)	20.7
	Sec 2 to Sec 6A	9.3
	KIIT College of Engg to Rajeev Chowk	14
	Sector 88A to Palam Vihar	15.1
Regional Routes (Connecting outside Gurgaon Metropolitan Area)	Railway Station to Dhaulkaun*	20.4
	Gurgaon Bus stand to Anand Vihar	48
	Gurgaon Bus stand to Karol Bagh	31.5
	Harsaru to Heli Mandi	22.6
	Sec 61 to Green Filed	27.2

II. Comprehensive Mobility Plan for GMUC, 2020

The study was carried out by School of Planning and Architecture, New Delhi for Gurgaon Metropolitan Development Authority in 2020. A number of traffic surveys were carried out

to access the socio-economic and traffic characteristics of resident population and commuter traffic. Important Proposals were as follows:

The Comprehensive Mobility Plan aims at overall improvement in the movement of people within the city as well as into and out of it. The proposals in this plan consist of a wide range of interventions targeted at various segments of travel demand, public transport being one of them, albeit the most important.

In order to develop an integrated mass transit system for the study area, alternative transport network options have been evolved based on combinations of road and Mass Transit System networks. These road network proposed under the scenario are as follows:

New Links

- Sector 111 to Dwarka Sector 21 (Dwarka Expressway road to 8 lane)
- Babur Village and Sector 114 (2 lanes to 4 lane)

Road Widening

- Patudi Road
- Faridabad Road
- MG Road
- Old Gurgaon Road
- Vishwakarma Chowk
- Ganpati Honda
- Sonam Nursery
- AtulKataria Chowk
- Huda City Centre

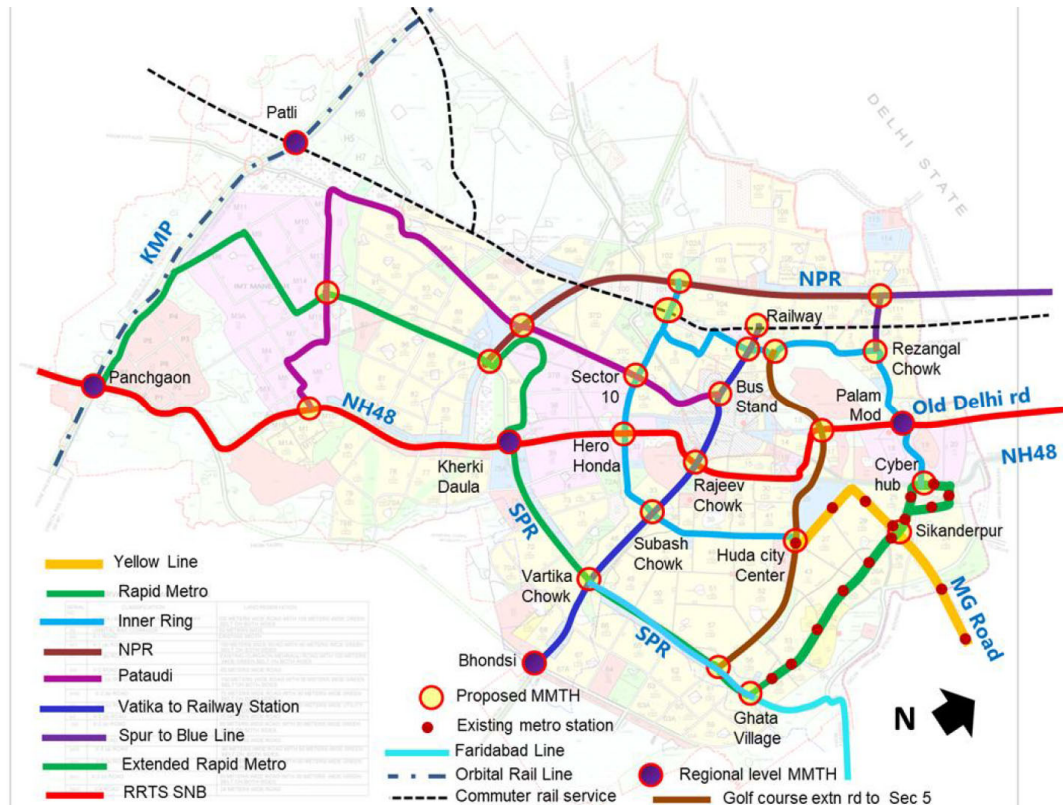
RUB/ ROB

- Connection to Dwarka Expressway between (Gopalpur and Dwarka Expressway at sector 37D.
- Between Vashino Mata Mandir and Sector 89A
- Farukh Nagar – Wazirpur road
- Between Jai Vision Public school (Chauma Road) and Major Sushil Aimamarg (Ansal Garden Homes)

The strategy includes road network in addition to the Mass Rapid Transit System (MRTS) with rationalization of bus routes and additional bus routes. Proposed bus routes by DIMTS were rationalized according to the MRTS network and new routes were added to enhance the Public Transport System in the study area. In addition to MRTS network an additional

link proposed between Panchgaon metro and extension of Huda city centre metro. Dwarka expressway and Faridabad – Gurgaon metro also considered. Figure shows the proposed Mass Rapid Transit Network for Horizon Year.

FIGURE 2-2: PROPOSED MASS TRANSIT NETWORK IN GURUGRAM



Source: Comprehensive Mobility Plan for GMUC, 2020

2.12 INTERCONNECTIONS AMONG VARIOUS STUDIES/PROPOSALS

The past studies carried out earlier have analyzed the existing conditions in detail and have come up with possible improvement proposals in Gurgaon. The City requires a mass transport system that would cater to the expected demand and provide a safe and convenient travel and alleviate the existing traffic woes. Various Non-motorised transport facilities and road improvements have also been part of proposals from Master Plan and CMP.

CMP proposes implementation of mass transit system for priority corridors in Gurgaon and Alternatives Analysis Report recommends Metro Rail System for priority corridors.

2.13 ISSUES AND PROSPECTS

Existing Traffic Characteristics and Related issue

The observed reasons for traffic congestion include encroachments along ROW, Unauthorized movement of auto-rickshaws and slow moving vehicles. Various stretches of roads show that congestion is occurring not just due to high traffic volume but also on

account of encroachment due to informal activity. Mixed land use and high volume of private cars & auto rickshaws along the roads are also responsible for slowing down the traffic flow. Heavy traffic flows and congestion at M.F. Hussain Marg near IFFCO Chowk, Hamilton Ct. Road, Golf Course Road, M.G. Road, Cyber city, Post office Chowk, Sadar Bazar, Hero Honda Chowk, Subhash Chowk, CRPF Camp Chowk, Basai Chowk has been observed. On-street parking of vehicles is predominant on the various roads stretches. However, major office and commercial hubs have their own adequate parking lots.

Bus queue shelters and bus box markings on carriageway are almost absent in the city, as a result of which the buses tend to stop erratically on roads depending on passengers' demand for boarding/ alighting. This hinders smooth traffic movement and also creates potential for accidents. Apart from road signages, another key element that must be given appropriate importance is street furniture. It includes streetlamps, street lighting, traffic lights, traffic signs, bus stops, dust bins, taxi stands, public lavatories and fountains and memorials. The functional widths of the major roads are reduced to about half due to encroachments, provision of vegetable markets, road-side parking and also the water logging due to poor drainage system. The reduced road width leads to increase in the volume-capacity ratio and thus, leading to congestion and vehicular pollution. The location of wholesale market in the Sadar Bazar leads to heavy movement of the LCVs and other small good carriages for to and fro transportation of goods.

Air Pollution Levels

The pollution levels in the City are determined by the existing Ambient Air Quality Index (AQI). The AQI considers eight pollutants (PM₁₀, M_{2.5}, NO₂, SO₂, CO, O₃, NH₃, and Pb) in which one of PM₁₀ or PM_{2.5} parameter is mandatory. There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The AQI values for identified eight pollutants are as provided in **TABLE 2.12**.

TABLE 2.12: AIR QUALITY INDEX PARAMETERS

AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)	PM ₁₀ 24-hr	PM _{2.5} 24-hr	NO ₂ 24-hr	O ₃ 8-hr	CO 8-hr (mg/m ³)	SO ₂ 24-hr	NH ₃ 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 –1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

Source: Central Pollution Control Board

As per available data of Gurugram from January 2021 to May 2021 as presented in **Table 2.13**, it can be seen that the ambient air quality varies from moderate to very poor at different locations in Gurugram. These pollution levels are alarming considering the future growth of the city.

TABLE 2.13: AMBIENT AIR QUALITY STATISTICS AT VARIOUS LOCATION IN CITY

Month/Year	AQI		
	Sector-51	Teri Gram	Vikas Sadan
Jan-21	367	226	395
Feb-21	376	285	312
Mar-21	245	221	186
Apr-21	120	199	251
May-21	295	237	228

Source: National Air Quality Index, Official Webpage

Prospects

With a view of developing effective and efficient mass transit system to address traffic woes and pollution levels in the City, the Government of Haryana has decided to implement Metro Rail system for Gurugram and compliment with other sustainable transport initiatives and transport infrastructure improvement measures.

Chapter – 3

TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

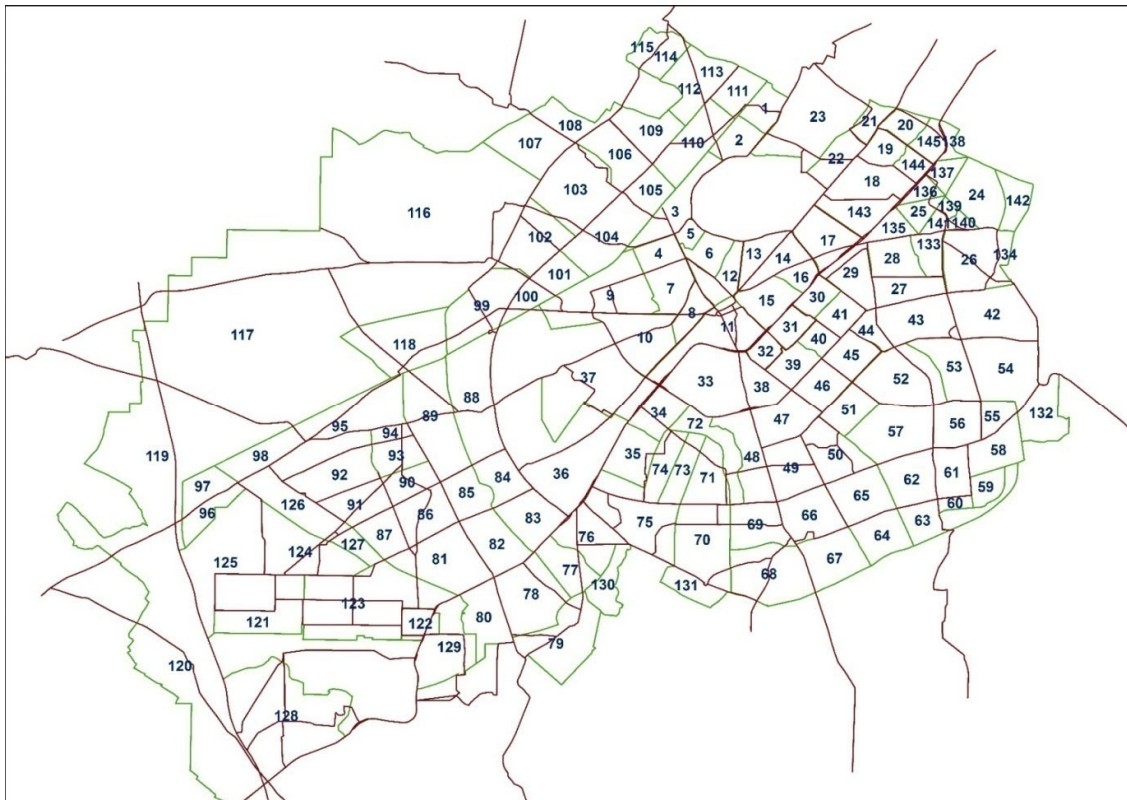
3. TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

3.1 VARIOUS TRAFFIC AND TRANSPORTATION STUDIES UNDERTAKEN

3.1.1 Study Area and Zoning

The geographic area within the jurisdiction Gurugram-Manesar Urban Complex (GMUC) is taken as the study area for this study. To understand the travel pattern of the city, a total of 149 zones called traffic analysis zones have been identified. Considering the ease of getting required zonal information, administrative wards were considered as zones within the GMUC Area. A total of 145 internal zones inside GMUC area and 4 external zones have been considered for the study. The zoning systems of the study area are presented in **Figure 3.1**.

FIGURE 3.1: ZONING SYSTEM



3.1.2 Landuse Surveys

Landuse surveys have been carried out to understand the pattern along existing road network of about 567.3 km. The abutting land use is presented in **Table 3.1**. It is seen that the road network is abutted by residential land use upto an extent of about 15.2% and commercial about 7.9%.

TABLE 3.1: DISTRIBUTION OF ABUTTING LANDUSE ALONG MAJOR ROADS

SN	Landuse	Percentage %
1	Residential	15.2
2	Commercial	7.9
3	Residential & Commercial	41.4
4	Educational & Institutional	0.9
5	Green/Agricultural/Vacant	1.5
6	Industrial	32.7
7	Transport Infrastructure	0.5
Total		100.0

3.1.3 Traffic and Transportation Surveys

A number of traffic & travel surveys were conducted to appreciate and quantify the characteristics of commuter travel within the Study Area. This data analysis has helped us in developing the Travel Demand Model.

3.1.3.1 Classified Traffic Volume Counts

Classified traffic volume surveys were carried on average weekday to quantify the volume of traffic moving along various road sections in the study area. The counts were carried out for 16-hour at mid block and Intersection locations and for 24 hour at outer cordon locations. The survey locations were selected in a manner that would cover the entire study area and assist in understanding the traffic pattern within the study area as well as with adjacent urban settlements. These surveys help in assessing the existing traffic problems in the study area as well as to validate the transport demand models.

i. Mid-Block/Screen Line Count Survey

The quantum and temporal variation of total and daily vehicles and trips moving in the study area has been carried out in the following sections. The survey locations are as follows:

- Subhash Chowk - Rajiv Chowk
- Rajiv Chowk – Gurugram
- Hero Honda Chowk - Kadipur Chowk
- Basai Chowk – Gurugram
- Railway Station – Gurugram
- India Post Office - Bhagwan Vishwakarma Chowk
- CRPF Camp Chowk - Sector 5 Chowk
- Pataudi Road - Kadipur Chowk

Average Daily and Peak Hour Traffic Characteristics

The daily and peak hour traffic counts both in terms of numbers of vehicles and Passenger Car Units (PCUs) are presented in **Table 3.3**. It is observed that the traffic at selected 8 survey locations varies from 30559 PCUs (38759 Vehicles) at Basai Chowk – Gurugram to 107242 PCUs (121403 Vehicles) at Subhash Chowk - Rajiv Chowk throughout a normal working day.

The morning peak hour volume varies from 2611 PCUs (3610 Vehicles) at Basai Chowk – Gurugram to 9030 PCUs (10894 Vehicles) at Subhash Chowk - Rajiv Chowk. Similarly, evening peak hour volume varies from 2261 PCUs (3028 Vehicles) at Basai Chowk – Gurugram to 8058 PCUs (9586 Vehicles) at Subhash Chowk - Rajiv Chowk throughout a normal working day among 8 surveyed locations.

Directional Distribution of Traffic

It can be observed that peak hour peak directional traffic at Mid-block locations varies from 51% to 69% with an average peak hour directional distribution of 61%.

ii. Classified Traffic Volume Counts at Outer Cordon Locations

The classified traffic volume counts were carried out at 3 outer cordon locations to assess the intensity of the traffic entering and leaving the study area. Outer Cordon survey locations are enlisted in **Table 3.2**.

TABLE 3.2: OUTER CORDON LOCATIONS

SN	LOCATION OF OUTER CORDON
1	Kherki Daula Toll Plaza (NH-48)
2	Mehrauli – Gurugram Road (Near Arjangarh metro station)
3	Kapasera MCD Toll Plaza (Old Delhi-Gurgaon Road)

Average Daily (24 hours) and Peak Hour Traffic Characteristics

Total daily and peak hour traffic at 3 locations is presented in **Table 3.4**. It is observed that the traffic at different locations varies from 68,647 Vehicle (57,820 PCUs) at Kapasera MCD toll plaza (both direction) to 121,694 Vehicle (144,941 PCU's) at Kherki Daula toll plaza (both direction) on a normal working day.

The morning peak hour volume varies from 4,125 vehicles (3,255 PCUs) to 9,720 vehicles (9,086 PCUs).

Directional Distribution of Traffic

It is observed that peak hour peak directional traffic at Outer Cordon generally varies from about 51.6% at Kherki Daula Toll Plaza (NH-48) to 65% at Mehrauli – Gurugram Road (OC_02).

TABLE 3.3: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT MID-BLOCK/SCREEN LINE LOCATIONS

SN	Name of Mid-Block/Screen Line Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCUs)	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	Peak Direction (PCUs)	%	Off Peak Direction (PCUs)	%
1	Subhash Chowk - Rajiv Chowk	121403	107242	10894	9%	9030	8%	9586	8%	8058	8%	5147	57%	3883	43%
2	Rajiv Chowk – Gurugram	76524	64227	6436	8%	5016	8%	5254	7%	4335	7%	3180	63%	1836	37%
3	Hero Honda Chowk - Kadipur Chowk	50533	44979	4910	10%	3610	8%	3723	7%	3065	7%	2506	69%	1105	31%
4	Basai Chowk – Gurugram	38759	30559	3610	9%	2611	9%	3028	8%	2261	7%	1498	57%	1113	43%
5	Railway Station – Gurugram	75178	58718	6913	9 %	4931	8%	6230	8%	4466	8%	3172	64%	1759	36%
6	India Post Office -Bhagwan Vishwakarma Chowk	68206	53367	5710	8%	4255	8%	4709	7%	3482	7%	2673	63%	1582	37%
7	CRPF Camp Chowk - Sector 5 Chowk	72727	62242	5832	8%	4630	7%	5314	7%	4432	7%	2938	63%	1692	37%
8	Pataudi Road - Kadipur Chowk	47760	37873	4429	9%	3261	9%	3783	8%	2842	8%	1631	51%	1630	49%

TABLE 3.4: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT OUTER CORDON LOCATIONS

SN	Name of Outer Cordon Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCU's)	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	Peak Direction (PCUs)	%	Off Peak Direction (PCUs)	%
1	Kherki Daula Toll Plaza (NH-48)	121694	144941	9720	8.0	9086	6.3	7926	6.5	7666	5.3	4693	51.6	4394	48.4
2	Mehrauli – Gurugram Road (Near Arjangarh metro station)	134828	111344	9351	6.9	7292	6.5	6264	4.6	5167	4.6	3360	65.0	1807	35.0
3	Kapasera MCD Toll Plaza (Old Delhi-Gurgaon Road)	68647	57820	4125	6.0	3255	5.6	5164	7.5	3894	6.7	2221	57.0	1674	43.0

i. Turning Movement Counts at Intersections

The survey involved 15 minutes interval direction wise classified traffic volume counts for each movement at the intersection-continuously for 16 hours (06:00 hours to 22:00 hours) on a typical working day. Direction-wise classified traffic volume surveys were carried at 4 intersections in the study area to quantify the mode-wise volume and intensity of traffic flow over the day (**Table 3.5**). The output provides daily traffic, hourly traffic volume variations and peak hour traffic flow/composition for all directional movements and individual arms at each intersection, as presented by the detailed survey data and traffic flow diagrams.

TABLE 3.5: TURNING MOVEMENT VOLUME COUNT SURVEY LOCATIONS

S. No	Name of intersection
1	Huda Chowk
2	Subhash Chowk
3	Hero Honda Chowk
4	Bhagwan Vishwakarma Chowk

Intensity of Traffic

The intensity of traffic at intersection locations is presented in **Table 3.6**. It is seen that Subhash Chowk handles the maximum daily traffic of 2,21,499 vehicles (1,99,475 PCUs) while the least daily traffic is observed at Bhagwan Vishwakarma Chowk with 1,23,633 vehicles (96,830 PCUs).

TABLE 3.6: TOTAL DAILY APPROACH TRAFFIC (INFLOW) AT INTERSECTIONS

S.No	Name of intersection	Grand Total (Nos.)	Grand Total (PCU's)
1	Huda Chowk	140928	126369
2	Subhash Chowk	221499	199475
3	Hero Honda Chowk	211104	199024
4	Bhagwan Vishwakarma Chowk	123633	96830

Total Daily Traffic composition

The composition of observed daily traffic at the intersections is presented in Table 3.7. For fast passenger vehicles, it varies from 83.9% at Hero Honda Chowk to 94.6% at Huda Chowk, while the share of slow modes varies from 2.1% at Subhash Chowk to 5.4% at Bhagwan Vishwakarma Chowk. Goods vehicles comprise about 1.5% at Huda Chowk to 10.5% at Hero Honda Chowk of the surveyed 16-hour daily traffic.

TABLE 3.7: COMPOSITION OF DAILY TRAFFIC AT INTERSECTIONS

Loc No	Name of intersection	Fast Moving Passenger Vehicles				Buses		Total Fast Passenger	Goods Vehicles			Slow Moving Vehicles			Total Slow
		Car/ Jeep/ Van	2- Wheeler	Auto	Shared Auto	Bus	Mini Bus		Truck	LCV/ Tempo	MAV	Cycles	Rickshaw	Others	
1	Huda Chowk	41.36	23.59	25.07	4.55	0.96	0.51	94.58	1.00	0.28	0.20	1.77	0.53	0.19	2.48
2	Subhash Chowk	48.14	28.16	7.64	8.53	1.43	0.41	92.47	2.23	0.60	0.79	1.36	0.21	0.49	2.06
3	Hero Honda Chowk	45.73	28.25	2.09	7.01	1.81	0.54	83.09	5.19	1.21	4.05	2.42	0.20	1.50	4.12
4	Bhagwan Vishwakarma Chowk	30.93	45.51	7.05	6.71	1.32	0.27	90.20	1.83	0.65	0.36	3.49	1.54	0.33	5.36

3.1.3.2 Speed-Delay Surveys

The Speed and delay survey was conducted along the road network using the running car method during peak and off-peak periods. The results of the survey with respect to the journey and running speed and delays are presented in the following paragraphs.

i. Journey Speed

The journey speed characteristics during peak period are presented in **Table 3.8**. It is observed that about 36.9% of the total road network has journey speeds less than 20 kmph during peak hours inside the core city. Average Journey Speed during peak period for a city as a whole is observed to be 22.2 kmph.

TABLE 3.8: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED

SN	Journey Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	89.3	15.7%
2	10-20	120.05	21.2%
3	21-30	171.35	30.2%
4	>30	186.6	32.9%
Total		567.3	100%

ii. Running Speed

The distribution of road length by Peak hour running speed is given in **Table 3.9**. It is observed that about 54.4% of the road network has running speeds more than 30 kmph during peak hours. The average running Speed during peak period for a city as a whole is observed to be 28.5 kmph.

TABLE 3.9: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR RUNNING SPEED

SN	Running Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	67.1	11.8%
2	10-20	89.4	15.8%
3	21-30	102.3	18.0%
4	>30	305.8	54.4%
Total		567.3	100%

iii. Delays

The distribution of causes of delays & their duration during peak hours and off-peak hours is presented in **Table 3.10**. It is observed that the delays are caused mostly by traffic jams/congestion which account for about 71.7% in the peak hour.

TABLE 3.10: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK HOURS

SN	Causes of Delays	Peak Hour	
		No. of Points	%
1	Traffic Jam/ Congestion	220	71.7%
2	Traffic Signal	54	17.6%
3	Poor Road Profile	33	10.7%
Total		307	100%

3.1.3.3 Public Transport & IPT Surveys

The public transport passenger surveys were conducted as part of the study at the following Terminals/Stations/Stops:

- Bus Terminal Surveys
- Rail Terminal Surveys
- Metro Rail Stations
- PT/IPT Stop Surveys

i. Bus Terminal Surveys

Gurugram Bus terminal was selected to conduct terminal survey within study area. It is observed from Table 3.11 that Gurugram Bus Terminal caters to the maximum number of passengers with 12,136 Boarding & 6,419 Alighting.

TABLE 3.11: DISTRIBUTION OF PASSENGERS AT BUS TERMINAL

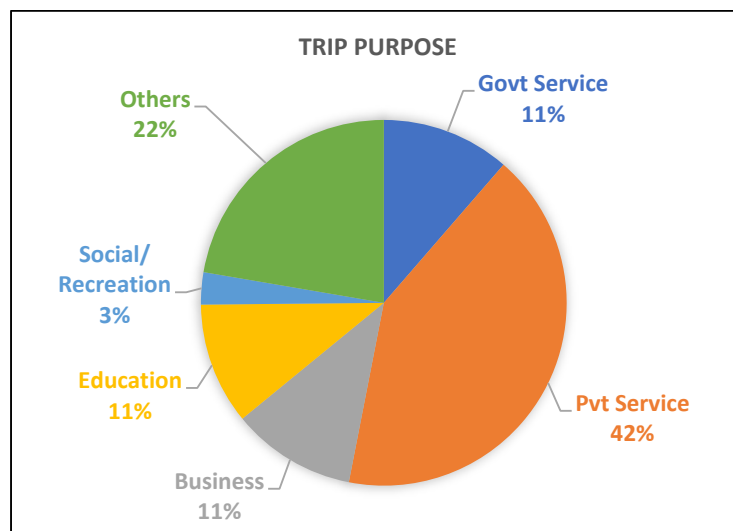
Name of Terminal	Boarding	Alighting	Total	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Total
Gurugram Bus Terminal	12136	6419	18555	12:00-13:00	1183	841	2024

Origin Destination Survey at Bus Terminal

It is observed from Table 3.12 that work trips contribute about 64% of total trips. The share of educational trips is 11%, followed by social trips which contribute 3.0%. The other trips which include tourist, shopping, recreation etc. contribute 25%. Distribution of passenger trips by purpose is presented in Figure 3.2.

TABLE 3.12: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

Trip Purpose	Govt Service	Pvt Service	Business	Education	Social	Others	Total
No. of Passengers	2110	7736	2042	1999	526	4140	18555
Composition (%)	11%	42%	11%	11%	3%	22%	100%

FIGURE 3.2: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

Distribution of passengers reaching bus terminals by different modes is presented in Table 3.13. It is observed that 38.0% and 33.7% of total passengers use buses and shared auto to reach bus terminals respectively. The share of 2-Wheeler and Car is 4.6% and 3.7% respectively.

TABLE 3.13: DISTRIBUTION OF BUS PASSENGERS BY MODE TO REACH TERMINAL

S.No	Modes	No. of Passengers	Share (%)
1	Car/ Jeep/ Van	854	4.6%
2	2 Whlr	681	3.7%
3	Auto	1514	8.2%
4	Share Auto	6255	33.7%
5	Taxi/ Share Taxi	747	4.0%
6	Bus/Mini bus	7050	38.0%
7	Cycle	136	0.7%
8	Cycle Rick	343	1.8%
9	Walk	975	5.3%
Total		18555	100%

Distribution of Passengers by Travel Frequency is presented in Table 3.14. It is observed that 66.6% of total passengers perform their trips on daily basis and 9.5% & 10.9% of total passengers perform weekly and monthly trips. It is also observed that about 13.0% of total passengers travel occasionally.

TABLE 3.14: DISTRIBUTION OF BUS PASSENGERS BY TRAVEL FREQUENCY

Bus Terminal	Daily	Weekly	Monthly	Occasionally	Total
Gurugram	12358	1758	2026	2413	18555
	66.6%	9.5%	10.9%	13.0%	100%

Distribution of passengers by travel time to reach bus terminal is presented in **Table 3.15**. It is observed that 14.7% of total passengers travel upto 20 minutes to reach bus terminal and 63.9% of total passengers have travel time ranging between 20-45 minutes. Further, about 21.4% of total passengers have travel time of more than 45 minutes.

TABLE 3.15: DISTRIBUTION OF BUS PASSENGERS BY TRAVEL TIME TO REACH BUS TERMINAL

Bus Terminal		Travel Time (minutes)							Total
		<=10	10-20	20-30	30-45	45-60	60-90	>90	
Gurugram	No.	483	2238	7025	4825	2497	1055	432	18555
	%	2.6%	12.1%	37.9%	26.0%	13.5%	5.7%	2.3%	100%

ii. Rail Terminal Surveys

Gurugram Railway Station was selected to conduct in and out, Origin-Destination and travel characteristics within study area. It is observed from **Table 3.16** that Gurugram railway station caters to 23,159 passengers daily (12,624 Boarding & 10,535 Alighting).

TABLE 3.16: PASSENGER VOLUME AT GURUGRAM RAILWAY STATION

Passenger		Total	Peak Passenger		Total
Boarding	Alighting		In	Out	
12624	10535	23159	2095	734	2829

Origin Destination Survey at Rail Terminals

Distribution of rail passenger by trip purpose is presented in **Table 3.17**. It is observed that work trips contribute about 65.7% of total trips. The share of business trips is 11.3%. The share of Social/Recreational trips is 2.4% followed by 14.5% share of educational trips. The Other trips which include tourism, shopping, religious purpose etc. contribute to 6.1%. Distribution of passenger trips by purpose is presented in Figure 3.3.

TABLE 3.17: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

S.No	Trip Purpose	No. of Passenger	%
1	Govt Service	4144	17.9%
2	Pvt Service	11062	47.8%
3	Business	2616	11.3%
4	Education	3354	14.5%
5	Social/ Recreational	562	2.4%
6	Others	1422	6.1%
Total		23159	100%

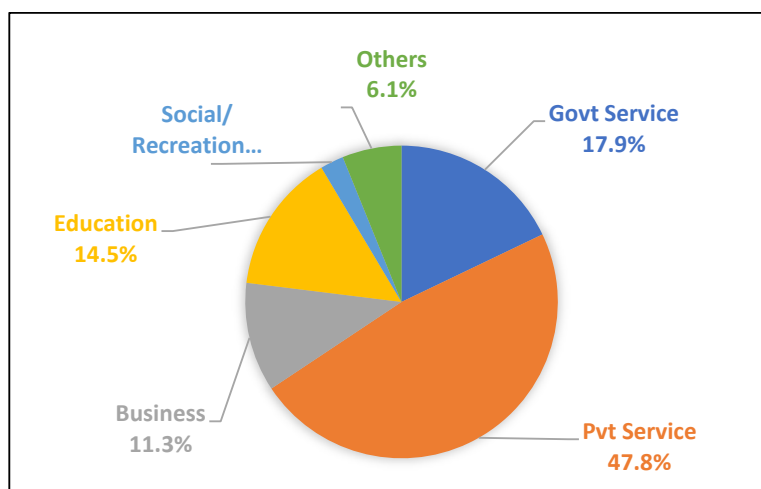
FIGURE 3.3: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

Table 3.18 shows that about 41% of passengers used auto/Shared Auto/Taxi to reach rail terminal. 2-Wheeler and Bus contributes about 11.50% and 17.40% respectively.

TABLE 3.18: DISTRIBUTION OF RAIL PASSENGERS BY MODE TO REACH TERMINAL

S.No	Mode	No. of Passenger	%
1	Car/ Jeep/ Van	2401	10.4%
2	2 Whlr	2662	11.5%
3	Auto	5267	22.7%
4	Share Auto	4263	18.4%
5	Taxi/Shared Taxi	2195	9.5%
6	Bus/Mini Bus	4039	17.4%
7	Cycle rickshaw	630	2.7%
8	Cycle	70	0.3%
9	Walk	1632	7.0%
Total		23159	100%

Distribution of passengers by travel frequency is presented in **Table 3.19**. It is observed that 61.7% of total passengers perform their trips on daily basis and 17.9% & 11.5% of total passengers perform weekly and monthly trips. Only 8.9% of total passengers travel occasionally.

TABLE 3.19: DISTRIBUTION OF RAIL PASSENGERS BY TRAVEL FREQUENCY

Rail Terminal		Daily	Weekly	Monthly	Occasionally	Total
Gurugram	Nos.	14292	4144	2669	2054	23159
	%	61.7%	17.9%	11.5%	8.9%	100%

Distribution of passengers by travel time to reach Rail terminal is presented in **Table 3.20**. It is observed that 20.5% of total passengers have travel less than 20 minutes to reach Rail terminal. About 57.3% of total passengers have travel time ranging between 20-45 minutes and about 22.2% of total passengers have travel time of more than 45 minutes.

TABLE 3.20: DISTRIBUTION OF RAIL PASSENGERS BY TRAVEL TIME TO REACH RAIL TERMINAL

Rail Terminal		Travel Time (minutes)							Total
		<=10	11-20	21-30	31-45	46-60	61-90	>90	
Gurugram	No.	1705	3037	6387	6895	3835	822	478	23159
	%	7.4%	13.1%	27.6%	29.8%	16.6%	3.5%	2.1%	100%

iii. Metro Rail stations Surveys

A total of 3 Metro Rail Stations were selected to conduct Boarding and Alighting, Origin-Destination, Travel characteristics within study area. It is observed from **Table 3.21** that HUDA City Centre metro station caters to the maximum number of daily passengers with 52,437 boarding & 52,554 alighting. However, IFFCO metro station caters to 25,274 boarding and 26,488 alighting passengers while these figures observed as 41,471 boarding and 43,840 alighting passengers at M.G. Road metro station.

TABLE 3.21: DISTRIBUTION OF PASSENGERS AT RAIL TERMINALS

SN	Name of Location	Total Boarding	Total Alighting	Total	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour
1	Huda City Centre	52437	52554	104991	08:45 - 09:45	5169	11479	16648
2	IFFCO Chowk	25274	26488	51762	09:15 - 10:15	3383	3686	7069
3	MG Road	41471	43840	85311	09:30 - 10:30	4229	6561	10790
Total		119182	122882	242064		12781	21726	34507

Origin Destination Survey at Metro Rail stations

Distribution of passengers by trip purpose at metro stations is presented in the Table 3.22 and Figure 3.4. It is observed that that work trips contributes to 63.4%, 71.8% and 70.6% at the HUDA city centre, IFFCO chowk and M.G.Road Stations respectively. Similarly, Educational purpose trips are observed as 8.1%, 11% and 11.1% while other trips are 27.9%, 16.2% and 16% at respective metro stations.

TABLE 3.22: DISTRIBUTION OF METRO PASSENGERS BY TRIP PURPOSE

Trip Purpose	Govt Service	Pvt Service	Business	Education	Social/ Recreational	Others	Total
Huda City Centre	6255	44219	16012	8474	730	29301	104991
IFFCO Chowk	4510	19804	12833	5715	493	8407	51762
M.G Road	2622	48044	9553	9983	1435	13674	85311

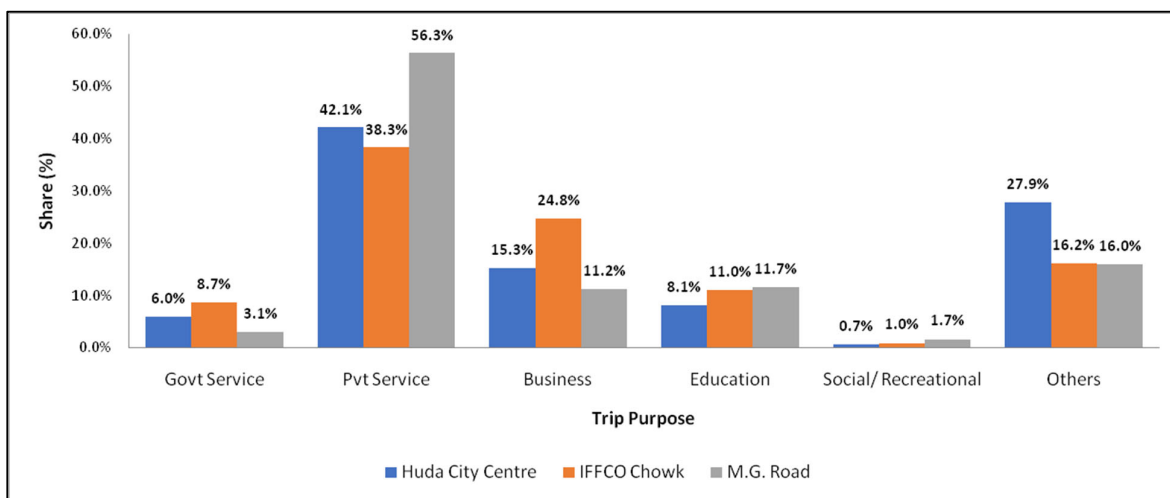
FIGURE 3.4: DISTRIBUTION OF METRO PASSENGERS BY TRIP PURPOSE

Table 3.23 shows that about 39% of total passengers use auto/shared auto & about 24.9% of total passenger use buses to reach metro station. The share of Car, 2-Wheeler and Walk trips is about 4.4%, 8.4% and 19.9% respectively.

TABLE 3.23: DISTRIBUTION OF PASSENGERS BY MODE TO REACH TERMINAL

Mode	Car	2 Whlr	Auto/Share Auto	Taxi/Share Taxi	Buses	Cycle	Cycle Rick.	Walk	Total
Huda City Centre	4545	9315	58220	3564	17481	0	1122	10744	104991
	4.3%	8.9%	55.5%	3.4%	16.6%	0.0%	1.1%	10.2%	100%
IFFCO Chowk	1916	4031	15182	1104	13515	0	147	15867	51762
	3.7%	7.8%	29.3%	2.1%	26.1%	0.0%	0.3%	30.7%	100%
MG Road	4492	7237	27579	2184	27142	250	312	16115	85311
	5.3%	8.5%	32.3%	2.6%	31.8%	0.3%	0.4%	18.9%	100%
Overall Composition	4.4%	8.4%	39.0%	2.7%	24.9%	0.1%	0.6%	19.9%	100%

Distribution of passengers by travel frequency is presented in **Table 3.24**. It is observed that 56.8% of total passengers perform their trips on daily basis while 21% & 17.6% passengers perform weekly and monthly trips and about 4.7% of total passengers travel occasionally.

TABLE 3.24: DISTRIBUTION OF METRO PASSENGERS BY TRAVEL FREQUENCY

Metro Station	Daily	Weekly	Monthly	Occasionally	Total
Huda City	61726	11307	25112	6846	104991
	58.8%	10.8%	23.9%	6.5%	100%
IFFCO Chowk	27099	16180	6956	1527	51762
	52.4%	31.3%	13.4%	3.0%	100%
MG Road	50424	17791	13290	3806	85311
	59.1%	20.9%	15.6%	4.5%	100%
Overall Composition	56.8%	21.0%	17.6%	4.7%	100%

Distribution of passengers by travel time to reach Metro station is presented in **Table 3.25**. It is observed that 49.2% of total passengers have travel less than 20 minutes to reach metro station while 43% of total passengers have travel time ranging between 20-45 minutes and about 7.9% of total passengers have travel time of more than 45 minutes.

TABLE 3.25: DISTRIBUTION OF PASSENGERS BY TRAVEL TIME TO REACH METRO STATION

Metro Station		Travel Time (minutes)						Total
		<=10	10-20	20-30	30-45	45-60	>60	
Huda City Centre	No.	12523	35351	31782	19820	3632	1883	104991
	%	11.9%	33.7%	30.3%	18.9%	3.5%	1.8%	100%
IFFCO Chowk	No.	16225	10741	14948	4712	3554	1582	51762
	%	31.3%	20.8%	28.9%	9.1%	6.9%	3.1%	100%
MG Road	No.	18195	24432	25801	9793	6228	862	85311
	%	21.3%	28.6%	30.2%	11.5%	7.3%	1.0%	100%

iv. PT/ IPT Stop Survey

A total of 50 stops were selected in the entire study area. It is observed from **Table 3.27** that IPT stop at Gurugaon Railway Station at Dauladabad main road caters to the maximum number of passengers viz. 6,677 boarding & 7,059 alighting.

Origin Destination Survey at PT/IPT Stops

It is observed from **Table 3.26** that the share of service purpose trips is about 60%, followed by educational trips which contribute to 8%. Distribution of passenger trips by purpose is presented in Figure 3.5.

TABLE 3.26: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE

Trip Purpose	Govt Service	Pvt Service	Business	Education	Social/ Recreation	Religious / Others	Total
No . of Passengers	20755	80931	25890	13084	7851	22286	170797
Composition (%)	12.2%	47.4%	15.2%	7.7%	4.6%	13%	100%

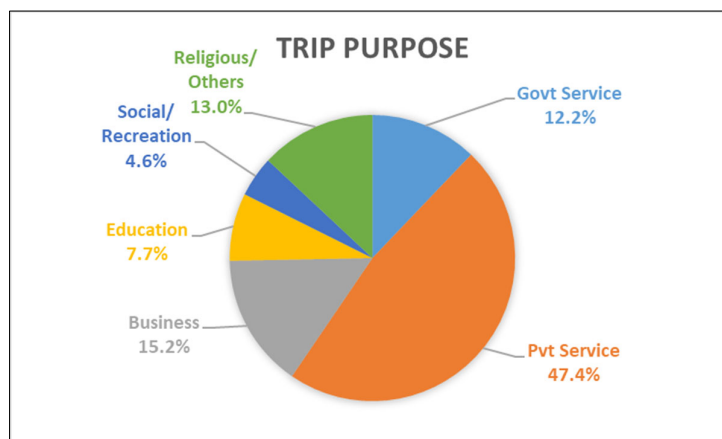
FIGURE 3.5: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE

TABLE 3.27: DISTRIBUTION OF PASSENGER AT PT / IPT STOPS

SN	Name of Location	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
1	Basai Chowk (Hero Honda Road)	2525	2081	4606	06:30 – 07:30	329	299	628
2	Basai Chowk (Near Sagar Hospital)	473	300	773	06:00 – 07:00	39	41	80
3	Bhagwan Vishwakarma Chowk (Neki ram marg)	4466	4033	8499	11:00 – 12:00	480	438	918
4	Bhagwan Vishwakarma Chowk (Old Railway road)	3488	3434	6922	14:00 – 15:00	339	318	657
5	Bhagwan Vishwakarma Chowk (Railway station rd)	1471	1152	2623	09:45 – 10:45	187	155	342
6	Bhagwan Vishwakarma Chowk (Sohna Road)	99	107	206	14:45 – 15:45	7	22	29
7	ESI Hospital (Neki ram marg)	1527	1507	3034	19:00 – 20:00	159	163	322
8	Gurgaon Rajiv Chowk (Old railway station road)	678	425	1103	10:45 – 11:45	84	62	146
9	Gurugaon Railway Station (Dauladabad main road)	6677	7059	13736	06:15 – 07:15	1317	1272	2589
10	Gurugaon Railway Station Gate-1	6711	6954	13665	08:45 – 09:45	1130	1158	2288
11	Gurugaon Railway Station Parking	246	-	246	18:30 – 19:30	24	-	24
12	Hero Honda Chowk (Subash chowk rd)	2098	1707	3805	20:15 – 21:15	197	186	383
13	Hero Honda Chowk (Baasai Road)	3775	3698	7473	20:45 – 21:45	310	326	636
14	Huda City Centre (Gate 1)	1238	997	2235	18:00 – 19:00	175	52	227
15	Huda City Centre (Gate 2)	901	-	981	07:00 – 08:00	380	-	380
16	Huda City Centre (Near Taj Vivanta (HUDA CC) bus stop)	1313	1724	3037	17:15 – 18:15	195	315	510
17	Huda City Centre (Gate 3)	1003	924	1927	12:00 – 13:0	104	206	310
18	Huda City Centre (Away IFFCO chowk metro)	1359	1325	2684	18:45 – 19:45	166	171	337
19	Huda City Centre (opp Gate 2)	3161	2903	6064	13:30 – 14:30	528	470	998
20	Huda City Centre (near cyber business park)	-	5227	5227	18:45 – 19:45	-	891	891
21	Huda City Centre (Opp Gate 1)	3859	-	3859	18:30 – 19:30	418	-	418
22	Jail Road Near Sohna Chowk (Near muthoot finance)	1955	-	1955	20:30 – 21:30	154	-	154
23	Jail Road Near Sohna Chowk (Near Reliance Stores)	1651	-	1651	10:00 – 11:00	151	-	151
24	Jail Road Near Sohna Chowk (Opp Reliance Stores)	2532	-	2532	08:30 – 09:30	361	-	361
25	Jail Road Near Sohna Chowk (Near Bulland TVS)	1761	159	1920	08:15 – 09:15	123	84	207
26	Jail Road Near Sohna Chowk (Opp Bulland TVS)	4562	-	4562	19:15 – 20:15	475	-	475
27	Prakash Puri Chowk (Near comfort INN)	1815	-	1820	14:00 – 15:00	251	-	251

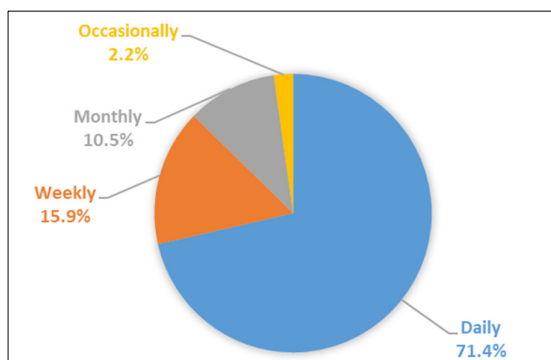
SN	Name of Location	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
28	Prakash Puri Chowk (Opp Comfort INN)	1563	1695	3258	15:15 – 16:15	145	154	299
29	Prakash Puri Chowk (Old Railway station road)	1127	1129	2256	16:30 – 17:30	149	79	228
30	Rajendar Hospital	1375	1318	2693	06:00 – 07:00	111	110	221
31	Subhash Chowk (Honda chowk Road)	852	649	1501	15:15 – 16:15	87	56	143
32	Subhash Chowk (Sohna road)	1241	753	1994	18:45 – 19:45	118	81	199
33	Subhash Chowk (Opp Unitech)	990	3289	4279	06:00 – 07:00	370	261	631
34	Subhash Chowk (Near Mata mandir)	5324	4131	9455	14:00 – 15:00	657	400	1057
35	Subhash Chowk (Near Policestation)	4886	-	4886	17:30 – 18:30	511	-	511
36	Subhash Chowk (Gurugram Road)	5620	4403	10023	18:15 – 19:15	729	444	1173
37	Subhash Chowk (Near Omaxe Mall)	3085	3489	6574	18:15 – 19:15	389	487	876
38	Subhash Chowk (Near Unitech)	2816	1197	4013	16:30 – 17:30	619	126	745
39	Unitech Cyber Park (Away Hudacity metro)	2816	1197	4013	16:15 – 17:15	611	103	714
40	Unitech Cyber Park (Away Subash Chowk)	2737	2760	5497	09:45 – 10:45	322	317	639
41	ACP Office	165	132	297	06:45 – 07:45	36	19	55
42	Caterpuri Village	4	4	8	06:00 – 07:00	4	4	8
43	Palam Vihar Gate 1	210	36	246	07:30 – 08:30	10	29	39
44	Palam Vihar Gate 2	55	119	174	14:00 – 15:00	15	15	30
45	Route Number 287 Bus Stop	230	145	375	16:45 – 17:45	14	30	44
46	Route Number 294 Bus Stop	115	53	168	07:15 – 08:15	24	2	26
47	Route Number 598 Hanuman Mandir Chowk	745	717	1462	10:00 – 11:00	62	68	130
48	Route Number 268 Sector 5 Chowk	36	14	50	12:00 – 13:00	13	2	15
49	Route Number 290 Bus Stop	233	162	395	17:15 – 18:15	27	28	55
50	Route Number 442 South Sector 5 Market	30	5	35	06:30 – 07:30	16	3	19
Total		97599	73198	170797		13122	9447	22569

Distribution of passengers by travel frequency is presented in **Table 3.28** and **Figure 3.6**. It is observed that 71.4% of total passengers perform their trips on daily basis and 15.8% and 10.5% perform weekly and monthly trips. About 2.2% of total passengers travel occasionally.

TABLE 3.28: DISTRIBUTION OF PT/IPT PASSENGERS BY TRAVEL FREQUENCY

IPT		Daily	Weekly	Monthly	Occasionally	Total
PT/IPT Passengers	Nos.	121999	27114.1	17859.9	3823.69	170797
	%	71.4%	15.8%	10.5%	2.2%	100%

FIGURE 3.6: DISTRIBUTION OF PT/IPT PASSENGER BY TRAVEL FREQUENCY

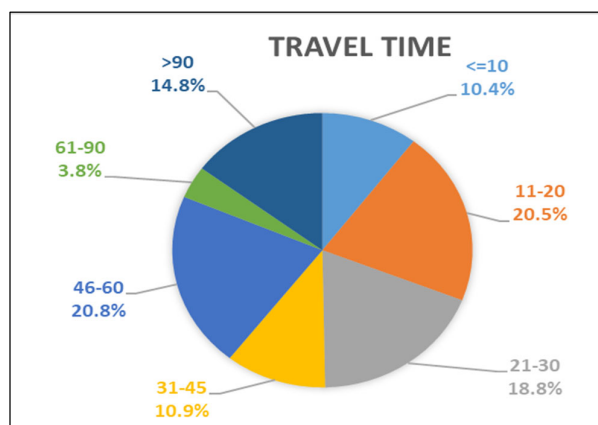


Distribution of passengers by travel time is presented in **Table 3.29** and **Figure 3.7**. It is observed that 31% of total passengers have travel time less than 20 minutes and about 29.7% passengers have travel time ranging between 21-45 minutes. About 24.5% of passengers have travel time ranging between 46-90 minutes and only 14.8% of passengers have travel time more than 90 minutes.

TABLE 3.29: DISTRIBUTION OF PT/IPT PASSENGERS BY TRAVEL TIME

IPT		Travel Time (minutes)							Total
		<=10	11-20	21-30	31-45	46-60	61-90	>90	
PT/IPT Passengers	No.	17763	35105	32033	18597	35473	6501	25325	170797
	%	10.4%	20.6%	18.8%	10.9%	20.7%	3.8%	14.8%	100

FIGURE 3.7: DISTRIBUTION OF PT/IPT PASSENGERS BY TRAVEL TIME



3.2 SOCIO-ECONOMIC CHARACTERISTICS

The household travel survey has been conducted to bring out socio-economic and travel characteristics like household size, income, vehicle ownership, per capita trip rates for various purposes viz. Work, education and other trips and expenditure on transport.

A total of 5000 households were interviewed in the study area consisting of 145 internal traffic zones. A random sampling technique was used to identify the sample. Further, care was taken that the representative households of all socio-economic strata i.e. High Income Groups (HIG), Middle Income Groups (MIG) and Lower Income Groups (LIG) were covered in the sample.

The data was collected through trained enumerators. The survey was initiated with a pilot survey in the field and amendments in the method of recording the observations were made wherever necessary before starting the actual survey. A daily programme for the household to be surveyed was prepared and the data was collected back from the enumerators on daily basis. The checked data set was compiled and coded in the office.

3.2.1 Household Socio Economic Characteristics

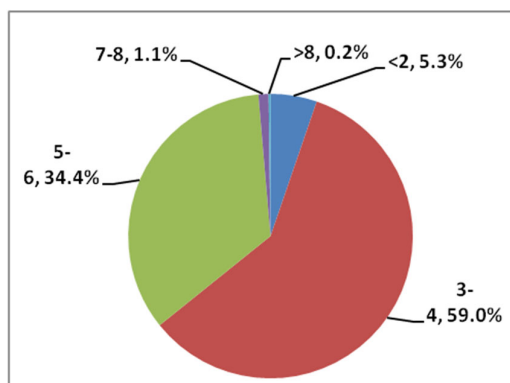
i. Household Size

The distribution of households by size is presented in **Table 3.30** and **Figure 3.8**. It can be observed that majorly i.e. 58.96% of the households fall under the category of 3-4 persons per household and 34.42% of household's falls under category of 5-6 persons group. The average household size in the study area is 4.2 persons per household.

TABLE 3.30: DISTRIBUTION OF HOUSEHOLDS BY SIZE

S. No.	Household by Size	Percentage (%)
1	<2	5.26%
2	3-4	58.96%
3	5-6	34.42%
4	7-8	1.14%
5	>8	0.22%
Total		100.0

FIGURE 3.8: DISTRIBUTION OF HOUSEHOLDS BY SIZE



ii. Age Wise Distribution

The distribution of individuals by age is presented in **Table 3.31**. It is observed that about 14.95% of residents are of age upto 14 years, about 46.83% are of age upto 35 years, about 32.47% of age upto 60 years and 5.74% are of age more than 60 years.

TABLE 3.31: DISTRIBUTION OF HOUSEHOLD MEMBERS BY AGE

SN	Age (in years)	Percentage (%)
1	0-6	5.82%
2	7-14	9.13%
3	15-21	15.22%
4	22-28	17.44%
5	29-35	14.17%
6	36-60	32.47%
7	>60	5.74%
Total		100.0

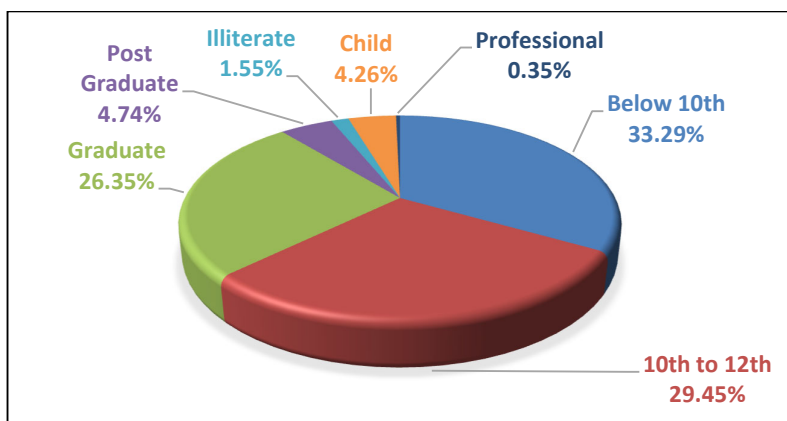
iii. Education Level

The distribution of individuals by educational qualifications is presented in Table 3.32 and Figure 3.9. The members of household, below four years of age are considered as child. It is observed that about 33.29% have studied below 10th level, 29.45% have studied up to 10th -12th level. Only 1.55% of the surveyed sample is illiterate.

TABLE 3.32: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL

SN	Education	Percentage (%)
1	Below 10 th	33.29%
2	10 th to 12 th	29.45%
3	Graduate	26.35%
4	Post Graduate	4.74%
5	Illiterate	1.55%
6	Child	4.26%
7	Professional	0.35%
Total		100.0

FIGURE 3.9: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL



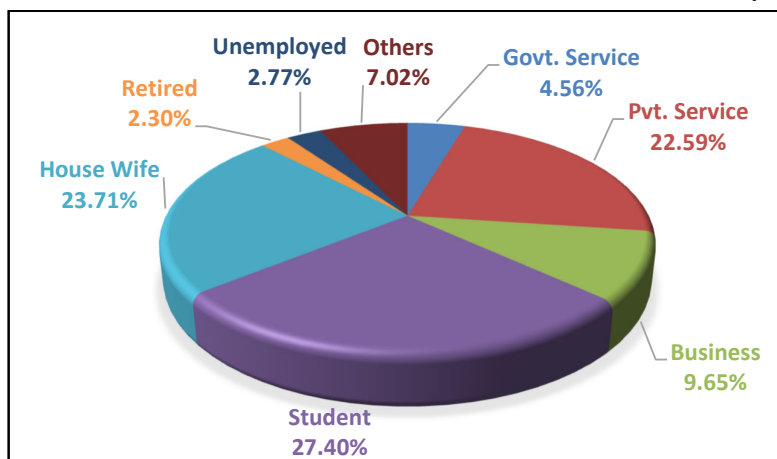
iv. Activity Status/Occupation

The Activity Status/ occupational structure of the surveyed household members are presented in **Table 3.33** and **Figure 3.10**. It is observed that about 56.18% sample population are non-workers comprising of students, housewives, retired and unemployed people. About 9.65% are engaged in business sector. Among the service class, about 22.59% are in private sector and about 4.56% in government services. About 27.4% surveyed population were students.

TABLE 3.33: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS/OCCUPATION

SN	Occupation	Percentage (%)
1	Govt. Service	4.56%
2	Pvt. Service	22.59%
3	Business	9.65%
4	Student	27.40%
5	House Wife	23.71%
6	Retired	2.30%
7	Unemployed	2.77%
8	Others	7.02%
	Total	100

FIGURE 3.10: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS/OCCUPATION



v. Income Distribution

Table 3.34 presents the distribution of Households by monthly income. It is observed that about 35.72% of the household earn less than Rs.20,000. About 25.08% household lie between monthly income of Rs.20,001 to Rs.30,000, whereas 16.6% of the household have monthly income more than Rs.50,000. The average monthly household income is observed as Rs.56,665.

TABLE 3.34: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME

SN	Income Group	Percentage (%)
1	<20000	35.72%
2	20001-30000	25.08%
3	30001-50000	22.60%
4	50001-100000	14.06%
5	>100000	2.54%

vi. Expenditure on Travel

Table 3.35 gives the distribution of the sampled households according to monthly expenditure on Transport. The table indicates that about 32.6% of Households spend less than or equal to Rs. 2000 per month on Transport and about 13.5% household have monthly expenditure more than Rs. 5000.

TABLE 3.35: DISTRIBUTION OF HOUSEHOLDS BY AVERAGE MONTHLY EXPENDITURE ON TRANSPORT

S. No.	Expenditure	Percentage
1	<1000	5.80%
2	1001-2000	26.80%
3	2001-3000	26.76%
4	3001-5000	27.14%
5	>5000	13.50%
Total		100%

vii. Vehicle Ownership per Household

Distribution of households owning vehicles is presented in **Table 3.36**. It is observed that about 6% of households have no vehicle.

TABLE 3.36: DISTRIBUTION OF HOUSEHOLDS BY VEHICLE OWNERSHIP

S. No.	Type of Vehicle	Percentage (%)
1	No Vehicle	6.02%
2	Only Car	2.32%
3	Only 2-Wheelers	33.18%
4	Only Cycle	5.90%
5	E-Rickshaw and Auto	0.78%
6	Car & 2-Wheeler	11.74%
7	Car & Cycle	0.30%
8	Car & E-Rickshaw and Auto	0.82%
9	2-Wheeler & Cycle	30.52%
10	2-Wheeler & E-Rickshaw and Auto	0.90%
11	Cycle & E-Rickshaw and Auto	0.36%
12	Car, 2-Wheeler & Cycle	5.68%
13	Car, 2-Wheeler & E-Rickshaw and Auto	0.64%
14	2-Wheeler, Cycle & E-Rickshaw and Auto	0.84%
Total		100.0

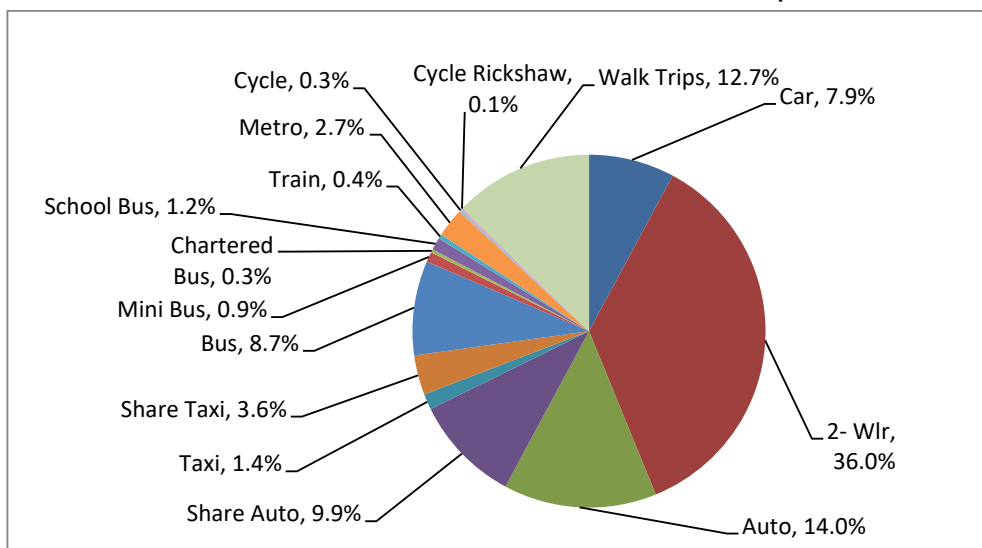
3.2.2 Travel Characteristics

i. Modal Split & Trip Rate

The total daily trips, as derived from the household survey in the study area is about 24.9 lakh trips. Distribution of daily trips by mode of travel is given in **Table 3.37** and shown in **Figure 3.11**. It is observed that about 12.7% of the trips are walk trips. However, the trips performed by 2 wheelers are about 36%. It is also observed that auto is the major public transport mode catering to about 14% of the total trips followed by Bus share of 8.7%. The trips performed by Cars & Taxi are about 9.3%. Per capita trip rate including walk is 1.48 and for motorised trips is 1.29.

TABLE 3.37: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)

Trip Type	Type of Vehicle	Number of Trips	Percentage (%)
Vehicular Trips	Car	195767	7.9%
	2- Wheeler	895896	36.0%
	Auto	349442	14.0%
	Share Auto	245581	9.9%
	Taxi	35617	1.4%
	Share Taxi	90661	3.6%
	Bus	215693	8.7%
	Mini Bus	22914	0.9%
	Chartered Bus	7223	0.3%
	School Bus	28643	1.2%
	Train	9963	0.4%
	Metro	66003	2.7%
	Cycle	7223	0.3%
	Cycle Rickshaw	3487	0.1%
Walk Trips		316565	12.7%
Total Trips		2490676	100%
PCTR Including Walk		1.48	
Total Motorised Trips		2163401	
PCTR (Motorised)		1.29	

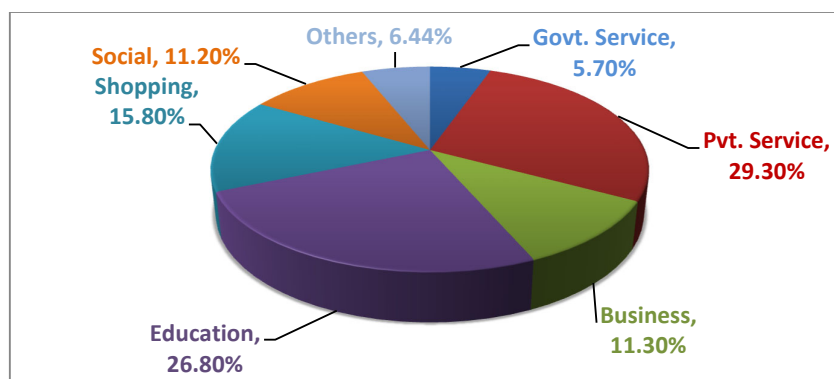
FIGURE 3.11: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)

ii. Trip Purpose

The purpose wise distribution of trips is presented in Table 3.38 and is pictorially represented in **Figure 3.12**. Among the total trips, government and private work trips together account for about 35%, education about 26.80%, business trips for about 11.3%, shopping trips about 15.8% and others account for remaining 6.44%.

TABLE 3.38: DISTRIBUTION OF TRIPS BY PURPOSE

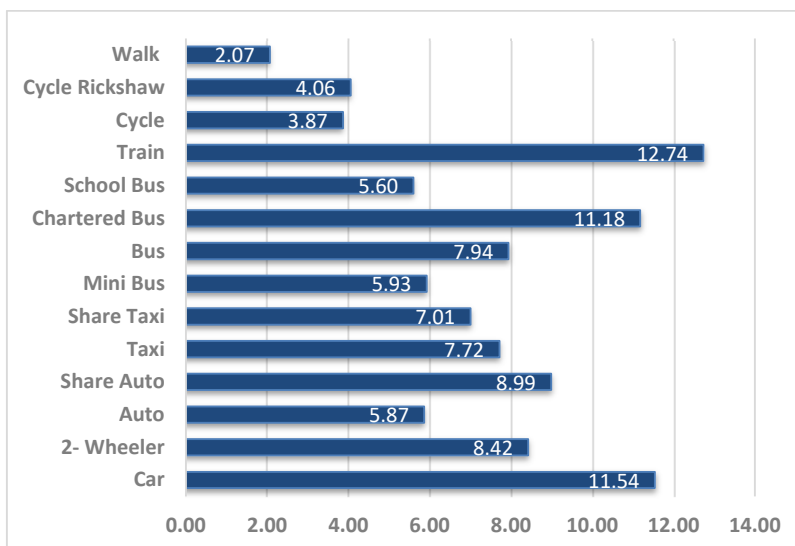
S. No.	Trip Purpose	Percentage %
1	Govt. Service	5.7%
2	Pvt. Service	29.3%
3	Business	11.3%
4	Education	26.8%
5	Shopping	15.8%
6	Social	11.2%
Total		100%

FIGURE 3.12: DISTRIBUTION OF PASSENGER TRIPS BY PURPOSE

iii. Trip Length

Figure 3.13 indicates that an average trip length of 2.07 Km is being covered up by walk. Cars travel an average trip length of 11.54 Km, two wheelers 8.42 Km, Autos 5.87Km, Share Auto 8.99 Km. Bus and Mini Bus cover 7.94 Km and 5.93 Km respectively.

FIGURE 3.13: DISTRIBUTION OF AVERAGE TRIP LENGTH BY MODE



3.3 TRAVEL DEMAND ANALYSIS

3.3.1 Approach for Demand Modeling

The travel demand assessment in urban environment is a complex exercise involving a large number of parameters and warrants the development of a transport model at the City level.

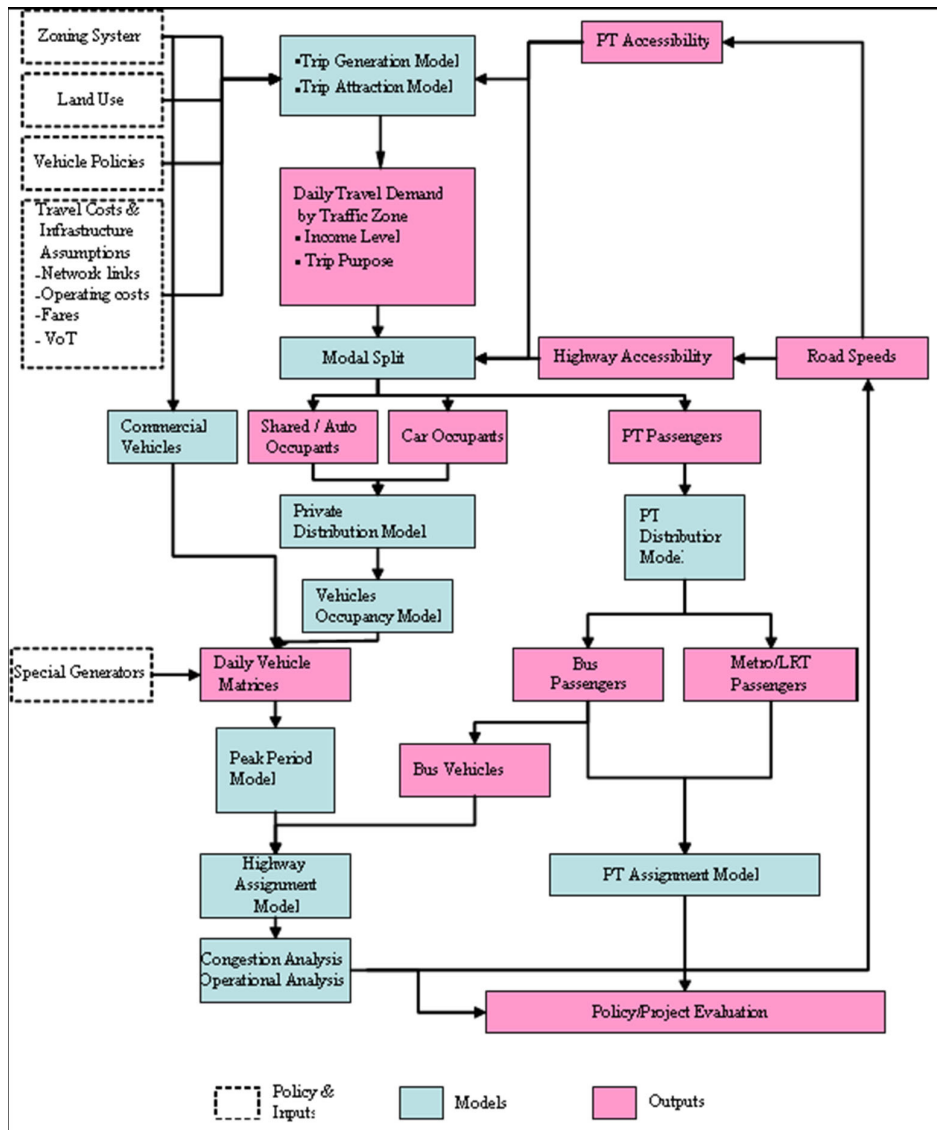
Detailed traffic and travel studies have been carried out as part of the assignment to establish the existing and future transport demand in the study area. An operational travel demand model is required to enable estimation of future travel demand that will help towards identifying transport requirements for the study area. The said model is also a pre-requisite to the fact that the consultants are able to validate the actual travel patterns (as observed) within an acceptable error range ($\pm 15\%$).

The standard 4 stage Urban Transport Planning System model has been adopted that inter-alia consists of:

- Trip Generation and Attraction Sub Model
- Trip Distribution Sub Model
- Modal Split Sub Model
- Assignment Sub Model

The sequence of activities involved in the model is depicted in **Figure 3.14**.

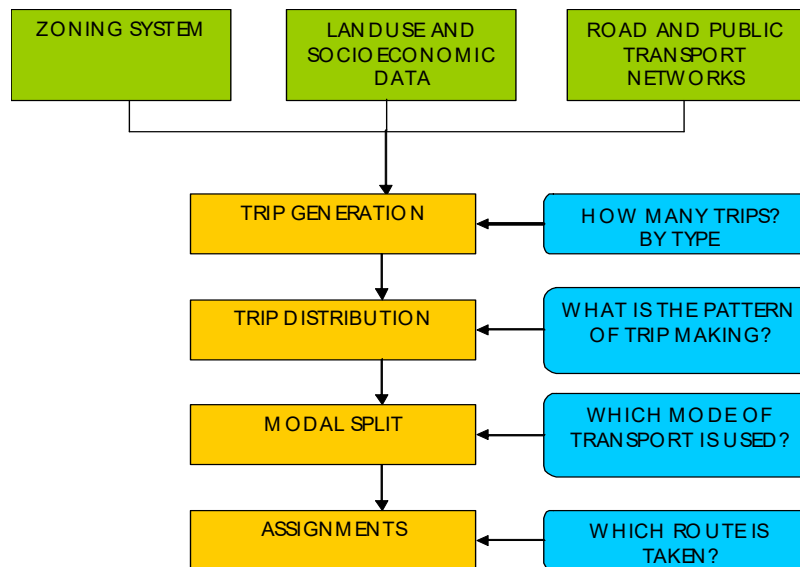
FIGURE 3.14: FOUR STAGE TRAVEL DEMAND MODEL



3.3.2 Model Structure

The model (**Figure 3.15**) is based on motorized trip productions / attractions and internal trips of Gurugram residents. The various modes of travel (i.e. Car, Two wheelers, Auto-rickshaw (including Taxi) and Public Transport) including Shared Auto, Bus & Mini bus) comprise about 23.58 Lakh daily trips. The remaining 3.56 Lakh daily trips are those relating to non-mechanized trips (walk, cycle and cycle rickshaw).

Four sub models are developed viz. Generation, Attraction, Distribution, Modal choice and Assignment models.

FIGURE 3.15: FOUR STAGE MODEL STRUCTURE

- The different sub-models i.e. generation, attraction, distribution, modal choice and assignment models have the following characteristics:
 - Generation and attraction models calculate trips generated and attracted by each zone, by purpose and mode;
 - Distribution models distribute trips generated into the possible destinations and provide all modes matrices;
 - Modal choice models split total travel demand matrices by mode;
 - Assignment models represent the last stage of the model, build paths, assign origin / destination (OD) matrices, and finally provide loaded networks for average hour and global AM peak hour. A standard average hour factor of 7% is applied to the daily OD matrices for hourly highway and public transport (PT) assignment.
- The model considers four modes i.e. Car, Two Wheelers (2W), Auto (including Taxi and Public Transport (Buses, Rapid Metro and Metro).
- The model considers four purposes i.e. Home Based Work (HBW), Home Based Education (HBE), Home Based Business (HBB) and Home Based Other (HBO).
- The model area covers the Gurgaon Manesar Urban Complex (GMUC). The adjoining areas are being treated as external zones. The model zoning system contains 149 zones, 145 internal zones (GMUC) and 4 external zones. The model development is largely based on the Households Interview after expansion from sample to total population. This is calculated at a zonal level.

The model development is largely based on the Households Interview Survey (HIS) and other traffic surveys after expansion from survey sample to total population. This is

calculated at a zonal level. The next step was to build the base year Road matrices necessary to obtain costs for the model development (distribution and modal choice).

The base year HIS person matrices converted to vehicles using occupancy factors, trip matrices, external zones matrices from road side interview at Outer Cordon locations and special generators (bus and railway station) matrices to get total traffic across the study area.

3.3.3 Generation and Attraction Models

The development and calibration of generation, and attraction models, as estimated based on 2018 Households Interview Survey database are as follows:

- Generation model calculates daily person trips generated by purpose (Home Base Work, Home Based Education, Home Based Business, and Home Based Other), and households group (segmentation by size);
- Attraction model produces daily person trip attracted by purpose.

3.3.3.1 Generation Model

A model estimating the distribution of households (HH) by household's size (1, 2, 3, 4, 5, and 6+ members) was developed. In the model application, the distribution is calculated for each individual zone based on each zone average households size.

Lines trends look sensible. The proportion of households with one, two, or three persons decrease when the average household size increases, and on the opposite side, the percentage of households with 5 or 6+ members increase.

As illustrated in **Table 3.39**, model distribution is very close to the HIS one: household proportion with only 1 member 1.2%, 2 members 12%, 3 members 38.9%, 4 members 29.9%, 5 members 12.3%, and 6+ members 5.8%.

TABLE 3.39 GENERATION MODEL CALIBRATION RESULTS (HOUSEHOLD'S SIZE DISTRIBUTION)

HH Size	HH1	HH2	HH3	HH4	HH5	HH6+	Total
HIS	2244	18832	87591	148656	81740	61626	400688
Model	2285	18722	87757	148814	81583	61739	400900
HIS	0.56%	4.70%	21.86%	37.10%	20.40%	15.38%	100.00%
Model	0.57%	4.67%	21.89%	37.12%	20.35%	15.40%	100.00%
Difference	0.01%	-0.03%	0.03%	0.02%	-0.05%	0.02%	

Households size models predict the number of households per size. Based on this segmentation (6 HH sizes), daily person trip rates were extracted by purpose and are presented in **Table 3.40** (6 groups x 4 trip purposes = 24 trip rates). Figures show a trip rate increase with household size increase for work trips. The generation is home based and therefore based on Productions / Attractions (PA), not Origins / Destinations. At the end of the generation models application, the segmentation by household size disappears since trips are aggregated by purpose i.e. 4 groups.

TABLE 3.40 ZONE WISE DISTRIBUTION OF HOUSEHOLD SIZE

HH Size / Purpose	HBW	HBE	HBB	HBO
1	1.75	0.51	0.00	0.89
2	1.80	0.63	0.37	1.26
3	1.71	0.56	0.69	1.03
4	1.66	0.47	1.63	1.07
5	1.95	0.57	2.01	1.25
6+	2.28	0.74	1.43	1.19

Note: external, walk, cycle, cycle rickshaw trips not included

Table 3.41 shows the numbers of daily person trips by purpose in the HIS database.

TABLE 3.41 HIS DATABASE DAILY PERSON TRIPS BY PURPOSE

Purpose	Total
HBW	830592
HBB	254909
HBE	579840
HBO	498060
Total	2163401

3.3.3.2 Attraction Model

The Generation model produces daily person trips generated by zone, whilst the attraction model estimates daily person trips attracted by zone (by purpose). For each of the four groups, a linear regression was estimated, explaining the number of trips attracted by the socio-economic data, total employment for HBW, HBB, population for HBO, and student enrolment for HBE. **Figure 3.16** presents for instance the linear regression of HBW - no vehicle available group: with a R-square value equal to 0.85, it shows a good match between the data from HIS and the estimated values from the linear regression (more R² is near to 1, more the linear regression is reliable). To be consistent with the generation model, the attraction model is based on PA. The Attraction model calibration is summarised in **Table 3.42**, by purpose: HIS and model figures are very similar, showing a very close correspondence between modelled and observed.

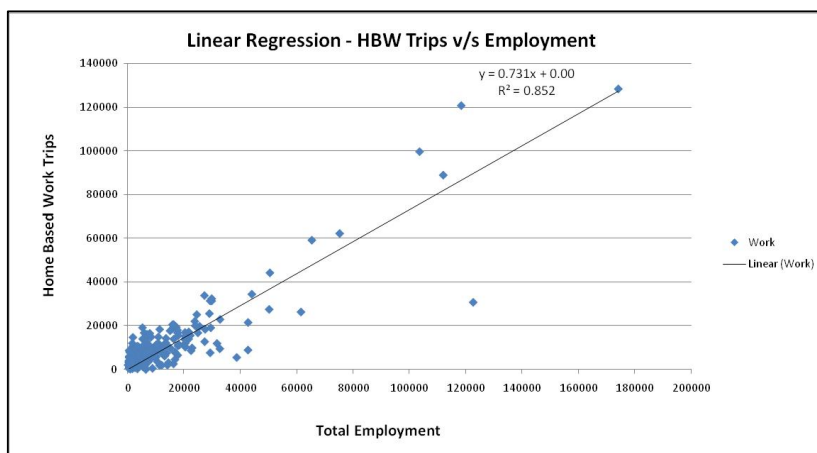
FIGURE 3.16 ATTRACTION MODEL (HBW LINEAR REGRESSION)

TABLE 3.42 ATTRACTION MODEL CALIBRATION RESULTS

Group	HIS	Model	Difference
HBW	830592	830588	0.0004%
HBB	254909	254902	0.0029%
HBE	579840	579831	0.0016%
HBO	498060	498054	0.0013%
TOTAL	2163401	2163374	0.006%

3.3.4 Distribution Models

The models were developed based on the HIS database and the Generalized Costs (GC) produced from the highway and Public Transport cost models implemented in Cube Voyager. The main features of the models are as follows:

- **4 segments:** 4 purposes (Home Base Work, Home Based Education, Home Based Business, and Home Based Other);
- **Unit:** Person (Productions / Attractions – PA);
- **Period:** Daily;
- **Model formulation:** gravity model, based on composite GC presents in **Figure 3.17**.

FIGURE 3.17 GRAVITY MODEL FORMULATION

$T_{ij} = a_i b_j P_i A_j F(C_{ij})$ Where T_{ij} = trips estimated from zone i to zone j P_i = productions from zone i A_j = attractions to zone j a_i, b_j = row/column balancing factors $F(C_{ij})$ = cost deterrence from zone i to zone j	$F(C_{ij}) = C_{ij}^{X_1} \exp(X_2 C_{ij})$ Where $F(C_{ij})$ = cost deterrence for zone i to zone j C_{ij} = generalised cost for zone i to zone j X_1, X_2 = coefficients to be calibrated.
--	--

The composite GC is the average of the GC for individual modes weighted by modal split proportions (produced by modal split models) by origin / destination movements.

For individual modes, the GC represents perceived costs, where the unit is minute equivalent, implying the use of values of time (VOT, 2015 prices, Rupees / hour) by mode to convert monetary costs (fare, vehicle operating cost - VOC) into minutes. Occupancy factors (OCC) are also used for car, 2w, and auto to obtain person based GC. The GC by mode is described below:

- **Car GC** = Time + [(VOC) / OCC] / VOT x 60;
- **2W GC** = Time + [(VOC) / OCC] / VOT x 60;
- **Auto GC** = Time + 1.5 x Wait Time + [(Fare / OCC) / VOT] x 60;
- **PT GC** = IVT + 1.5 x Walk Time + 2 x Wait Time + (Fare / VOT) x 60 + Transfer Time;

Table 3.43 summarises the model values of VOT, VOC, and OCC for use in the base year model calibration;

TABLE 3.43 BASE YEAR VALUES OF TIME, VEHICLE OPERATING COSTS AND VEHICLE OCCUPANCY RATES

Mode	VOT (Rs/hour)	VOC (Rs/km)	OCC
Car	100	9.0	2.1
2W	50	4.0	1.1
Auto	50	5.0	2.5
PT	50	-	-

3.3.4.1 Calibration Results

This section provides the distribution models calibration results by market segment: X1 and X2 parameters, intra-zonal trips, average GC (in minutes), and trip GC distribution. As illustrated by **Table 3.44**, the overall models results are similar to the HIS database.

TABLE 3.44 DISTRIBUTION MODELS CALIBRATION RESULTS

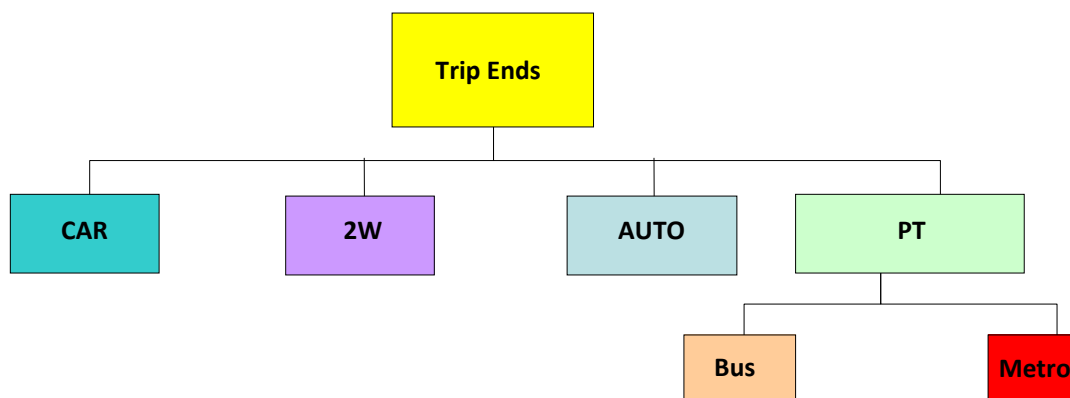
Segments	Trips	HIS		Model	Difference
		X1	X2	Trips	Trips
HBW	830592	-0.235	-0.008	830589	0.0003%
HBB	254909	-0.513	-0.004	254903	0.0025%
HBE	579840	-0.214	-0.006	579837	0.0005%
HBO	498060	-0.282	-0.006	498057	0.0007%

3.3.5 Modal Split Model

The models were developed based on the HIS database and the Generalized Costs (GC) produced from the highway and Public Transport cost models implemented in Cube Voyager.

Figure 3.18 illustrates the modal split models structure: trips are split into the four modes (Car, 2W, Auto and PT). It should be noted that the PT matrix produced by the modal split models contains trips using school and public buses, but only the public bus category is retained for the PT assignment, the other two groups (school) not using the public network. However, these are taken into account in the highway assignment.

FIGURE 3.18 MODAL SPLIT MODELS STRUCTURE



The main features of the modal split model are as follows:

- **4 modes:** Car, two wheelers, auto (including taxi), and PT;
- **Unit:** Person (productions / attractions – PA);
- **Period:** Daily;
- **Model formulation:** Combined Split, Multi-Logit Formulas (equations provided in **Figure 3.19**, where P means Probability and C is the Generalized Cost);
- **Logit Parameters Estimation:** The mode choice sensitivity revealed by the model is mainly determined by the parameter λ . This model parameter was developed based on statistical regression analysis, which also provided some initial estimates on the mode biases between private and public modes of travel. As shown below, for illustrative purpose only (example with Private versus Public Travel modes), when λ increases, the model becomes more responsive to the difference in cost.

FIGURE 3.19 : MULTI-LOGIT FORMULAS (COMBINED SPLIT)

$$P_{Car} = \frac{e^{(-\lambda C_{Car})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto+taxi})} + e^{(-\lambda C_{PT})}}$$

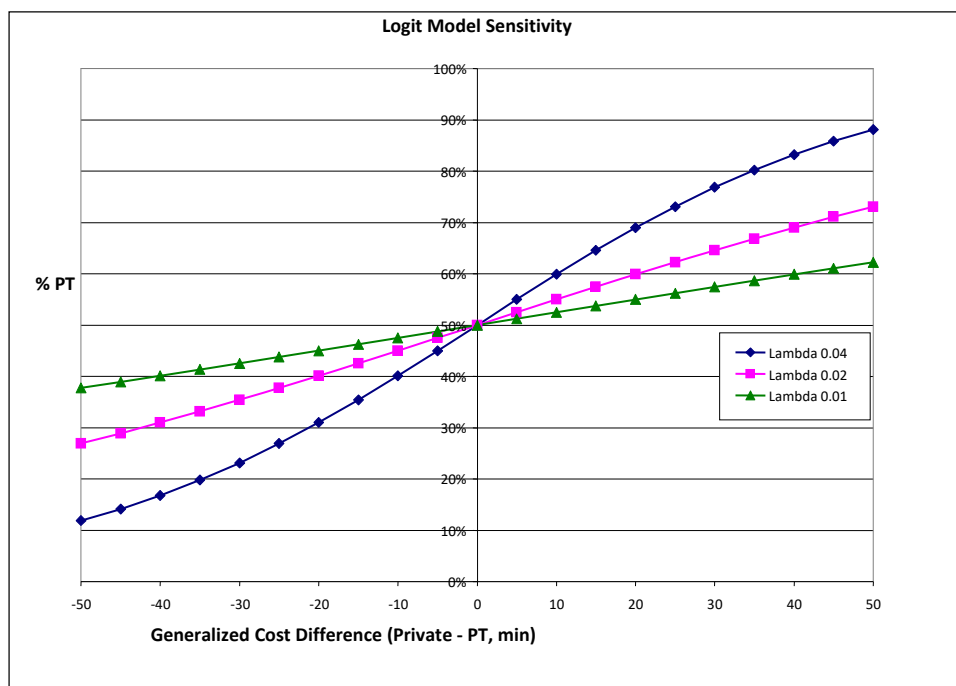
$$P_{2W} = \frac{e^{(-\lambda C_{2W})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto+taxi})} + e^{(-\lambda C_{PT})}}$$

$$P_{Auto+taxi} = \frac{e^{(-\lambda C_{Auto})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto+taxi})} + e^{(-\lambda C_{PT})}}$$

$$P_{PT} = \frac{e^{(-\lambda C_{PT})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto+taxi})} + e^{(-\lambda C_{PT})}}$$

Logit parameters estimation: the mode choice sensitivity revealed by the model is mainly determined by the parameter λ . This model parameter was developed based on statistical regression analysis, which also provided some initial estimates on the mode biases. As shown by **Figure 3.20** for illustrative purpose only (example with two modes, car and PT), when λ increases, the model becomes more responsive to the difference in cost.

FIGURE 3.20 LOGIT MODEL SENSITIVITY



The GC represents perceived costs, where the unit is minute equivalent, implying the use of Values of Time (VOT, Rupees / hour) by mode to convert monetary costs (fare, Vehicle Operating Cost - VOC, parking cost at destination, and toll) into minutes. Occupancy factors (OCC) are also used for Car, 2W, and Auto (including Taxi) to obtain person based GC. Below are described the GC by mode, IVT means In Vehicle Time:

- **Car GC** = Time + $[(VOC + Toll + Parking Cost) / OCC] / VOT \times 60$;
- **2W GC** = Time + $[(VOC + Toll + Parking Cost) / OCC] / VOT \times 60$;
- **Auto GC** = Time + 1.5 x Wait Time (4) + $[(Fare / OCC) / VOT] \times 60$;
- **PT GC** = IVT + 1.5 x Walk Time + 2 x Wait Time + (Fare / VOT) x 60 + Transfer Time (Penalty of 5', apart for transfer from / to metro: 0.5').

3.3.5.1 Calibration Results

Table 3.45 and Table 3.46 demonstrate that there is close correspondence between the synthesized and observed values from the HIS. Some specific comments can be made:

- In theory, for any multi-logit model with four possible choices, there are a maximum of three bias factors available;

- The Lambda parameters trends are sensible, lower for car and higher for Bus, meaning less sensitivity to cost for car

TABLE 3.45 CALIBRATED MODAL CHOICE MODELS PARAMETERS

Segments	Lambda	Bias Car	Bias 2-wheeler	Bias Auto
HBW	0.004225	-12.354505	-1.3001	-2.426823
HBB	0.00891	-1.60001	-1.08095	-2.823493
HBE	0.0649	-7.530998	-4.496026	-5.052795
HBO	0.09234	-7.54139	-1.7553	-3.272361

TABLE 3.46 MODAL SPLIT MODELS CALIBRATION RESULTS

Modes	HIS	Model	Difference
Car	205850	208918	-1.49%
2W	941441	938617	0.30%
Auto	581310	576311	0.86%
PT	434800	435843	-0.24%

3.3.5.2 Model Split Validation

This section describes the model validation results, which is the last step in the model development. Model validation is done for daily Model. All the models built are linked together through the output files and therefore the model validation only uses synthetic data, all produced by the model itself.

The model validation has no impact on the generation and attraction model results, therefore they are the same as the ones presented earlier.

The model validation actually consists of slight adjustment of the model calibration data to match the observed figures. The calibration adjustments will remain as part of the model for future years and scenario application. It should also be noted that the model validation results come from iterative run of the model in order to ensure the convergence of the results and the consistency with the model runs for future years.

TABLE 3.47 MODAL SPLIT MODELS VALIDATION RESULTS

Modes	HIS	Model	Difference
Car	9.5%	9.7%	-0.2%
2W	43.5%	43.5%	0.1%
Auto	26.9%	26.7%	0.2%
PT	20.1%	20.2%	-0.1%

3.3.6 Trip Assignment Models

The trip assignment procedure determines the route choice of trip maker to whole or a part of a network and is the last part of travel demand modeling process where the inter-zonal modal trips are assigned to the various links of the network. There are at least four factors that lead people to choose one route over another. They are travel time,

generalized travel cost, Travel distance and level of service. Taking a single parameter to determine the shortest path between each zone pair assumes that there is only one preferred path between each origin and destination.

The Road assignment is a multiple user class assignment using equilibrium algorithm and capacity constraint. In this method of assignment, trip matrices are loaded onto the network, using an incremental assignment method. The trip matrices are assigned to the shortest paths generated successively after assignment of small lots each of 15-20% increment of the trips matrices. The incremental assignment proceeds by updating the transport networks using the speed flow relationships of the links. The assignment is largely controlled by alternative paths, which are built by the shortest path algorithm through the network. The output of the assignment is a loaded Road network with volumes (PCU unit) by link and vehicle type, and network speeds.

For the public transport assignment, the person trips unit is retained. The public transport network is developed from the Road network following the Road assignment, a process which produces a loaded road network representing congested travel times on the road network.

The public transport assignment considers multiple routes at an origin / destination level, and includes the modeling of fares for different modes. The selection of public transport route choice is based on the travel costs, including walk access time to bus or metro stops, wait time, in vehicle time and fare, transfer or interchange walk times and subsequent wait times, and the time to reach the final destination. The output of the assignment is a loaded public transport network with patronage by service.

The 4-stage model produces daily matrices therefore a standard average hour factor of 7% is applied to the matrices for both the daily private and public transport assignments. Peak hour model assignment is done separately to exhibit the constrained level of services during the peak hour.

3.4 FUTURE TRAVEL DEMAND SCENARIOS

3.4.1 Forecast of Planning Parameters

3.4.1.1 Future Growth Scenario

One of the important aspects of traffic demand modelling exercise is the estimation of base and horizon year land-use parameters. Base year land-use parameters like population, employment and student enrolment have been assessed based on the existing information available on the sector wise residential units, employment and educational centers within the Study Area.

Land use parameters for various horizon years have been estimated as per the proposed landuse distribution in the Development Plan for GMUC (2031). Development Plan for GMUC (2031) gives the likely growth to take place within the various areas of study area. The development plan also gives locations of various land uses such as residential,

commercial, industrial uses etc. Traffic zone wise distribution of population, employment and student enrolment in 2021, 2031 and 2041 are given in this section.

The proposed growth of population and economy is expected to generate high travel demand. An integrated landuse transportation model has been built to enable estimation of future travel demand. As per travel demand modeling exercise, daily intra travel demand is expected to grow from 21.63 Lakh vehicular person trips in year 2019 to 54.82 Lakh in the year 2031 and 65.47 Lakh in the year 2041.

3.4.1.2 Population and Employment Forecast

Population has been forecasted separately for Core, Middle, Outer and special areas collectively forming the study area in addition to existing growth pattern from Census Data. The study area population in the base year 2019 is 16.83 Lakh. The study area is estimated to have population of about 42.5 Lakh in 2031 and 50.75 Lakh by 2041. Similarly, student enrolment is expected to grow from 3.68 Lakh in 2019 to 9.3 Lakh in 2031 and 11.1 Lakh in 2041.

Total employment of study area has been estimated on the basis of total population and work force participation rate (WFPR) and considered GMUC development plan 2031 prepared by Department of Town and Country Planning, Haryana. The base year zone wise distribution of employment has been worked out on the preliminary reconnaissance survey of landuse and details given in landuse plans.

The horizon year employment has been distributed in various traffic zones based on the land-use given in GMUC development plan 2031 & detailed discussions with planning officials of GMDA. The employment in this area, which is 6.25 Lakh in 2019, is expected to grow to about 17 Lakh in 2031 and 20.86 Lakh in 2041. The zone wise forecasted population and employment for horizon years is presented in **Table 3.49**.

TABLE 3.48: FORECASTED POPULATION AND EMPLOYMENT IN THE STUDY AREA FOR HORIZON YEARS

Year	Population	Employment	WFPR (%)
2019	16,82,889	6,25,445	37.2%
2021	18,73,097	6,97,842	37.3%
2031	42,50,000	16,99,525	40.0%
2041	50,75,000	20,86,451	41.1%

TABLE 3.49: ZONEWISE FORECASTED POPULATION AND EMPLOYMENT FOR HORIZON YEARS

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
1	7449	4105	47395	6911	47395	6911
2	11632	6157	48754	9224	48754	9224
3	34491	3592	50665	4974	50665	4974
4	17981	4105	42366	6082	42366	6082
5	34800	3079	40000	3805	40000	3805
6	39445	3079	44795	3790	44795	3790
7	59581	3592	66362	4383	66362	4383
8	30142	6671	34000	8091	34000	8091
9	74054	3079	85842	3946	85842	3946
10	79662	5131	113889	11953	113889	12953
11	74510	7184	84075	12994	84075	13994
12	46551	4618	55000	10261	55000	11261
13	22362	4618	25324	10103	25324	11103
14	20468	14367	39792	21616	39792	22616
15	27046	9236	46544	11981	46544	11981
16	8206	3079	10000	6425	10000	7425
17	15674	5131	33945	9463	33945	10463
18	31406	15394	35000	19902	35000	20902
19	8952	3079	16000	6403	16000	7403
20	23828	10262	28000	14343	28000	15343
21	30177	12315	34000	14894	34000	14894
22	25986	12315	55123	16180	55123	16180
23	28360	3079	58000	9720	88000	13220
24	50261	7184	66299	9222	66299	9222
25	10416	4105	20141	5386	20141	5386
26	10901	3592	30000	5233	50000	6233
27	17059	4105	40324	6031	40324	6031
28	32109	2566	42755	3471	42755	3471
29	381	18472	500	50252	500	60252
30	9027	6157	12189	16864	12189	19864
31	4189	3079	26562	4811	26562	4811
32	26009	6157	30000	14824	30000	17824
33	27510	5644	31545	16256	31545	19256
34	2593	9236	10000	20482	10000	23482
35	8152	10262	10000	21302	10000	24302
36	32627	1026	43568	51515	43568	71515
37	29423	3079	55859	304555	145861	409055
38	14699	8210	22768	14332	22768	17332
39	4259	7184	32861	10071	32861	10071
40	2844	2566	19463	3911	19463	3911
41	12997	2566	29319	3847	29319	3847
42	3120	10262	69204	17538	69204	19538
43	13072	13341	72060	18972	72060	18972
44	912	12315	1000	16498	1000	18498

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
45	17140	5644	38934	7813	38934	7813
46	13400	3592	39833	5588	39833	5588
47	12297	4105	49934	11322	49934	14322
48	6943	5131	62439	8928	62439	8928
49	14091	6157	59773	9640	59773	9640
50	7594	5644	60975	9438	60975	9438
51	9806	6157	38402	8807	38402	8807
52	35085	5131	76769	8102	76769	8102
53	7740	4618	56577	7973	56577	7973
54	5881	3079	69108	6845	69108	6845
55	8579	3592	20642	4893	20642	4893
56	19678	3592	45655	8141	45655	10141
57	12700	4618	90274	9386	90274	9386
58	14298	2052	49314	4157	49314	4157
59	4242	6157	16667	8025	23810	8382
60	3415	1026	7091	1405	10129	1557
61	6401	1026	28736	2323	41051	2939
62	9257	1539	32541	7807	46487	11504
63	5927	1539	33440	8034	47771	11751
64	912	1026	1000	6125	1000	9125
65	9384	2052	34129	8442	48755	12173
66	18233	2052	30042	7753	42918	11396
67	5131	2052	31420	8790	47029	12570
68	6294	1539	47599	7722	69428	11314
69	8203	5131	32315	9041	48307	11340
70	13576	4105	53216	7366	70308	8721
71	8295	3079	24609	9150	35155	15678
72	1363	1026	5044	1302	7206	1410
73	5541	1026	19305	6786	27578	10200
74	912	1026	1000	21125	1000	31125
75	912	513	1000	20562	1000	30562
76	6967	3079	26081	8297	37258	11856
77	4898	1026	16165	5665	23093	9011
78	10099	1026	32447	6194	46352	9889
79	3504	513	50773	2909	72533	3997
80	4823	513	20452	1321	29218	1759
81	3688	3592	40986	11784	58551	15662
82	9670	513	34345	7750	49065	11486
83	8749	3079	28555	10323	40793	13935
84	6218	513	21172	7280	30246	10734
85	4081	513	29163	1797	41661	2422
86	6595	513	39896	2196	56995	3051
87	912	513	1000	5562	1000	11562
88	385	513	57112	18397	81589	29621
89	10222	513	66082	8306	94402	12722

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
90	4867	513	23666	1479	33809	1986
91	5878	513	16271	1054	23245	1403
92	10415	513	47657	2374	68082	3396
93	6976	513	8000	580	10000	680
94	91	513	1000	607	1000	607
95	6248	3592	7000	3945	10000	4095
96	91	513	100	3562	100	5562
97	91	513	100	3562	100	5562
98	91	513	100	3562	100	5562
99	91	513	31268	5121	44669	7791
100	91	513	100	3562	100	5562
101	91	513	100	3562	100	5562
102	3142	513	42286	2505	60409	3411
103	7271	1026	60896	6771	89553	10204
104	16876	1026	57899	3095	85145	4457
105	22917	1026	26705	1204	33381	1538
106	11207	1026	31643	5093	46533	7837
107	9441	3079	19619	6838	28851	9300
108	12426	2052	25563	2847	37592	3448
109	17231	4105	28412	7976	41782	10644
110	17532	4618	48482	6525	71297	7666
111	11038	1539	23826	2274	35038	2834
112	11876	1539	18571	6965	26530	10363
113	10748	513	13251	5636	18931	8920
114	912	103	1000	10112	1000	15112
115	912	103	1000	5112	1000	8112
116	10745	3079	14447	3846	20639	4155
117	10499	1539	16649	2113	23784	2470
118	19869	1539	30269	3112	43242	4260
119	4318	513	7801	5716	11144	8883
120	10234	4105	12951	5036	18501	5314
121	2157	15394	3500	23930	5000	27005
122	1869	5644	3500	13259	5000	16334
123	2276	25656	3500	30172	5000	31247
124	2153	5131	3500	12681	5000	15756
125	2748	15394	3500	23897	5000	26972
126	91	513	1000	8607	1000	12607
127	91	513	1000	5607	1000	8607
128	6678	513	8000	10596	10000	15696
129	54080	5131	65499	6498	81874	7317
130	91	91	100	100	100	100
131	3490	91	5480	100	7829	100
132	3402	91	7507	100	10724	100
133	10951	6157	13530	11826	19329	15115
134	1902	91	2135	100	3050	100

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
135	17755	5131	20597	6244	20597	6244
136	7916	56443	8714	71869	12448	77056
137	3925	66705	6735	83238	9622	88382
138	2600	5131	4166	11690	5951	14779
139	1258	5131	2579	6684	3684	7240
140	5873	5131	9135	6322	9135	6322
141	7335	1539	9272	2749	9272	3249
142	1617	456	3150	500	3150	500
143	22717	5131	30946	10927	30946	12927
144	9691	15394	12626	21973	12626	23973
145	16847	5131	20404	10721	20404	12721

3.4.2 Assumptions for Transport Demand Forecasting

The following assumptions have been made for transport demand forecasting:

- Calibrated and validated travel demand model has been used
- Land use parameters (population, employment and student enrolment) have been distributed in various traffic zones for 2026, 2031 and 2041.
- The fare levels of metro have been considered same as that of the existing Delhi Metro Rail Corporation.
- Inter-city passenger to/from the study area will grow at the growth rate of 3.0%.
- The special generator passenger traffic of Bus terminal and railway station in Gurugram is expected to grow at 3% per annum.
- Goods traffic is expected to grow at 2% per annum.

3.4.3 Network Considered for Transport Demand Forecast

The following Metro Network in Gurugram has been considered for the Ridership Assessment:

- HUDA City Centre – Cyber City
- Spur to Dwarka Expressway

In addition, the following Metro Corridors have also been considered:

- RAPID METRO: Sector 56 – Sikanderpur – Cyber City (loop)
- DMICDC: Sohna Bus Stand – Rajiv Chowk – Subhash Chowk – Manesar
- DMRC: Samayapur Badli – Guru Dronacharya – HUDA City Centre

- NCRTC (RRTS): Sarai Kale Khan – Udyog Vihar – Panchgaon

Considering the above assumptions and calibrated/validated traffic demand model, forecasting of transport demand has been carried out for the years 2026, 2031, 2041 & 2051 for the Study Corridor.

3.5 RIDERSHIP ASSESSMENT FOR HORIZON YEARS

3.5.1 Transport Demand Forecast

The trips made between two adjacent stations of proposed mass transit corridors have been worked out for the years 2026, 2031, 2041 and 2051. The maximum peak hour peak direction trips for proposed Metro corridor are given in **Table 3.50**.

TABLE 3.50: MAXIMUM PEAK HOUR SECTION LOADING ON STUDY CORRIDOR

Corridor details	Maximum PHPDT			
	2026	2031	2041	2051
HUDA City Centre – Cyber City and Spur to Dwarka Expressway	19359	27263	34309	43878

3.5.2 Ridership on Metro Corridor for 2026, 2031, 2041 & 2051

Daily Ridership on the study corridor for the years 2026, 2031, 2041 and 2051 is expected to be 5.34 Lakh passenger trips, 7.26 Lakh passenger trips, 8.81 passenger trips and 10.70 Lakh passenger trips respectively. Daily passenger boardings and trips for 2026, 2031, 2041 and 2051 are shown in **Table 3.51**.

TABLE 3.51: DAILY RIDERSHIP FOR THE STUDY CORRIDOR

Corridor Name	Details	Horizon Years			
		2026	2031	2041	2051
HUDA City Centre – Cyber City and Spur to Dwarka Expressway	Daily Boarding	563175	772925	940286	1150076
	Daily Trips	534294	726098	881563	1070315

3.5.3 Peak Hour Section Loads and Station Boarding & Alighting

The daily Station Loads and peak hour Section loads are given in **Table 3.52**, **Table 3.53**, **Table 3.54** and **Table 3.55** respectively.

TABLE 3.52: STATION LOADS ON STUDY CORRIDOR IN 2026

Station Name	HUDA CC - CYBER CITY - SEC 56		SEC 56 - CYBER CITY - HUDA CC		Total	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
HUDA City Centre	75694	0	0	77321	75694	77321
Sector 45	10100	5535	6431	8653	16530	14189
Cyber Park	8812	5072	5101	7468	13913	12539
District Shopping Centre, Sector 47	11532	6508	6025	11126	17556	17634
Subhash Chowk	7950	4716	5049	8445	12999	13161
Sector 48	49749	32036	34348	49381	84097	81417
Sector 72A	2436	4983	5032	2178	7468	7162
Hero Honda Chowk	7112	5098	6451	4802	13563	9900
Udyog Vihar Phase 6	4167	6167	6167	5699	10333	11866
Sector 10	15959	13862	4963	20613	20922	34475
Sector 37	21850	15323	15382	24904	37231	40228
Basai Village	5425	1969	2667	1577	8092	3546
Sector 9	9230	8823	10304	9734	19534	18557
Sector 7	6160	7013	7316	5961	13476	12974
Sector 4	3929	4377	4613	3783	8541	8160
Sector 5	9399	5980	6753	11658	16152	17638
Ashok Vihar	11298	11881	8198	15896	19496	27777
Sector 3	7797	4281	4800	9171	12597	13452
Bajghera Road	10280	6011	6433	9825	16713	15836
Palam Vihar Extension	6870	3844	4131	6973	11001	10817
Palam Vihar	5932	2702	3153	5667	9085	8369
Sector 23A	5332	5104	5234	5473	10566	10576
Sector 22	38546	34883	24963	43326	63509	78209
Udyog Vihar Phase IV	6995	12814	10821	11058	17816	23873
Udyog Vihar Phase V	7104	8804	7577	8379	14681	17183
Cyber City	8608	30548	3000	2000	11608	32548
Moulsari Avenue	34839	35064	3000	2500	37839	37564
Dlf Phase-3	6667	6171	2000	2500	8667	8671
Belvedere Towers	2500	2000	75437	37440	77937	39440
Dlf Phase-2	4395	23158	25091	16968	29486	40126
Sikanderpur	13296	56469	69528	13310	82824	69778
DLf Phase-1	1068	7422	7773	720	8841	8141
Sector 42-43	905	12502	15517	1144	16422	13646
Sector 53-54	533	7490	12486	319	13018	7809
Sector 54 Chowk	34	6656	6872	147	6905	6803
Sector 55-56	0	17235	23502	0	23502	17235
Total	422501	422501	446115	446115	868616	868616

TABLE 3.53: STATION LOADS ON STUDY CORRIDOR IN 2031

Station Name	HUDA CC - CYBER CITY - SEC 56		SEC 56 - CYBER CITY - HUDA CC		Total	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
HUDA City Centre	100114	0	0	106689	100114	106689
Sector 45	11845	7243	8199	10290	20044	17533
Cyber Park	11891	6988	7098	10439	18989	17427
District Shopping Centre, Sector 47	16962	9244	8604	17806	25566	27050
Subhash Chowk	11051	6869	7564	15108	18615	21977
Sector 48	67381	41086	51592	57877	118973	98963
Sector 72A	4047	7283	7367	2577	11414	9859
Hero Honda Chowk	8372	6677	9154	4965	17526	11642
Udyog Vihar Phase 6	5385	8385	8385	16160	13769	24545
Sector 10	19747	17181	6955	33489	26702	50670
Sector 37	45741	26837	26855	42361	72596	69198
Basai Village	6768	3574	3808	2403	10576	5977
Sector 9	9422	9989	11407	10565	20830	20554
Sector 7	6915	9091	8031	6593	14946	15685
Sector 4	4614	6484	6832	4489	11446	10973
Sector 5	10855	6389	6824	12227	17679	18616
Ashok Vihar	18495	19082	10792	19289	29287	38371
Sector 3	8695	5032	5564	10042	14259	15074
Bajghera Road	12475	9223	9233	13088	21708	22312
Palam Vihar Extension	9641	6433	6731	9865	16372	16297
Palam Vihar	9028	5687	6496	8901	15524	14588
Sector 23A	6872	7194	7425	7018	14297	14211
Sector 22	53770	44108	33706	58685	87476	102793
Udyog Vihar Phase IV	7668	14821	12661	11908	20329	26729
Udyog Vihar Phase V	8806	10878	9891	10169	18697	21047
Cyber City	10689	32410	4500	3000	15189	35410
Moulsari Avenue	37226	37962	4500	3750	41726	41712
Dlf Phase-3	9135	8389	3000	3750	12135	12139
Belvedere Towers	3750	3000	81737	39777	85487	42777
Dlf Phase-2	6011	22873	30190	18553	36201	41426
Sikanderpur	17923	73791	87375	18141	105298	91932
DLf Phase-1	1346	11286	12073	1085	13419	12370
Sector 42-43	1536	19833	21316	2732	22852	22565
Sector 53-54	1462	13682	24093	735	25554	14417
Sector 54 Chowk	48	8609	8753	278	8801	8888
Sector 55-56	0	38073	36093	0	36093	38073
Total	565687	565687	594805	594805	1160492	1160492

TABLE 3.54: STATION LOADS ON STUDY CORRIDOR IN 2041

Station Name	HUDA CC - CYBER CITY - SEC 56		SEC 56 - CYBER CITY - HUDA CC		Total	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
HUDA City Centre	126420	0	0	132009	126420	132009
Sector 45	13515	9212	10101	11653	23616	20866
Cyber Park	12766	8744	8868	10786	21634	19530
District Shopping Centre, Sector 47	18364	10878	10841	18641	29205	29519
Subhash Chowk	13585	8450	9853	16601	23438	25051
Sector 48	79768	49214	61507	67762	141275	116977
Sector 72A	5874	10427	10539	3380	16413	13807
Hero Honda Chowk	9982	7880	11308	5287	21290	13166
Udyog Vihar Phase 6	7692	11692	11692	21065	19385	32758
Sector 10	24163	22047	8449	42597	32611	64644
Sector 37	50032	32388	32219	44317	82252	76705
Basai Village	9408	5566	5846	3014	15254	8580
Sector 9	12058	11301	12209	12340	24267	23641
Sector 7	9517	11111	10223	9013	19740	20123
Sector 4	5517	7375	7751	5324	13268	12698
Sector 5	12324	7133	7355	14014	19678	21147
Ashok Vihar	23389	25477	13132	24031	36521	49508
Sector 3	10105	5043	5671	11414	15776	16457
Bajghera Road	16182	13188	12912	16727	29093	29915
Palam Vihar Extension	11025	6618	6849	13045	17874	19662
Palam Vihar	10383	5850	6707	11967	17090	17817
Sector 23A	8874	10163	10535	9032	19408	19195
Sector 22	69410	54025	40203	74664	109613	128688
Udyog Vihar Phase IV	8972	17903	15088	13838	24060	31741
Udyog Vihar Phase V	10225	13336	12480	11741	22705	25077
Cyber City	12399	39432	6000	4000	18399	43432
Moulsari Avenue	42688	45530	6000	5000	48688	50530
Dlf Phase-3	12692	11696	4000	5000	16692	16696
Belvedere Towers	5000	4000	95221	41806	100221	45806
Dlf Phase-2	7449	25085	31155	20844	38603	45929
Sikanderpur	21018	95842	108335	22023	129353	117866
DLf Phase-1	2630	14628	15661	1228	18291	15856
Sector 42-43	1888	21186	24729	2906	26617	24092
Sector 53-54	1653	14716	25588	1033	27240	15748
Sector 54 Chowk	195	10060	10256	318	10451	10378
Sector 55-56	0	39964	39136	0	39136	39964
Total	687162	687162	708418	708418	1395580	1395580

TABLE 3.55: STATION LOADS ON STUDY CORRIDOR IN 2051

Station Name	HUDA CC - CYBER CITY - SEC 56		SEC 56 - CYBER CITY - HUDA CC		Total	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
HUDA City Centre	159639	0	0	163338	159639	163338
Sector 45	15421	11717	12444	13198	27865	24914
Cyber Park	13706	10942	11078	11145	24784	22087
District Shopping Centre, Sector 47	19882	12802	13659	19515	33541	32317
Subhash Chowk	16699	10396	12836	18241	29535	28637
Sector 48	94433	58951	73327	79336	167760	138286
Sector 72A	8527	14930	15075	4433	23602	19363
Hero Honda Chowk	11902	9299	13969	5628	25871	14927
Udyog Vihar Phase 6	10989	16305	16305	27459	27294	43764
Sector 10	29566	28291	10262	54183	39828	82474
Sector 37	54726	39087	38656	46363	93381	85450
Basai Village	13077	8669	8976	3779	22053	12448
Sector 9	15432	12786	13066	14414	28498	27200
Sector 7	13097	13578	13014	12320	26111	25899
Sector 4	6597	8387	8793	6314	15390	14701
Sector 5	13991	7964	7927	16063	21918	24027
Ashok Vihar	29578	34015	15979	29938	45557	63954
Sector 3	11742	5054	5780	12973	17523	18027
Bajghera Road	20989	18858	18056	21377	39045	40235
Palam Vihar Extension	12608	6808	6970	17250	19577	24058
Palam Vihar	11941	6018	6924	16088	18866	22106
Sector 23A	11458	14357	14947	11626	26405	25983
Sector 22	89600	66171	47952	94993	137551	161163
Udyog Vihar Phase IV	10498	21626	17981	16080	28479	37706
Udyog Vihar Phase V	11872	16350	15747	13556	27619	29906
Cyber City	14382	47976	8000	5333	22382	53309
Moulsari Avenue	48951	54606	8000	6667	56951	61272
Dlf Phase-3	17636	16307	5333	6667	22969	22974
Belvedere Towers	6667	5333	110930	43939	117597	49272
Dlf Phase-2	9973	27154	32150	23847	42123	51001
Sikanderpur	24648	124483	134323	26736	158971	151219
DLf Phase-1	5140	18960	20315	1390	25455	20350
Sector 42-43	2321	22632	28689	3090	31010	25722
Sector 53-54	1868	15827	27176	1451	29044	17278
Sector 54 Chowk	788	11754	12016	364	12804	12118
Sector 55-56	0	41950	42436	0	42436	41950
Total	840342	840342	849092	849092	1689434	1689434

TABLE 3.56: SECTION LOADING FOR 2026, 2031, 2041 & 2051

Station Name		2026		2031		2041		2051	
From	To	Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2
HUDA City Centre	Sector 45	8483	8678	11665	12520	16435	17161	23155	23524
Sector 45	Cyber Park	9091	9005	12398	12926	16994	17363	23381	23387
Cyber Park	District Shopping Centre, Sector 47	9600	9349	13170	13496	17517	17612	23492	23149
District Shopping Centre, Sector 47	Subhash Chowk	10263	10021	14309	14827	18490	18626	24202	23666
Subhash Chowk	Sector 48	10711	10489	14988	15942	19158	19503	24781	24104
Sector 48	Sector 72A	12896	12353	18541	16895	23130	20317	29195	24689
Sector 72A	Hero Honda Chowk	12651	12070	18255	16407	22538	19386	28040	22984
Hero Honda Chowk	Udyog Vihar Phase 6	12932	11913	18566	15952	22811	18603	28238	21751
Udyog Vihar Phase 6	Sector 10	12732	11896	18266	17053	22291	19822	27357	23010
Sector 10	Sector 37	13014	13804	18667	20570	22566	24261	27402	28609
Sector 37	Basai Village	13827	14977	21192	22653	24860	25834	29327	29503
Basai Village	Sector 9	14252	14856	21629	22493	25359	25465	29824	28749
Sector 9	Sector 7	14307	14794	21569	22397	25458	25483	30161	28914
Sector 7	Sector 4	14210	14637	21300	22224	25250	25325	30091	28809
Sector 4	Sector 5	14163	14544	21070	21933	25009	25010	29844	28473
Sector 5	Ashok Vihar	14529	15088	21552	22536	25684	25875	30765	29669
Ashok Vihar	Sector 3	14415	15968	21377	23542	25412	27292	30353	31644
Sector 3	Bajghera Road	14793	16449	21754	24025	26070	28039	31369	32717
Bajghera Road	Palam Vihar Extension	15261	16812	22078	24427	26459	28535	31824	33321
Palam Vihar Extension	Palam Vihar	15580	17109	22396	24735	27032	29340	32718	34845
Palam Vihar	Sector 23A	15924	17366	22731	24949	27622	30024	33631	36232
Sector 23A	Sector 22	15907	17351	22590	24797	27454	29829	33440	35984
Sector 22	Udyog Vihar Phase IV	15987	19194	23036	27234	29454	34309	38379	43878
Udyog Vihar Phase IV	Udyog Vihar Phase V	15308	19243	22151	27182	28293	34146	36856	43551
Udyog Vihar Phase V	Cyber City	15124	19359	21927	27263	27889	34050	36181	43155
Cyber City	Moulsari Avenue	12512	19259	19148	27113	24374	33790	31737	42704
Moulsari Avenue	Dlf Phase-3	12495	19209	19075	27038	24005	33660	30954	42479
Dlf Phase-3	Belvedere Towers	12544	19259	19149	27113	24134	33790	31176	42704
Belvedere Towers	Dlf Phase-2	12594	14689	19224	21636	24264	26846	31401	33999
Dlf Phase-2	Sikanderpur	10313	13685	16965	20055	21972	25506	29172	32964
Sikanderpur	DLf Phase-1	5652	7459	10872	12225	12244	14285	13782	16900
DLf Phase-1	Sector 42-43	4929	6652	9670	10886	10685	12409	11824	14279

Station Name		2026		2031		2041		2051	
From	To	Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2
Sector 42-43	Sector 53-54	3578	4967	7381	8560	8176	9572	9078	10826
Sector 53-54	Sector 54 Chowk	2783	3547	5882	5614	6478	6380	7153	7377
Sector 54 Chowk	Sector 55-56	2028	2780	4859	4602	5195	5088	5594	5728
MAXIMUM PHPDT		19359		27263		34309		43878	

3.5.4 Design Ridership

The Metro corridor has maximum PHPDT of 19359, 27263, 34309 and 43878 in years 2026, 2031, 2041 and 2051 respectively. These PHPDT figures will rely on proposed developments as envisaged in Master Plan of Gurgaon, realization of other planned transport infrastructure projects and a number of other issues that could appear during next 20-40 years. Generally, it takes 4-5 years to achieve the estimated ridership on a new mass transit system. Hence, the design ridership has been taken as slightly lower at 70% of the maximum ridership for the commencement year 2026 i.e., 13551 PHPDT and then has been gradually increased every year to stabilize to estimated ridership by the year 2031.

Chapter – 4

SYSTEM AND TECHNOLOGY SELECTION

4. SYSTEM & TECHNOLOGY SELECTION

4.1 INTRODUCTION

Selection of a particular mass transit system largely depends on the characteristics of the city and its metropolitan area, the projection of traffic demand for transit travel and the availability of suitable right-of-way (ROW). Mass Transit System is selected and planned to provide comfortable, safe, reliable and fast/high frequency connectivity across the cityscapes.

The urban transport requirements of Gurugram City have been evaluated based on projected traffic demand. Considering the city specific characteristics, traffic demand, availability of right of way, Metro rail system, which can cater to design PHPDT is proposed to be adopted for Gurugram corridor.

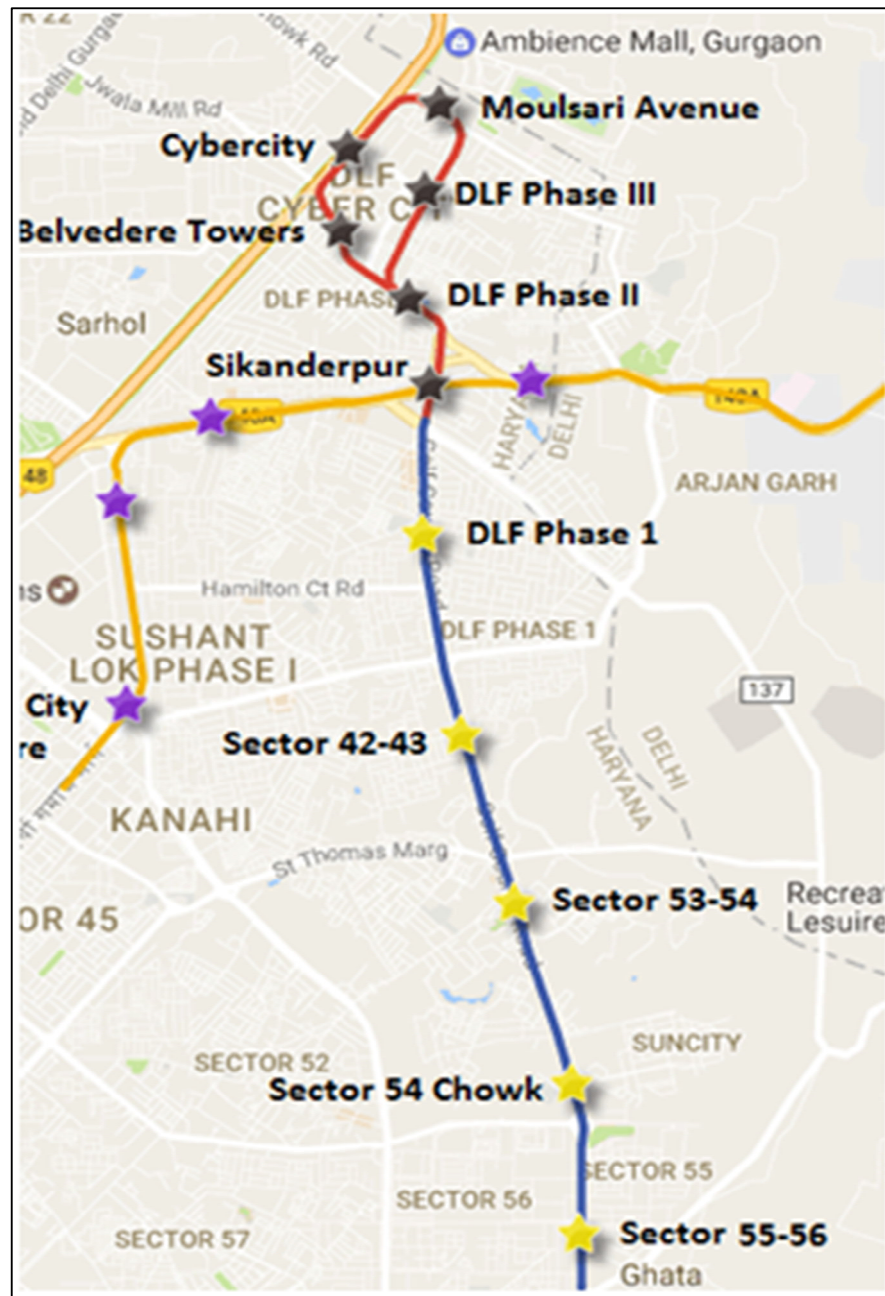
Metro Rail system is most prevalent mass transit system adopted worldwide. In India, MRTS is operational in various cities viz. Delhi, Chennai, Kolkata, Mumbai, Bangalore, Kochi, Jaipur etc. Metro rail technology offers the advantage of latest technology being available off the shelf with standardization, indigenization and has already stabilized for reliability, acceptance and availability of manufacturing infrastructure (for spare parts etc.) around the world and also in India. It is a grade separated system with exclusive right of way characterized by short distances of stations spaced at about 1 km and modern state of the art rolling stock having high acceleration and deceleration with maximum speed of 80-120 kmph. Sharpest curve of 120m radius is permitted for MRTS. The system can be designed to meet the peak hour peak direction traffic (PHPDT) carrying capacity from 10,000 to up to 80,000 depending upon the type of systems and infrastructure adopted such as rolling stock, train set configurations, signaling system, stations platform length etc.

Considering the city specific characteristics, traffic demand, availability of right of way, **Medium capacity Metro rail system with 3 car train composition** can be adopted for the proposed corridor of Gurugram for initial years and 6 car train composition in future years.

4.2 SYSTEM SPECIFICATIONS ADOPTED FOR THE CRRIDOR

Gurugram has a fully elevated network of Metro Rail (Rapid Metro) from Sector 56 – Sikanderpur – Cyber City with a total length of 11.7 km. The Rapid Metro is operational since 2013. Trains with 3 car length run on the corridor. The infrastructure and the facilities such as stations, depot etc. are also planned for 3 car train length.

FIGURE 4.1: EXISTING RAPID METRO NETWORK



It is proposed to integrate the proposed Gurugram metro rail system with Rapid Metro. This integration will help in utilization of existing infrastructure of Rapid Metro System.

Since, the system will be integrated with rapid metro system, it is essential to ensure operational compatibility of the two systems. Therefore, it is important that the system specifications similar to rapid metro are adopted for the proposed corridors. Following system specification parameters are considered for the Gurugram Metro corridors:

TABLE 4.1: SYSTEM SPECIFICATION PARAMETERS

Parameters		System Specification
Corridor		Huda City Centre to Cyber City
Traffic Handling capacity (PHPDT)		30000 with 3 coach trains at 2 min headway
		60000 with 6 coach trains at 2 min headway
Gauge		Standard gauge (1435 mm)
Traction System		750V DC Third Rail Traction
Rolling Stock	Coach Width	2.8 m wide coaches
	Coach length	19.98 m
	Basic Unit	3 car basic unit (DMC-TC-DMC)
	Train Composition	3 car – DMC-TC-DMC
		6 car – DMC-TC-MC-MC-TC-DMC
	Coach construction	Aluminum body
	Axle load	≤16 T
	Braking System	Regenerative Braking
	Propulsion system	3 phase drive system with VVVF control
	Performance Characteristics	Max. Design speed : 80 kmph Max. Acceleration : 1.0 m/s² Max. Deceleration : 1.1 m/s² (Normal brake) More than 1.3 m/s² (Emergency brake)

Chapter – 5

CIVIL ENGINEERING & ALIGNMENT DETAILS

5. CIVIL ENGINEERING

5.1 ALIGNMENT DESCRIPTION OF APPROVED ALIGNMENT, AVAILABILITY OF ROAD SPACE

5.1.1 Engineering Survey and Alignment Design

5.1.1.1 Introduction

The study for “Detailed Project Report for Metro Rail Connection from HUDA City Centre to Cyber City and Spur to Dwarka Expressway, Gurgaon” consists of one corridor and a spur. The corridor starts from HUDA City Centre and joins Rapid Metro at Cyber City, Gurgaon; the Spur starts from Basai Village and terminates at Dwarka Expressway (Sector-101).

Metro Route of the corridor was initially planned on Google Map. For detailed planning of the proposed metro route, ground survey was carried out with the help of GPS, Total Station and Auto levels. Details of all the existing features falling in the proposed corridor were collected for proper planning of the alignment and Depot. Detailed Methodology of the Survey and other descriptions are given in subsequent paragraphs.

5.1.1.2 Survey Methodology

- i. Before starting the detailed topographical survey work, a team of expert in the field of alignment design and survey has conducted reconnaissance survey to familiarize with the area and selection of control points along the proposed Metro Route.
- ii. Topographical survey of the Corridor (HUDA City Centre to Cyber City alongwith the Spur to Dwarka Expressway) has been carried out from April’2018 to April’2019 to collect all manmade and natural features like roads, building, drain, railway line telephone/electric pole etc., falling in the proposed metro corridor for better and accurate planning of the metro alignment.
- iii. Topographical survey was carried out in detail covering all the activities which are mentioned in Terms of Reference of the Contract using modern surveying instrument like GPS, Total Station and Auto/Digital Level. Survey Drawings were prepared in AutoCAD format.
- iv. Topographical survey and alignment design has been carried out in following steps:
 - a. Establishment of Horizontal Control Points using DGPS
 - b. Densification of Horizontal Control Points using Total station
 - c. Establishment of Vertical Control Points
 - d. Detailed survey of corridor
 - e. Preparation of drawings.
 - f. Site verification of features and finalization of drawings.

g. Alignment design on basis of verified drawings.

A. Establishment of Horizontal Control Points using DGPS



Before starting the GPS work, network has been planned and a pair of concrete pillars of 300x300x400mm size of M15 grade concrete has been fixed at every one Km in both corridors. A mild steel rod of 20mm diameter and 350mm long has been provided at the centre of pillar to mark location of GPS point. Location of these pillars has been selected such that these are obstruction free towards sky at an angle of 15 degree with Horizontal plane to achieve required degree of accuracy in GPS observation.

For carrying out GPS work, first control point (base point) was set-up at Gurgaon Railway station. At this point, 24hrs GPS observation was done to achieve higher degree of accuracy

and for other points, sufficiently long hours common period observation was carried out. Common period observation at three points have been carried out to form the triangle and to calculate the accuracy of the loop with the help of loop closer reports by solving these triangle with the help of data processing software.

In this survey, **Sokkia GRX-2** GPS has been used for collecting GPS Data. Data was downloaded and processed with **Spectrum office** software. In this processing UTM Projection system and WGS84 Datum has been used for horizontal controls whereas for vertical control Earth Gravitation Model 2008 (EGM 08) has been used. Grid Co-ordinates have been converted in Ground Co-ordinate by using combined scale factor. These Ground Co-ordinates are used in total station during the traversing and topographical survey. Details of GPS Control points (GPS) established are provided given in **TABLE 5.1**.

TABLE 5.1: LIST OF GPS CONTROL POINTS

S. No.	Point ID	Ground Coordinate		MSL Level (M)	Description
		Easting	Northing		
1	DGPS1	696897.588	3153044.948	216.100	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF WINE AND BEER SHOP, NEAR MADHUSHALA RESTAURANT SECTOR 33 GURGAON.
2	DGPS1A	696836.518	3152970.405	215.972	MARKED ON C.C. TILES OF RAILWAY PARKING FOOTPATH IN FRONT OF TOILET NEAR BOB ATM MAIN GURGAON RAILWAY STATION.
3	DGPS2	696193.187	3150745.549	216.059	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SK PROPERTIES, FIROZ GANDHI COLONY-2 SECTOR 9, NEAR INDIAN OIL PETROL PUMP, IN NEKI RAM MARG.
4	DGPS2A	696082.791	3150703.536	215.772	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF DEEPAK PROPERTIES, FIROZ GANDHI COLONY-2 SECTOR 9, NEAR INDIAN OIL PETROL PUMP, IN NEKI RAM MARG.
5	DGPS3	694894.908	3149466.144	216.265	MARKED ON RCC. PILLAR, SITUATED IN DIVIDER OF BASAI CHOWK, OPPOSITE SIDE OF CHAPPAN BHOG SWEETS & RESTAURANT, NEAR RAIN BASERA, IN HERO HONDA MARG.
6	DGPS3A	694931.896	3149310.897	216.174	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF JUICE SHOP AND NEAR AIR INDIA TRANSPORT OFFICE BASAI CHOWK, IN HERO HONDA MARG.

S. No.	Point ID	Ground Coordinate		MSL Level (M)	Description
		Easting	Northing		
7	DGPS4	696066.103	3147642.997	218.818	MARKED ON RCC. PILLAR, SITUATED IN BACK SIDE OF SULABH SAUCHALAYA, NEAR TREATMENT PLANT SECTOR 37 AND ABOUT 25 M(APX) NW OF OLD KHANDSA ROAD GURGAON.
8	DGPS4A	696177.079	3147550.867	219.254	MARKED ON RCC. PILLAR, SITUATED IN SERVICE ROAD BACK SIDE OF HCG CNG GAS PUMP, UDYOG VIHAR INDUSTRIAL AREA PH-VI SECTOR 37 GURGAON.
9	DGPS5	698092.49	3146231.011	222.939	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF POOJA BUILDING MATERIAL SUPPLIER SECTOR 33 NEAR HCG PUMP, SUBHASH CHOWK ROAD GURGAON.
10	DGPS5A	698308.653	3146112.128	223.480	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF WINE AND BEER SHOP, NEAR MADHUSHALA RESTAURANT SECTOR 33 GURGAON.
11	DGPS6	700279.929	3146572.137	228.137	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SRI RAM SARNAM BUILDING, NEAR NATURE HEALZ BUILDING SECTOR 47, NETAJI SUBHASH MARG.
12	DGPS6A	700409.466	3146711.694	227.249	MARKED ON RCC. PILLAR, SITUATED IN DIVIDER OPPOSITE SIDE OF OYO DEV PALACE, NETAJI SUBHASH MARG.
13	DGPS7	701269.573	3147752.75	229.271	MARKED ON RCC. PILLAR, SITUATED IN DIVIDER FRONT OF REJUVA SKIN CLINIC SECTOR 39, NEAR CYBER PARK, NETAJI SUBHASH MARG.
14	DGPS7A	701355.527	3147856.8	229.227	MARKED ON RCC. PILLAR, SITUATED IN DIVIDER BETWEEN RESIDENCY GREENS MAIN GATE AND UNITECH CYBER PARK MAIN GATE, NETAJI SUBHASH MARG.
15	DGPS8	702865.833	3149672.467	235.543	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH FRONT OF FORTIS HOSPITAL SECTOR 44, NEAR HUDA CITY CENTER METRO STATION.
16	DGPS8A	702808.439	3149700.49	235.358	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH FRONT OF UNITECH BUSINESS PARK BUILDING SECTOR 41, NEAR HUDA CITY CENTER METRO STATION.

S. No.	Point ID	Ground Coordinate		MSL Level (M)	Description
		Easting	Northing		
17	DGPS9	698157.04	3154185.469	216.025	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF NARAYANA E TECHNO SCHOOL SECTOR 3, REZANG LA MARG GURGAON.
18	DGPS9A	698286.282	3154293.653	215.717	MARKED ON RCC. PILLAR, SITUATED IN 170M NORTH EAST SIDE FROM DGPS9 ON SERVICE ROAD OF C1 BLOCK PALAM VIHAR SECTOR3, REZANG LA MARG GURGAON.
19	DGPS10	699787.924	3155374.063	219.134	MARKED ON RCC. PILLAR, SITUATED IN MEDIAN OF DIVIDER FRONT OF WINE AND BEER SHOP, NEAR REZANG LA CHOWK, REZANG LA MARG GURGAON.
20	DGPS10A	699887.218	3155389.879	219.891	MARKED ON RCC. PILLAR, SITUATED IN MEDIAN OF DIVIDER FRONT OF HANUMAN TEMPLE, NEAR REZANG LA CHOWK, MAJOR SUSHIL AIMA MARG GURGAON.
21	DGPS11	702034.927	3154598.837	227.106	MARKED ON RCC. PILLAR, SITUATED IN SERVICE ROAD FRONT OF OPEN PLOT AND OPPOSITE SIDE SHOP NO 102-103 HUDA MARKET SECTOR 22-22A, MAJOR SUSHIL AIMA MARG GURGAON.
22	DGPS11A	702100.714	3154655.873	227.882	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF AUTO PARKING, NEAR HUDA MARKET SECTOR 22-22A, MAJOR SUSHIL AIMA MARG GURGAON.
23	DGPS 12	704325.1	3153949	238.1822	MARKED AT INTERSECTION OF ON PARKING TO ROAD IFFCO CHOWK ROAD AND OPPOSITE RAPID METRO LINE TO VODAFONE BELVEDERE TOWER METRO STATION
24	DGPS 12A	704452.8	3154102	239.1477	MARKED AT INTERSECTION ON SERVICE ROAD OPPOSITE OF UNDERPAAS NEAR BY INDUSIND BANK CYBER CITY METRO STATION BUILDING ON DOWN SIDE

B. Densification of Horizontal Control Points using Total Station



For densification of Horizontal Control Points, five to six additional pillars of same size on traverse points have been fixed between GPS control points which were used during the detailed topographical survey of the corridors.

For densification of horizontal points, traversing was carried out by Leica Total Station of 1" (one second) accuracy between GPS points which co-ordinates are already determined with help of GPS observation. Co-ordinates of intermediate points established with the help of total station have been determined by solving the traverse network between GPS control Points. Closing error of traverse network was calculated and errors which were within permissible limits, were adjusted by transit rule method after adjusting the angular error of the traverse. Total linear error in traverse after angular adjustment was permitted as 1 in 50,000 whereas angular error of traverse was permitted as $15''\sqrt{n}$ where n is the number of angle measured in the traverse network. Details of traverse Control points established are provided in **Table 5.2**.

TABLE 5.2: LIST OF TRAVERSE CONTROL POINTS

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
DGPS 1A TO DGPS 2					
1	TBM1	696853.440	3152971.792	216.864	MARKED ON CIRCLE OF CONCRETE TILES IN FRONT OF BANK OF BARODA ATM AT GURGAON RAILWAY STATION VEHICLE PARKING GURUGARAM.
2	G1	696934.338	3152803.274	215.462	MARKED STEEL NAIL IN ROAD EDGE OPPOSITE SIDE OF COSCO SPORTS FITNESS SECTOR 3, OLD RAILWAY STATION ROAD GURGAON.
3	G2	696992.556	3152661.713	215.687	MARKED STEEL NAIL IN ROAD EDGE FRONT OF SHREE SHEETLA ENTERPRISES B-BLOCK ASHOK VIHAR SECTOR 3, OLD RAILWAY STATION ROAD GURGAON.
4	G3	697036.090	3152535.916	215.828	MARKED STEEL NAIL IN DIVIDER EDGE FRONT OF BHART PETROLEUM PUMP, OLD RAILWAY STATION ROAD GURGAON.
5	G4	697103.063	3152398.233	216.281	MARKED STEEL NAIL IN ROAD EDGE FRONT OF ASHOK YADAV HOUSE, ASHOK VIHAR PH-1, OLD RAILWAY STATION ROAD GURGAON.
6	TBM2	697140.028	3152251.929	216.488	MARKED ON RCC MANHOLE IN FRONT OF SHRI SHAYAM VANDANA PROPERTIES, GURGAON RAILWAY STATION ROAD GURUGARAM.
7	G5	697208.745	3152143.775	216.561	MARKED STEEL NAIL IN ROAD EDGE FRONT OF CANARA BANK ASHOK VIHAR SECTOR-3, OLD RAILWAY STATION ROAD GURGAON.
8	G6	697268.138	3151954.581	216.582	MARKED STEEL NAIL IN ROAD EDGE FRONT OF BUZZ KNIGHT RESTAURANT SECTOR-4, OLD RAILWAY STATION ROAD GURGAON.
9	G7	697341.718	3151804.935	217.323	MARKED STEEL NAIL IN DIVIDER EDGE FRONT OF KATARIA HARDWARE, OLD RAILWAY STATION ROAD GURGAON.
10	G7A	697359.879	3151738.899	217.415	MARKED STEEL NAIL IN ROAD EDGE OPPOSITE SIDE OF MATA CHINTPURNI MANDIR, OLD RAILWAY STATION ROAD GURGAON.
11	G8	697428.250	3151588.182	217.78	MARKED STEEL NAIL IN ROAD EDGE OPPOSITE SIDE OF SHUBHAM COLOUR LAB & STUDIO, OLD RAILWAY STATION ROAD GURGAON.
12	G9	697513.660	3151441.881	218.345	MARKED STEEL NAIL IN ROAD EDGE FRONT OF MRF TYRES SERVICE SECTOR-6, OLD RAILWAY STATION ROAD GURGAON.
13	TBM4	697543.243	3151307.644	218.088	MARKED ON RCC PILLAR, SITUATED IN TRINGULAR DIVIDER OF 4-7 SECTOR CHOWK,FRONT OF POLICE BOOTH, NEAR INOX MALL NEKI RAM MARG GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
14	G10	697415.764	3151265.451	217.265	MARKED STEEL NAIL IN ROAD EDGE OPPOSITE SIDE OF SECURITY ARRANGEMENT SOCIETY POCKET 1 SECTOR7, NEKI RAM MARG GURGAON.
15	G11	697296.955	3151201.698	217.109	MARKED STEEL NAIL IN ROAD EDGE BACK SIDE OF RADHA KRISHNA TEMPLE POCKET 1 SECTOR7, NEKI RAM MARG GURGAON.
16	G12	697188.082	3151153.568	216.978	MARKED STEEL NAIL IN ROAD EDGE OPPOSITE SIDE OF SECURITY ARRANGEMENT SOCIETY POCKET 1 SECTOR7, NEKI RAM MARG GURGAON.
17	G13	696980.280	3151063.244	216.69	MARKED STEEL NAIL IN ROAD EDGE BACK SIDE OF H.NO 340&341 SECTOR7, NEKI RAM MARG GURGAON.
18	G14	696825.791	3151005.974	216.445	MARKED STEEL NAIL IN ROAD EDGE BACK SIDE OF H.NO 211-212 SECTOR4, NEKI RAM MARG GURGAON.
19	G15	696669.151	3150923.04	216.256	MARKED STEEL NAIL IN ROAD EDGE BACK SIDE OF H.NO 251-252 SECTOR 7, NEKI RAM MARG GURGAON.
20	G16	696496.706	3150850.583	215.94	MARKED STEEL NAIL IN ROAD EDGE BACK SIDE OF H.NO 635-636 SECTOR 7, NEKI RAM MARG GURGAON.
21	G17	696328.031	3150786.517	215.892	MARKED STEEL NAIL IN ROAD EDGE FRONT OF TIGER AUTO WORKSHOP SECTOR 4-7-9 CHOWK, NEKI RAM MARG GURGAON.
22	G18	696270.600	3150753.328	215.723	MARKED STEEL NAIL IN ROAD EDGE FRONT OF HDFC ATM AND SANDEEP MOTORS, NEAR INDIAN OIL PETROL PUMP, NEKI RAM MARG GURGAON.
DGPS 2A TO DGPS 3					
1	G19	696012.493	3150652.748	215.61	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH OPPOSITE SIDE OF SURYA VIHAR BLOCK-C, NEKI RAM MARG GURGAON.
2	G20	695839.975	3150594.899	215.123	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH FRONT OF AASHIYANA PROPERTIES SECTOR 9A, NEKI RAM MARG GURGAON.
3	G21	695674.469	3150513.021	214.997	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH FRONT OF VACANT PLOT NO. 587-88 SECTOR 9, NEKI RAM MARG GURGAON.
4	G22	695509.744	3150445.299	215.064	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH FRONT OF H NOS 236-237 SECTOR 9, NEKI RAM MARG GURGAON.
5	G23	695369.586	3150401.062	215.204	MARKED ON CC TILES IN FRONT OF PLOT NO 57 SECTOR 9A, NEKI RAM MARG GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
6	G24	695149.802	3150296.705	215.058	MARKED ON CC TILES IN FRONT OF HOUSE NO 186 SECTOR 9, NEKI RAM MARG GURGAON.
7	G25	694935.030	3150206.506	214.833	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH FRONT OF H NO. 7, SECTOR 9, NEKI RAM MARG GURGAON.
8	TBM7	694821.018	3150210.527	214.718	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF MADRASI COLONY SECTOR 9A NEAR GREEN WOOD PUBLIC SCHOOL, NEKI RAM MARG GURGAON.
9	G26	694883.551	3150052.483	215.581	MARKED ON RCC PILLAR, SITUATED IN FRONT OF GREEN WOOD PUBLIC SCHOOL GATE, GURGAON.
10	G27	694941.387	3149880.987	215.223	MARKED ON RCC PILLAR, SITUATED IN FRONT OF OM SAI RAM BUILDING MATERIAL STORE NEAR RADHA KRISHNA GAUSHALA, GURGAON.
11	G28	694950.682	3149689.632	215.654	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF EMERGING MINDS INSTITUTE NEAR BASAI CHOWK, GURGAON.
12	G29	694873.483	3149531.106	216.086	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF SHIV SHAKTI SHANI SAI MANDIR NEAR BASAI CHOWK, GURGAON.
DGPS 3A TO DGPS 4					
1	G30	695072.712	3149233.505	216.501	MARKED ON RCC PILLAR OF LIGHT, IN FRONT OF SHIV CONSTRUCTION AND BUILDING MATERIAL NEAR ALPINE CONVENT SCHOOL, GURGAON.
2	G31	695202.372	3149204.863	216.895	MARKED ON RCC PILLAR, SITUATED IN TRIANGULAR DIVIDER NEAR ALPINE CONVENT SCHOOL SECTOR 10, GURGAON.
3	G32	695317.419	3149011.333	216.977	MARKED ON RCC PILLAR OF LIGHT, IN FRONT OF AVR PLAY SCHOOL VIKAS NAGAR HERO HONDA ROAD SECTOR 10, GURGAON.
4	G33	695380.590	3148854.18	217.152	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF VACANT PLOT NO 27 SECTOR 10 NEAR LAMBA PROPERTIES HERO HONDA ROAD, GURGAON.
5	G34	695482.935	3148693.515	217.003	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF FOREST VACANT LAND KADIPUR IND. AREA HERO HONDA ROAD, GURGAON.
6	G35	695553.321	3148518.116	218.094	MARKED ON RCC PILLAR, SITUATED IN FRONT OF HANUMAN TEMPLE KADIPUR CHOWK, KADIPUR IND. AREA HERO HONDA ROAD, GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
7	G36	695634.616	3148394.987	218.06	MARKED ON FOOTPATH RCC CULVERT IN CORNER OF SANASKRITI APT. SECTOR 10A AND OPPOSITE SIDE OF HIMGIRI BHAWAN, HERO HONDA ROAD GURGAON.
8	G37	695713.583	3148233.105	217.972	MARKED ON RCC PILLAR, SITUATED IN FRONT OF HIMANSHU PROPERTIES PLOT NO 1677 SECTOR 10A, HERO HONDA ROAD, GURGAON.
9	G38	695783.232	3148052.365	218.038	MARKED ON RCC PILLAR, SITUATED IN APX.15 M SE SIDE OF 66KV SUB STATION CONER SECTOR 10, HERO HONDA ROAD, GURGAON.
10	G39	695910.543	3147915.122	218.607	MARKED ON RCC PILLAR, SITUATED IN FRONT OF MEGHDOOT APT. G.H.15 SECTOR 10A, HERO HONDA ROAD, GURGAON.
11	G40	696025.383	3147774.864	218.898	MARKED ON RCC PILLAR, SITUATED IN FRONT OF SHREE KRISHNA ESTATE PLOT NO 1647 SECTOR 10A, HERO HONDA ROAD, GURGAON.
DGPS 4A TO DGPS 5					
1	G41	696320.075	3147438.653	219.37	MARKED ON RCC PILLAR, SITUATED IN SERVICE ROAD FOOTPATH FRONT MAIER VIDORNO UDYOG VIHAR IND AREA SECTOR 37, HERO HONDA ROAD, GURGAON.
2	G42	696376.339	3147475.217	219.446	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH OPPOSITE SIDE OF EMBLEM HOTEL NEAR AMBEDKAR CHOWK, HERO HONDA ROAD, GURGAON.
3	G43	696499.757	3147365.327	220.23	MARKED ON RCC PILLAR, SITUATED IN FRONT OF HOTEL PACE NEAR HERO HONDA CHOWK, GURGAON.
4	TBM10	696647.416	3147312.173	219.772	MARKED ON RCC PILLAR, SITUATED IN FRONT OF SOBOHEMA AUTOMOBILE AND START POINT OF UNDER BY PASS NEAR HERO HONDA CHOWK, HERO HONDA ROAD GURGAON.
5	G44	696801.449	3147199.551	220.151	MARKED ON RCC PILLAR, SITUATED IN FRONT OF BIG BOY TOYZ, NEAR HERO HONDA CHOWK, GURGAON.
6	G45	696960.906	3147103.16	220.54	MARKED ON FOOTPATH RCC PILLAR OF LIGHT, IN FRONT OF HERO COMPANY STARTING WALL NEAR HERO HONDA CHOWK, GURGAON.
7	G46	697140.216	3146968.56	220.89	MARKED ON RCC OF COVER DRAIN IN FRONT OF HERO MOTO CORPORATION LTD. GATE NEAR HERO HONDA CHOWK, GURGAON.
8	G47	697279.408	3146841.406	221.996	MARKED STEEL NAIL IN DIVIDER EDGE FRONT OF SIGAMA CENTRE NEAR HERO HONDA CHOWK, GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
9	G48	697391.312	3146762.344	221.789	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF MARUTI SUZUKI COMPETENT SUBHASH CHOWK ROAD, GURGAON.
10	G49	697508.923	3146679.782	222.048	MARKED ON RCC PILLAR, SITUATED IN CIRCLE FRONT OF INFOCITY GATE NO 1, SUBHASH CHOWK ROAD, GURGAON.
11	G50	697691.914	3146565.677	221.957	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH OPPOSITE SIDE OF HUDA AND EXCISE OFFICE NEAR HVPNL 66KV SUBSTATION SECTOR 33, GURGAON.
12	G51	697813.162	3146456.859	222.697	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF AMBEY MARBEL TILES NEAR MARBEL MARKET, SUBHASH CHOWK ROAD, GURGAON.
13	G52	697982.769	3146348.788	222.604	MARKED ON RCC PILLAR, SITUATED IN FRONT OF 220KV HVPNL SUBSTATION SECTOR 33, SUBHASH CHOWK ROAD, GURGAON.
14	G53	698005.979	3146289.619	222.56	MARKED STEEL NAIL IN DIVIDER EDGE FRONT OF HCG PUMP, SUBHASH CHOWK ROAD GURGAON.
DGPS 5A TO DGPS 6					
1	G54	698470.928	3146113.242	223.321	MARKED ON RCC PILLAR, SITUATED IN FRONT OF UNITECH THE VILLAS, NEAR YADUVANSHI SCHOOL SECTOR 33 GURGAON.
2	G55	698660.704	3146149.421	223.899	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF UNITECH VILLAS NEW BUILDING AND BUS STOP, NEAR YADUVANSHI SCHOOL SECTOR 33 GURGAON.
3	G56	698825.982	3146202.466	224.069	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF ALIGHT AON BUILDING, NEAR YADUVANSHI SCHOOL SECTOR 33 GURGAON.
4	TBM13	698985.536	3146247.246	224.069	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH, OPPOSITE SIDE OF COLT BUILDING NEAR SUBHASH CHOWK, GURGAON.
5	G57	699110.636	3146290.489	224.258	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF CENTRAL PARK RESORTS MAIN GATE SECTOR 48, NEAR SUBHASH CHOWK GURGAON.
6	G58	699281.504	3146338.018	224.961	MARKED ON RCC PILLAR, SITUATED IN FRONT OF KUNDU AUTO PARTS TEMP.SHOP SECTOR 33, NEAR SUBHASH CHOWK GURGAON.
7	G59	699453.708	3146387.423	225.202	MARKED ON RCC PILLAR, SITUATED APX. 20 M SW SIDE OF AL BAILE CHICKEN CORNER SECT 33, SUBHASH CHOWK GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
8	G60	699666.053	3146443.624	225.453	MARKED ON FOOT PATH TILES SE CORNER OF ISLAMPUR POLICE STATION SECTOR 38 NEAR SUBHASH CHOWK, NETA JI SUBHASH MARG, GURGAON.
9	TBM14	699881.53	3146479.429	226.008	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF PRAGTI HILLS SOCIETY SECTOR 47 PARK NEAR SUBHASH CHOWK, NETA JI SUBHASH MARG, GURGAON.
10	G61	700032.058	3146536.133	226.207	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH OPPOSITE SIDE OF PRAGTI HILLS SOCIETY SECTOR 47 PARK NEAR SUBHASH CHOWK, NETA JI SUBHASH MARG, GURGAON.
11	G62	700194.424	3146566.936	227.266	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF BHAGWATI ESTATE AGENCIES SECTOR 38, NEAR SUBHASH CHOWK, NETA JI SUBHASH MARG, GURGAON.
DGPS 6A TO DGPS 7					
1	G63	700502.044	3146846.012	227.39	MARKED ON RCC OF FOOTPATH IN FRONT OF GREEN ESTATE PLOT NO. 612 SECTOR 38, NETA JI SUBHASH MARG, GURGAON.
2	G64	700628.013	3146978.36	228.265	MARKED ON RCC PILLAR, SITUATED IN DIVIDER, NEAR SUKHMANI HOSPITAL SECTOR 38, NETA JI SUBHASH MARG, GURGAON.
3	G65	700793.735	3147199.198	228.384	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF RAJ RESTAURANT AND WINE SHOP SECTOR 39, NETA JI SUBHASH MARG, GURGAON.
4	G66	700922.765	3147334.288	229.314	MARKED ON RCC OF DIVIDER EDGE IN FRONT OF CH. BAKHATAWER SINGH THAKRAN BHABAN SECTOR 39, NETA JI SUBHASH MARG, GURGAON.
5	G67	701021.932	3147475.224	228.568	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF MRF SHANTI TYRE ZONE SECTOR 39, NETA JI SUBHASH MARG, GURGAON.
6	G68	701140.577	3147598.42	228.934	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF SUBHAM PROPERTIES PLOT NO.620 SECTOR 39, NETA JI SUBHASH MARG, GURGAON.
7	G69	701185.34	3147707.884	228.402	MARKED ON RCC PILLAR, SITUATED IN SERVICE ROAD EDGE AND ENTRY GATE OF POKED D (RWA) SECTOR 39, NETA JI SUBHASH MARG, GURGAON.
DGPS 7A TO DGPS 8					

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
1	G70	701454.378	3147995.477	229.177	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF UNITECH CYBER PARK BUILDING AND OPPOSITE SIDE OF VISTA VILLAS MAIN GATE, NETA JI SUBHASH MARG, GURGAON.
2	G71	701546.312	3148087.827	229.448	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF WINE SHOP AND AMAR SHAHEED CH. GALAM SINGH ENTRY GATE SECTOR 39, NETA JI SUBHASH MARG, GURGAON.
3	G72	701652.126	3148238.227	229.162	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF UNITECH CYBER PARK BUILDING AND OPPOSITE SIDE OF VISTA VILLAS MAIN GATE, NETA JI SUBHASH MARG, GURGAON.
4	G73	701782.966	3148377.607	229.725	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF VAMSOR HEIGHTS BUILDING SECTOR 40, NETA JI SUBHASH MARG, GURGAON.
5	G74	701825.404	3148428.955	230.389	MARKED ON RCC OF DIVIDER EDGE BETWEEN AANGAN PROPERTIES AND PREMIA MEDICARE BUILDING SECTOR 45, NETA JI SUBHASH MARG, GURGAON.
6	G75	701945.97	3148597.43	230.24	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH AND FRONT OF PLOT NO Q58 SOUTH CITY 1 SECTOR 40, NETA JI SUBHASH MARG, GURGAON.
7	G76	702070.438	3148725.131	231.434	MARKED ON RCC PILLAR, SITUATED IN DIVIDER OPPOSITE SIDE OF TREE BO NEO RESIDENCY SECTOR 45, NETA JI SUBHASH MARG, GURGAON.
8	G77	702156.787	3148854.281	231.555	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF PLOT NO K190 SOUTH CITY-1, SECTOR 41, NETA JI SUBHASH MARG, GURGAON.
9	G78	702277.125	3148978.957	232.263	MARKED ON RCC PILLAR, SITUATED IN DIVIDER BETWEEN PLOT NO1805 SECTOR 45 AND SECTOR 41 PARK, NETA JI SUBHASH MARG, GURGAON.
10	G79	702357.734	3149077.088	232.878	MARKED ON RCC OF DIVIDER EDGE IN T JUNCTION OF BHAGWAN MAHAVEER MARG NEAR INFINITE COMPUTER SOLUTIONS SECTOR 44, NETA JI SUBHASH MARG, GURGAON.
11	G80	702502.189	3149261.047	233.464	MARKED ON RCC PILLAR, SITUATED IN DIVIDER NEAR METRO PILLAR NO 218A&B UNITECH SOUTH CITY - 1, NETA JI SUBHASH MARG, GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
12	G81	702614.137	3149430.672	233.854	MARKED ON RCC OF FOOTPATH IN FRONT OF UNITECH THE PALMS BLOCK F SOUTH CITY 1 TOWER, SECTOR 41, NETA JI SUBHASH MARG, GURGAON.
13	G82	702732.424	3149582.608	234.653	MARKED ON RCC OF FOOTPATH IN FRONT OF PLOT NO F 65 SOUTH CITY 1 SECTOR 41, NETA JI SUBHASH MARG, GURGAON.
DGPS 8A TO DGPS 9					
1	R1	696942.831	3153136.836	215.328	MARKED CIRCLE ON CONCRETE TILES IN FRONT OF RAILWAY STATION PARKING AND OPPOSITE SIDE OF PLATFORM NO 1 AT GURGAON RAILWAY STATION, GURGAON.
2	R2	696992.047	3153205.942	215.207	MARKED CIRCLE ON CC IN FRONT OF PANDIT JI TEA STALL, OPPOSITE SIDE OF PLATFORM NO 1 AT GURGAON RAILWAY STATION, GURUGARAM.
3	R2A	697072.58	3153325.615	215.927	MARKED CIRCLE ON CC IN FRONT OF END OF PLATFORM NO 1 AT GURGAON RAILWAY STATION, GURUGARAM.
4	R3	697187.797	3153476.899	215.649	MARKED ON RCC PILLAR, SITUATED IN FRONT OF GURGAON -DELHI R TRACK AND NEAR MAIN MORE OF DRAIN LEFT SIDE, BHEEM GARH KHERI GURGAON.
5	R3A	697315.294	3153413.764	215.592	MARKED ON RCC IN DRAIN LEFT EDGE AND BACK SIDE OF GEMS INTERNATIONAL SCHOOL BOUNDARY WALL SECTOR 3, BHEEM GARH KHERI GURUGARAM.
6	R4	697286.781	3153311.356	215.811	MARKED ON RCC PILLAR, SITUATED IN LEFT EDGE OF DRAIN MORE AND BACK SIDE OF GEMS INTERNATIONAL SCHOOL BOUNDARY WALL SECTOR 3, BHEEM GARH KHERI GURUGARAM.
7	R4A	697395.035	3153246.731	216.005	MARKED ON C CURVE STONE OF FOOTPATH IN OPPOSITE SIDE OF KUNDU HAVELI GATE ASHOK VIHAR SECTOR 3, GURGAON.
8	R5	697552.896	3153204.154	216.303	MARKED ON RCC PILLAR, SITUATED IN RIGHT SIDE OF COVER DRAIN WHICH IS 100 M NW OF SHEETLA MATA TEMPLE, ASHOK VIHAR GURGAON.
9	R6	697673.365	3153142.27	217.034	MARKED ON RCC SLAB OF COVER DRAIN IN FRONT OF HISAR AUTO MOBILE ASHOK VIHAR NEAR HP PETROL PUMP, GURGAON.
10	R6A	697702.487	3153312.879	216.135	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF ROSHAN WELDING WORKS NEAR INDUSLND BANK ATM ASHOK VIHAR PH III EXTENSION, REZANG LA MARG GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
11	R7	697705.663	3153514.348	215.939	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SHREE SHYAM STORE ASHOK VIHAR PH III EXTENSION, REZANG LA MARG GURGAON.
12	R7A	697782.906	3153666.545	216.408	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF KAMAL TRADERS ASHOK VIHAR PH III, REZANG LA MARG GURGAON.
13	R8	697837.122	3153805.884	215.525	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF FRESH FRUIT AND VEGITABLE SHOP ASHOK VIHAR PH III, REZANG LA MARG GURGAON.
14	R9	697939.984	3153906.662	216.346	MARKED ON CC SLAB OF COVERED DRAIN OPPOSITE SIDE OF ANSAL PALAM CORPORATE PLAZA AND WINE SHOP ASHOK VIHAR PH III, REZANG LA MARG GURGAON.
15	R10	698011.983	3154041.351	216.289	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SHREE RAM BUILDING MATERIAL AND TRADING, REZANG LA MARG GURGAON.
16	R11	698143.894	3154122.784	216.256	MARKED ON CC SLAB OF COVERED DRAIN OPPOSITE SIDE OF PARK VIEW PUBLIC SCHOOL PALAM VIHAR, REZANG LA MARG GURGAON.
DGPS 9A TO DGPS 10					
1	R12	698355.77	3154296.637	216.479	MARKED ON CC SLAB OF COVERED DRAIN FRONT OF SHEETLA AUTO PARTS SHOP ASHOK VIHAR PH III, REZANG LA MARG GURGAON.
2	R13	698466.492	3154417.318	216.385	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF GAMLA SHOP C1 BLOCK PALAM VIHAR, REZANG LA MARG GURGAON.
3	R14	698588.666	3154500.144	216.398	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF RAJMAHAL GARDENS WALL CORNER IN KRISHNA CHOWK, REZANG LA MARG GURGAON.
4	R15	698663.712	3154595.196	216.439	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF PRESIDUM SCHOOL C BLOCK PALAM VIHAR NEAR KRISHNA CHOWK, REZANG LA MARG GURGAON.
5	R16	698820.526	3154634.264	217.032	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF R K BEAUTY LUP B BLOCK DHARM COLONY PALAM VIHAR, REZANG LA MARG GURGAON.
6	R17	698964.246	3154670.638	216.844	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF POWER HOUSE AND OPPOSITE SIDE NATIONAL AUTOMOBILE SHOP DHARM COLONY PALAM VIHAR, REZANG LA MARG GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
7	R18	699145.162	3154658.169	217.208	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF QUALITY PAINTS HARDWARE STORE E BLOCK DHARM COLONY, PALAM VIHAR, REZANG LA MARG GURGAON.
8	R19	699303.068	3154692.681	217.758	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF RAJ PROPERTIES, CARTERPURI ROAD, DHARAM COLONY, PALAM VIHAR, REZANG LA MARG GURGAON.
9	R20	699415.921	3154849.587	217.678	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, FRONT OF ANSALS PALAM TRIANGLE WALL CORNER PALAM VIHAR, REZANG LA MARG GURGAON.
10	R21	699553.872	3155039.873	217.912	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF F BLOCK CARTERPURI VILLAGE SECTOR 23A, REZANG LA MARG GURGAON.
11	R22	699632.3	3155172.817	218.311	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF POCKET F SECTOR 2 PALAM VIHAR, REZANG LA MARG GURGAON.
12	R23	699739.091	3155283.897	218.57	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, FRONT OF COLUMBIA ASIA HOSPITAL SECTOR 23A PALAM VIHAR, REZANG LA MARG GURGAON.
DGPS 10A TO DGPS 11					
1	R24	700037.48	3155327.564	220.258	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF F BLOCK PRACHIN SHIV TEMPLE CARTERPURI VILLAGE SECTOR 23A, MAJOR SUSHIL AIMA MARG GURGAON.
2	R25	700167.346	3155295.38	220.593	MARKED ON RCC. PILLAR, SITUATED NEAR BUS STOP GATE NO 3 SECTOR 23, MAJOR SUSHIL AIMA MARG GURGAON.
3	R26	700330.669	3155217.528	221.072	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, FRONT OF GREEN BELT AND PLOT NO1290 F BLOCK CARTERPURI VILLAGE SECTOR 23A, MAJOR SUSHIL AIMA MARG GURGAON.
4	R27	700449.425	3155188.688	221.416	MARKED ON CC SLAB OF MEDIAN DIVIDER, FRONT OF GATE NO 2 SECTOR 23, MAJOR SUSHIL AIMA MARG GURGAON.
5	R28	700568.399	3155128.044	221.585	MARKED ON C CURVE STONE OF FOOTPATH OPPOSITE SIDE OF HOUSE NO 3705A/23 SECTOR 23, MAJOR SUSHIL AIMA MARG GURGAON.
6	R29	700712.114	3155087.302	222.018	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF HOUSE NO 3717A/23 SECTOR 23, MAJOR SUSHIL AIMA MARG GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
7	R30	700833.905	3154989.724	222.558	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF HOUSE NO 4208 SECTOR 23A NEAR BUS STOP NO 220, MAJOR SUSHIL AIMA MARG GURGAON.
8	R31	701029.809	3154875.896	223.306	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, OPPOSITE SIDE OF DISTRICT SHOPPING CENTRE SECTOR 23, MAJOR SUSHIL AIMA MARG GURGAON.
9	R32	701181.41	3154756.482	224.02	MARKED ON C CURVE STONE OF FOOTPATH, OPPOSITE SIDE HOUSE NO 91 SECTOR 23 NEAR HVPNL SUB STATION, MAJOR SUSHIL AIMA MARG GURGAON.
10	R33	701278.913	3154708.494	224.419	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, FRONT OF HOUSE NO 85 SECTOR 23 NEAR HVPNL SUB STATION, MAJOR SUSHIL AIMA MARG GURGAON.
11	R34	701363.107	3154634.819	224.834	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF TAU DEVI LAL PARK BOUNDARY WALL NEAR BUS STOP, MAJOR SUSHIL AIMA MARG GURGAON.
12	R35	701471.938	3154598.31	225.3	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF TAU DEVI LAL PARK BOUNDARY WALL AND OPPOSITE SIDE HUDA NURSERY, MAJOR SUSHIL AIMA MARG GURGAON.
13	R36	701659.391	3154619.349	225.654	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, OPPOSITE SIDE OF TAU DEVI LAL PARK VEHICALE PARKING, MAJOR SUSHIL AIMA MARG GURGAON.
14	R37	701776.936	3154609.898	226.151	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF ROTARY PUBLIC SCHOOL SECTOR 22 BOUNDARY WALL CORNER, MAJOR SUSHIL AIMA MARG GURGAON.
15	R38	701944.6	3154630.407	226.694	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, IN FRONT OF BIKANER SHOP SECTOR 22 MAIN MARKET, MAJOR SUSHIL AIMA MARG GURGAON.
R6 TO G5					
1	R39	697706.731	3153075.689	216.314	MARKED ON RCC SLAB OF COVER DRAIN IN FRONT OF HISAR AUTO MOBILE ASHOK VIHAR PH III EXTENSION, REZANG LA MARG GURGAON.
2	R40	697701.624	3152954.073	216.715	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF KATARIA COMPLEX BLOCK E, ASHOK VIHAR PH III, REZANG LA MARG GURGAON.

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
3	R41	697721.069	3152781.345	217.098	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SAHANI FURNITURE SHOP, NEAR BALA TRADING COMPANY, REZANG LA MARG GURGAON.
4	R42	697687.506	3152619.111	216.719	MARKED ON C CURVE STONE OF FOOTPATH IN TRIANGULAR OF DIVIDER, FRONT OF SECTOR 5 CHOWK CIRCLE, NEAR TRANSFORMER, ASHOK VIHAR PH II, REZANG LA MARG GURGAON.
5	R43	697573.431	3152563.389	216.932	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF HOUSE NO 146 NEAR BUS STOP, ASHOK VIHAR SECTOR 3, REZANG LA MARG GURGAON.
6	R44	697519.812	3152462.715	216.656	MARKED ON CC SLAB OF DIVIDER EDGE, BETWEEN HOUSE NO 384 SECTOR 5 AND H NO. 136 SECTOR 3, ASHOK VIHAR, REZANG LA MARG GURGAON.
7	R45	697459.064	3152339.837	216.316	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF HOUSE NO 233, ASHOK VIHAR SECTOR 5, REZANG LA MARG GURGAON.
8	R46	697350.873	3152159.886	217.07	MARKED ON C CURVE STONE OF FOOTPATH OPPOSITE SIDE OF DRONACHARYA COLLEGE OF ENGINEERING OFFICE, ASHOK VIHAR SECTOR3, REZANG LA MARG GURGAON.
9	R47	697232.914	3152119.787	217.015	MARKED ON CC SLAB OF DIVIDER EDGE, BETWEEN CANARA BANK SECTOR 3 AND POLICE BOOTH SECTOR 5, ASHOK VIHAR, REZANG LA MARG GURGAON.
DGPS 11A TO DGPS 12A					
1	R-49	702320.060	3154630.960	228.980	TRAVERSING POINT MARKED ON INTERSECTION OF MAJOR SUSHIL AIMA MARG AND OLD DELHI GURUGOAN ROAD AND IN FRONT OF ROYAL PG
2	R-50	702430.270	3154706.630	229.260	TRAVERS POINT MARKED ON DIVIDER IN FRONT OF PALAM VIHAR CHOWK BUS STATION AT OLD DELHI GURGOAN ROAD
3	R-51	702591.264	3154672.346	228.407	TRAVERSE POINT MARKED ON APPROACHING ROAD OF NAGARRO BUILDING SHAKESPEARE, JWALA MILL ROAD
4	R-52	702722.235	3154562.353	223.382	TRAVERSE POINT MARKED IN FRONT OF AVL INDIA PRIVATE LIMITED OFFICE AT JWALA MILL ROAD,
5	R-53	702857.210	3154473.347	229.773	TRAVERSE POINT MARKED INF FRONT OF WENS LINK OFFICE AT JWALA MILL ROAD
6	R-54	702986.519	3154440.241	230.050	TRAVERSE POINT MARKED INF FRONT OF RK INTERNET CAFÉ & CSC CENTER AT JWALA MILL ROAD

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
7	R-55	703202.152	3154410.249	230.760	TRAVERSE POINT MARKED INF FRONT OF CSD CANTEEN AT JWALA MILL ROAD
8	R-56	703432.295	3154446.726	232.729	TRAVERSE POINT MARKED NEAR THE BUS STOP OF ASF CENTER SNAPDEAL AT JWALA MILL ROAD
9	R-57	703542.025	3154416.510	232.734	TRAVERSE POINT MARKED INF FRONT OF MTS TOWERS AT JWALA MILL ROAD
10	R-58	703670.667	3154307.165	233.292	TRAVERSE POINT MARKED INF FRONT OF PARK FOR JUMMA MUBARAK PRAYERAT JWALA MILL ROAD
11	R-59	703820.985	3154196.784	234.049	TRAVERSE POINT MARKED INF FRONT OF PARK FOR THE SOCIAL STREET, HOUSE NO.329 AT JWALA MILL ROAD
12	R-60	704012.210	3154036.989	235.341	TRAVERSE POINT MARKED INF FRONT OF PROLOGIC FIRST INDIA PVTAT JWALA MILL ROAD
13	R-61	704149.496	3153923.858	235.895	TRAVERSE POINT MARKED AT INTERSECTION OF JWALA MILL ROAD AND DELHI JAIPUR EXPRESSWAY, OPPOSITE TO THE HVPNL SUB STATION
14	R-62	704248.172	3154032.235	236.743	TRAVERSE POINT MARKED IN FRONT OF OVERSEA INDAIN FACILITATION CENTER 249-F, SECTOR 18, UDYOG VIHAR, SECTOR 19,DELHI JAIPUR EXPRESSWAY
15	R-63	704356.251	3154155.949	237.811	TRAVERSE POINT MARKED INCOME TAX DEPARTMENT BUILDING,DELHI JAIPUR EXPRESSWAY
16	A1	704484.070	3154219.971	240.1407	TRAVERSE POINT MARKED AT INTERSECTION OF DELHI JAIPUR EXPRESSWAY , HIGHWAY ROAD OPPOSITE TO THE INDUSIND BANK CYBER CITY METRO STATION
17	A2	704574.061	3154298.836	239.2417	TRAVERSE POINT MARKED ALONG DELHI JAIPUR EXPRESSWAY HIGHWAY ROAD MARKED ON SERVICE ROAD OPPOSITE TO UNDER PASS ROAD NEAR BY INDUSIND BANK CYBER CITY METRO STATION
18	A3	704510.975	3154145.826	239.5354	TRAVERSE POINT MARKED ON FOOTPATH OF ROAD TO DLF PHASE II METRO STATION ROAD NEAR BY INDUSIND BANK CYBER CITY METRO STATION AND OPPOSITE OF DLF GATEWAY TOWER
19	A4	704505.099	3154179.293	239.1941	TRAVERSE POINT MARKED ABOVE UNDER PASS AND ON SERVICE ROAD AND BELOW INDUSIND BANK CYBER CITY METRO STATION BUILDING

S. NO.	STN. NO.	GPS CO-ORDINATES			DESCRIPTION
		EASTING	NORTHING	ELEVATION	
20	A5	704354.912	3153948.945	238.4419	TRAVERSE POINT MARKED AT INTERSECTION OF ON UNDER PAAS ROAD AND OPPOSITE CYBER HUB INDUS-IND BANK METRO EXIT GATE
21	A6	704484.035	3154179.805	239.324	TRAVERSE POINT MARKED AT INTERSECTION OF DELHI JAIPUR EXPRESSWAY, HIGHWAY ROAD OPPOSITE TO THE INDUSIND BANK CYBER CITY
22	A7	704201.996	3153786.964	237.0665	TRAVERSE POINT MARKED AT BEGINNING OF UNDERPASS ROAD TO DLF PHASE II METRO STATION
23	A8	704249.930	3153756.62	237.8157	TRAVERSE POINT MARKED ON FOOTPATH BETWEEN SERVICE ROAD AND DELHI JAIPUR EXPRESSWAY AND OPPOSITE OF INDUSIND BANK CYBER CITY METRO STATION
24	A9	704354.120	3153555.484	237.7404	TRAVERSE POINT MARKED ON SERVICE ROAD FROM INDUSIND BANK CYBER CITY METRO STATION TO VODAFONE BELVEDERE TOWER METRO STATION AND OPPOSITE OF INDUS TOWERS LIMITED
25	A10	704403.797	3153485.793	238.4984	TRAVERSE POINT MARKED ON SERVICE ROAD UNDER THE METRO LINE OF VODAFONE BELVEDERE TOWER METRO STATION
26	A11	704417.647	3153376.583	239.6275	TRAVERSE POINT MARKED AT SERVICE ROAD OPPOSITE OF VODAFONE METRO CAR PARKING RESERVED AND IN FRONT OF HOTEL CORPORATE PRIME

C. Establishment of Vertical Control





Establishment of vertical control was started from known benchmarks in drawings provided by HSIIDC for Gurgaon – Bawal MRTS Corridor. From this location, benchmark was transferred along the corridor using three stadia method of leveling with Auto levels. Every loops of level has been closed and closing error of leveling loops has been worked with the formula given below:

$$\sum BS - \sum FS = \sum RISE - \sum Fall = \text{Last R.L.} - \text{First R.L.}$$

Closing error within permissible limit has been adjusted. Permissible error in leveling is $6\sqrt{K}$ mm where K is length of the loop in km. The Leveling was carried out by a precision auto level with accuracy of $\pm 6\sqrt{K}$. Reduced levels of all traverse stations and permanent control points were taken by Double territory method. Benchmark has been established at interval of 500m along the corridor or as per instruction of site in- charge. Details of benchmarks are given in **TABLE 5.3**.

TABLE 5.3: LIST OF TBM

S. NO.	TBM NO.	EASTING	NORTHING	RL	DESCRIPTION
1	TBM1	696853.440	3152971.792	216.864	MARKED ON CIRCLE OF CC TILES IN FRONT OF BOB ATM IN GURGAON RAILWAY STATION PARKING GURGAON.
2	TBM2	697140.028	3152251.929	216.488	MARKED ON RCC MANHOLE IN FRONT OF SHRI SHAYAM VANDANA PROPERTIES, GURGAON RAILWAY STATION ROAD GURUGARAM.
3	TBM3	697395.207	3151763.59	217.158	MARKED ON CC TILES OF FOOT PATH APX.20M NE SIDE OF CHINTPURNI MATA MANDIR SECTOR 5 IN HUDA ROAD GURUGARAM.

S. NO.	TBM NO.	EASTING	NORTHING	RL	DESCRIPTION
4	TBM4	697543.243	3151307.644	218.088	MARKED ON RCC. PILLAR, SITUATED IN TRIANGULAR DIVIDER OF 4-7 SECTOR CHOWK, FRONT OF POLICE BOOTH, NEAR INOX MALL NEKI RAM MARG GURGAON.
5	TBM5	696799.462	3150964.666	217.17	MARKED IN RCC OF UNDERGROUND WATER TANK CIRCLE, PUMP HOUSE SECTOR 7 AND OPP. SITE SECTOR 4 NEKI RAM MARG GURGAON.
6	TBM6	695376.842	3150391.1	215.303	MARKED ON RCC MANHOLE OPPOSITE SIDE OF H.N. 56 SECTOR 9A, NEKI RAM MARG GURGAON.
7	TBM7	694821.018	3150210.527	214.718	MARKED ON RCC PILLAR, SITUATED IN OPPOSITE SIDE OF MADRAS COLONY SECTOR 9A NEAR GREEN WOOD PUBLIC SCHOOL, NEKI RAM MARG GURGAON.
8	TBM8	695459.772	3148644.457	216.859	MARKED ON RCC MANHOLE IN GREEN BELT (WOOD STORE) KADIPUR IND. AREA SECT. 37, OPPOSITE SIDE WINE SHOP SECTOR 10 HERO HONDA ROAD GURGAON.
9	TBM9	695748.915	3148120.885	218.136	MARKED ON RCC PILLAR, SITUATED NEAR 66KV POWER HOUSE GATE, SARASWATI ENCLAVE SECT. 10, HERO HONDA ROAD GURGAON.
10	TBM10	696647.429	3147312.163	219.772	MARKED ON RCC PILLAR, SITUATED IN FRONT OF SOBOHEMA AUTOMOBILE AND START POINT OF UNDER BY PASS NEAR HERO HONDA CHOWK, HERO HONDA ROAD GURGAON.
11	TBM11	697235.46	3146850.691	221.55	MARKED ON CC TILES IN FRONT OF SUDHIR POWER LTD SECTOR 34 NEAR UNDER BY PASS SUBHASH CHOWK ROAD GURGAON.
12	TBM12	697821.394	3146390.681	222.797	MARKED ON RCC PILLAR, SITUATED IN APX.37M SW SIDE OF HONDA CHOWK NEAR MALANI MARBLE, HONDA CHOWK SUBHASH ROAD GURGAON.
13	TBM13	698985.536	3146247.246	224.069	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH, OPPOSITE SIDE OF COLT BUILDING NEAR SUBHASH CHOWK, GURGAON.
14	TBM14	699881.523	3146479.434	226.008	MARKED ON RCC PILLAR, SITUATED IN DIVIDER FRONT OF PRAGATI HILLS SOCIETY SECT 47 PARK NEAR SUBHASH CHOWK, NETA JI SUBHASH MARG, GURGAON.

S. NO.	TBM NO.	EASTING	NORTHING	RL	DESCRIPTION
15	G64	700628.013	3146978.36	228.265	MARKED ON RCC PILLAR, SITUATED IN DIVIDER, NEAR SUKHMANI HOSPITAL SECTOR 38, NETA JI SUBHASH MARG, GURGAON.
16	G75	701945.97	3148597.43	230.24	MARKED ON RCC PILLAR, SITUATED IN FOOTPATH AND FRONT OF PLOT NO Q58 SOUTH CITY 1 SECTOR 40, NETA JI SUBHASH MARG, GURGAON.
17	G78	702277.125	3148978.957	232.263	MARKED ON RCC PILLAR, SITUATED IN DIVIDER BETWEEN PLOT NO1805 SECTOR 45 AND SECTOR 41 PARK, NETA JI SUBHASH MARG, GURGAON.
18	R6	697673.365	3153142.27	217.034	MARKED ON RCC SLAB OF COVER DRAIN IN FRONT OF HISAR AUTO MOBILE ASHOK VIHAR NEAR HP PETROL PUMP, GURGAON.
19	R10	698011.983	3154041.351	216.289	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SHREE RAM BUILDING MATERIAL AND TRADING, REZANG LA MARG GURGAON.
20	R18	699145.162	3154658.169	217.208	MARKED ON RCC. PILLAR, SITUATED IN FRONT OF QUALITY PAINTS HARDWARE STORE E BLOCK DHARM COLONY, PALAM VIHAR, REZANG LA MARG GURGAON.
21	R22	699632.3	3155172.817	218.321	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF POCKET F SECTOR 2 PALAM VIHAR, REZANG LA MARG GURGAON.
22	R26	700330.669	3155217.528	221.072	MARKED ON RCC. PILLAR, SITUATED IN FOOTPATH, FRONT OF GREEN BELT AND PLOT NO1290 F BLOCK CARTERPURI VILLAGE SECTOR 23A, MAJOR SUSHIL AIMA MARG GURGAON.
23	R29	700712.114	3155087.302	222.018	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF HOUSE NO 3717A/23 SECTOR 23, MAJOR SUSHIL AIMA MARG GURGAON.
24	R34	701363.107	3154634.819	224.834	MARKED ON C CURVE STONE OF FOOTPATH, IN FRONT OF TAU DEVI LAL PARK BOUNDARY WALL NEAR BUS STOP, MAJOR SUSHIL AIMA MARG GURGAON.
25	R41	697721.069	3152781.345	217.098	MARKED ON RCC. PILLAR, SITUATED IN OPPOSITE SIDE OF SAHANI FURNITURE SHOP, NEAR BALA TRADING COMPANY, REZANG LA MARG GURGAON.

S. NO.	TBM NO.	EASTING	NORTHING	RL	DESCRIPTION
26	R45	697459.064	3152339.837	216.316	MARKED ON C CURVE STONE OF FOOTPATH IN FRONT OF HOUSE NO 233, ASHOK VIHAR SECTOR 5, REZANG LA MARG GURGAON.
27	R-50	702430.270	3154706.630	229.260	MARKED ON DIVIDER IN FRONT OF PALAM VIHAR CHOWK BUS STATION AT OLD DELHI GURGOAN ROAD
28	R-53	702857.210	3154473.347	229.773	MARKED INF FRONT OF WENS LINK OFFICE AT JWALA MILL ROAD
29	R-56	703432.295	3154446.726	232.729	MARKED NEAR THE BUS STOP OF ASF CENTER SNAPDEAL AT JWALA MILL ROAD
30	R-59	703820.985	3154196.784	234.049	MARKED INF FRONT OF PARK FOR THE SOCIAL STREET, HOUSE NO.329 AT JWALA MILL ROAD
31	R-61	704149.496	3153923.858	235.895	MARKED AT INTERSECTION OF JWALA MILL ROAD AND DELHI JAIPUR EXPRESSWAY , OPPOSITE TO THE HVPNL SUB STATION
32	A9	704354.120	3153555.484	237.740	MARKED ON SERVICE ROAD FROM INDUSIND BANK CYBER CITY METRO STATION TO VODAFONE BELVEDERE TOWER METRO STATION AND OPPOSITE OF INDUSIND TOWERS LIMITED
33	A11	704417.647	3153376.583	239.628	MARKED AT SERVICE ROAD OPPOSITE OF VODAFONE METRO CAR PARKING RESERVED AND IN FRONT OF HOTEL CORPORATE PRIME

D. Detailed Survey of the Corridor

Based on Easting & Northing co-ordinates arrived by the traversing and Elevation by Precise Leveling, Detailed survey was carried out along the proposed metro route for 100m wide corridor (50m either side of the centre line of the road) or upto Built up line using total stations of desired accuracy. At some places instrument having reflector-less facilities has been used for collecting details of features due to inaccessibility of the area.

Survey covered picking up of relevant details like roads, footpaths, dividers/central verges, railway tracks, trees, manholes and other structures, H.T., L.T., Transmission lines, bridges, ROBs / RUBs, ponds, streams, major drains, level crossing, religious structures such as Temples, Gurudwaras, Mosques, Churches, Monuments, tombs etc. Spot/ Ground levels were taken at 25 m intervals in longitudinal as well as traverse direction and at sudden change of levels.

E. Preparation of Drawings

Drawings were prepared in Auto CAD format in 1: 1000 scale as per project requirement showing all the manmade and natural features. Different features are shown in different layers. Attributes of all the features like name of the road its width, name of railway line, name of the building and its number of stories, width of drains and its HFL, Type of overhead crossings (Electric and Telephone lines) and its rating have been provided in this drawings.

Details of all the religious structure such as Temple, Gurudwara, Church, Monuments, Tomb, etc have been shown in the drawing as per standard legend.

Spot levels have been shown in drawing to access the terrain of the area along with trees falling in said survey corridor of 100m. Control points, established during conducting the survey work, have been also shown in the drawings.

F. Site Verification of Features

Details of features shown in the drawings were verified at site and additional details were collected and incorporated in the drawing wherever needed.

G. Preparation of Alignment Drawing

Based on the finalized topographical survey drawing, the alignment design was done using Mx-Rail software.

5.1.2 Route Alignment

One corridor alongwith a spur, has been finalized for implementation in Gurgaon Metro Rail Project network. **The total length of the corridor and the spur comes out to be 28.50 km.** The details of the corridor are as follows:

1. Main Corridor from HUDA City Centre to Cyber City, Gurgaon (26.65 Km).
2. Spur from Basai Village to Dwarka Expressway (1.85 Km).

5.1.2.1 Corridor: HUDA City Centre to Cyber City, Gurgaon

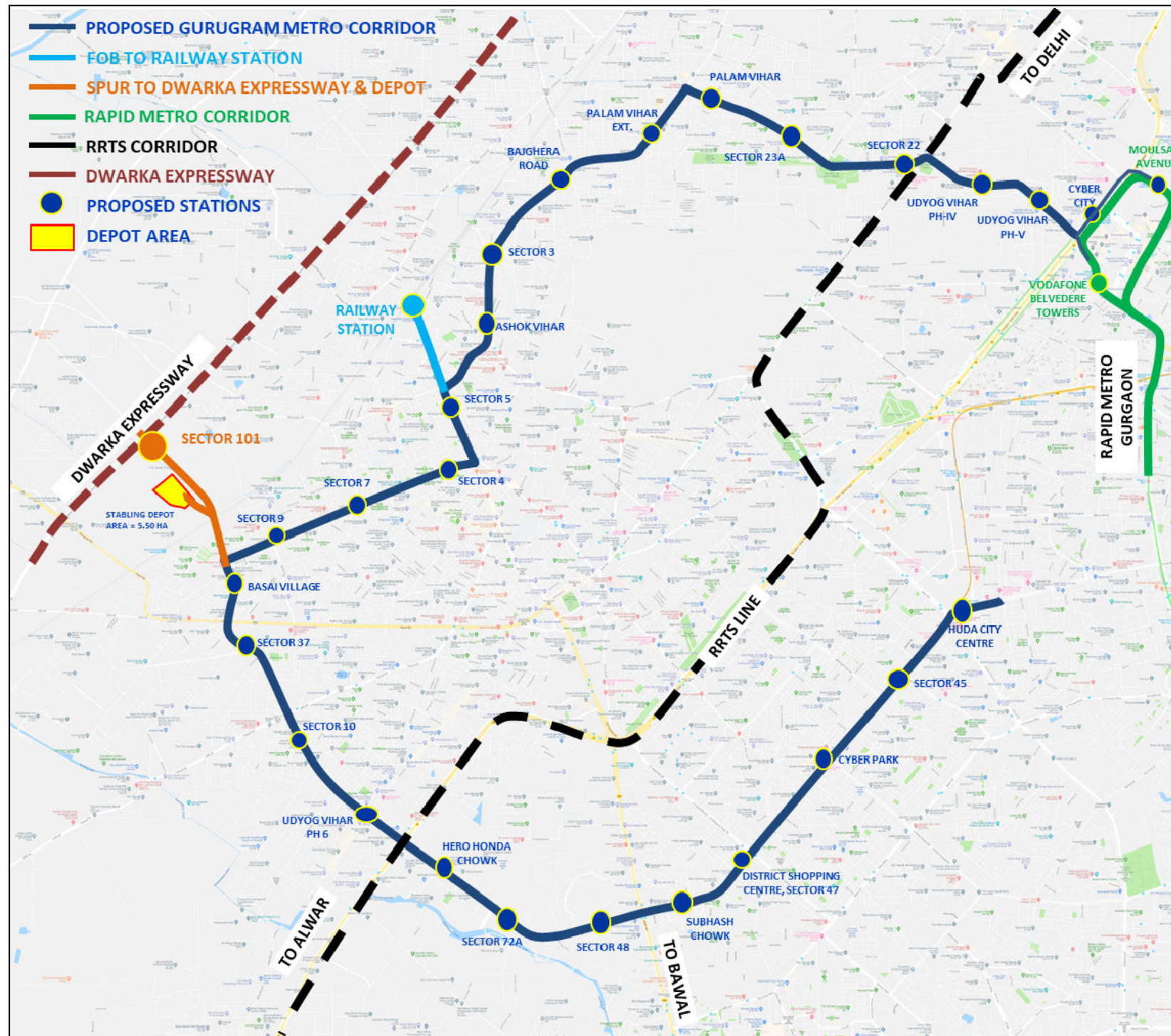
Alignment Description

Considering centre line of HUDA City Centre station as 0.00m, this corridor is 26.65 km long starting from Ch: (-)400m at HUDA City Centre and terminates at Ch: 26250m at Cyber City. This corridor consists of completely elevated stretch as detailed in **Figure 5.1**.

The Alignment of main corridor i.e. HUDA City Centre to Cyber City is described in detail in following sub sections:-

- i. HUDA City Centre to Subhash Chowk
- ii. Subhash Chowk to Basai Village
- iii. Basai Village to Sector-5
- iv. Sector-5 to Udyog Vihar Phase-V
- v. Udyog Vihar Phase-V to Cyber City

FIGURE 5.1: PROPOSED GURGAON METRO CORRIDOR



i. HUDA City Centre to Subhash Chowk

- Total length of the section is about 4.50 Km and is completely elevated.
- 5 elevated stations namely HUDA City Centre, Sector-45, Cyber Park, District Shopping Centre, Sector 47 and Subhash Chowk have been proposed in this section.
- HUDA City Centre Station has been proposed near the existing HUDA City Centre Station of Delhi Metro. Both the stations will be integrated using a foot-over bridge.
- Three options have been worked out for the location of HUDA City Centre Station, which have been discussed in detail in **para 5.2.1.4**. From HUDA City Centre Metro Station, the alignment runs along Netaji Subhash Marg on its green belt since the Delhi Metro's viaduct for reversal facility, lies on the median of the road. Thereafter, the alignment runs on the median along Netaji Subhash Marg.
- GMDA has proposed a low height flyover in front of HUDA City Centre Metro station and an underpass for the right turning traffic coming from Signature Tower. The construction of the flyover and the underpass has already begun. **Figure 5.3** and **Figure 5.3** show the plan and cross-section of the under-construction flyover.
- During the meeting held on 14th March, 2019 under the chairmanship of CEO, GMDA, it was decided that since the HUDA City Centre Metro station of the proposed corridor is also planned along the existing median of the road, where new flyover is proposed by GMDA. GMDA will modify the design of the flyover keeping space of 3.0m in centre for locating the piers of the proposed Metro Corridor. The Metro station height shall be proposed duly considering the road level of the proposed flyover.
- Rest of the four stations have also been proposed on Netaji Subhash Marg, having an RoW of 60m. No land acquisition will be required for planning these four stations. The entry/exits have also been planned on government land including footpaths and service roads.
- These stations will serve the major residential and business centre of Sector-41, 44, 45, 40, 46, 39 (Jharsa Village), 38 and 47.
- 4 Nos. of HT towers fall in the way of proposed alignment between HUDA City Centre station and Subhash Chowk station. Consequently, shifting/relocation of the towers would be required.
- Due to the presence of reversal facility extended from Delhi Metro's HUDA City Centre Station, portal has been proposed for elevated span to bring the alignment from off the road to the median of the road, as shown in **Figure 5.4**.
- The proposed Metro alignment is following the Netaji Subhash Marg median and to cross the Bakhtawar Chowk, one option is to provide portal arrangement to become off the road and then again come back to the median. However, this arrangement will traverse through private land and also introduce additional curves in the alignment. To avoid this, special span is proposed with span configuration of (34m + 60m + 34m). The arrangement has been shown in **Figure 5.5**.
- Portals are also proposed at start and end of Subhash Chowk Flyover due to the deviation of alignment from median of the road to off the road and vice versa, respectively, as shown in **Figure 5.6** and **Figure 5.7**.

FIGURE 5.2: PLAN OF UNDER-CONSTRUCTION FLYOVER & UNDERPASS NEAR EXISTING HUDA CITY CENTRE METRO STATION

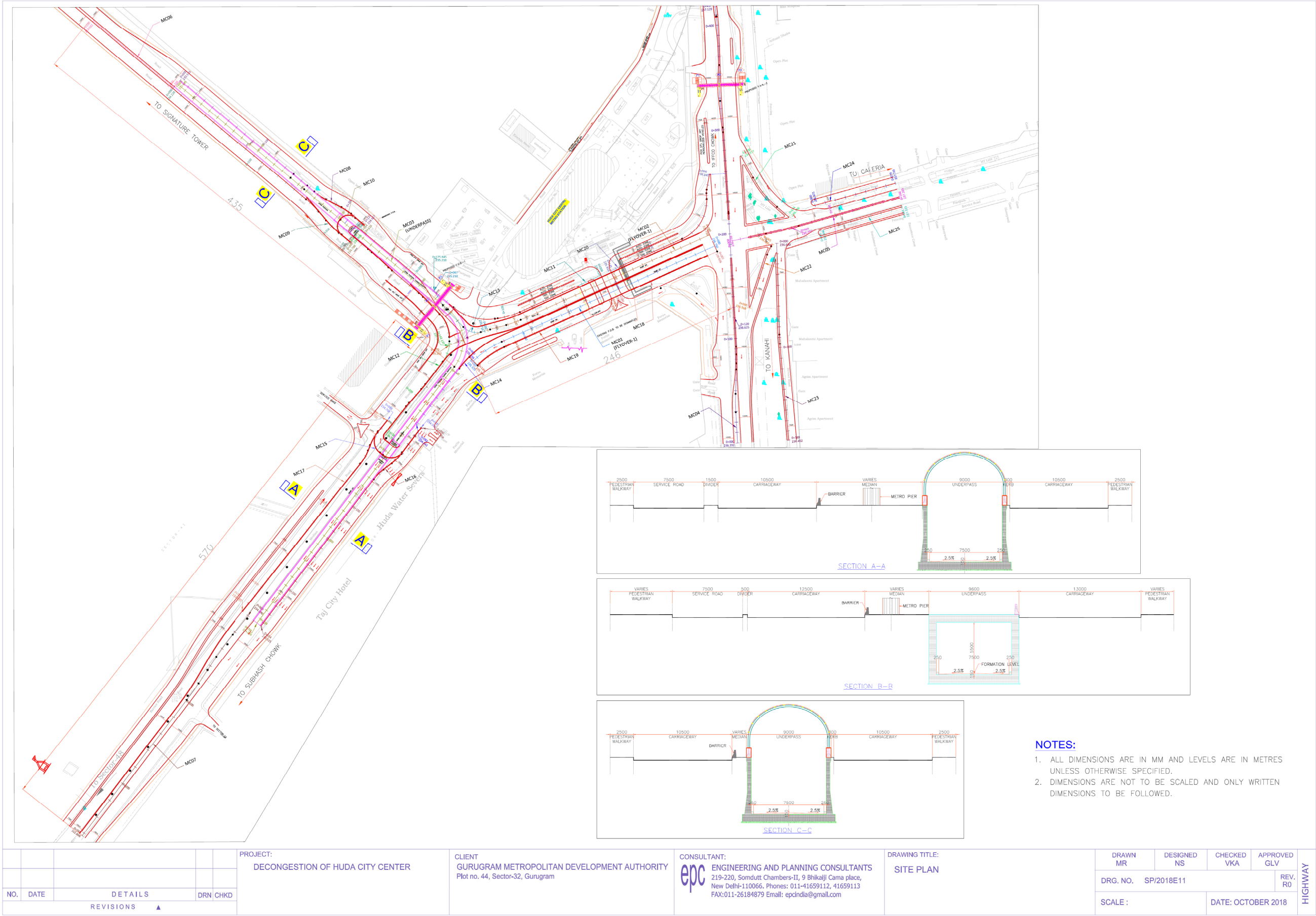
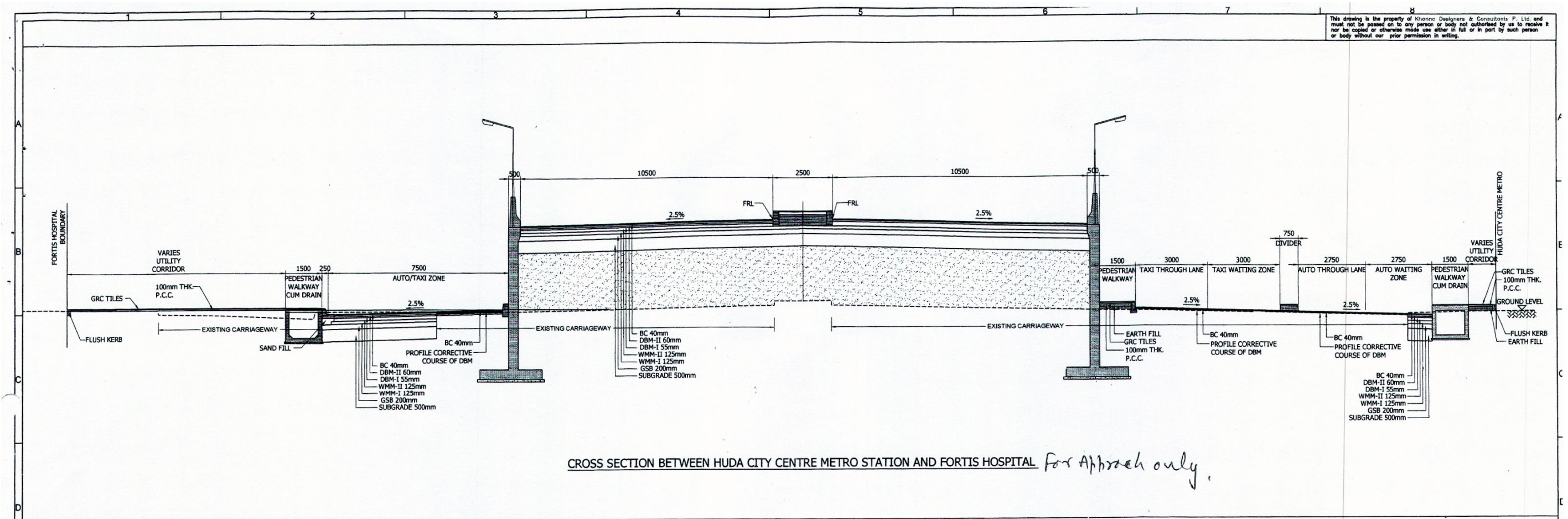


FIGURE 5.3: CROSS-SECTION OF UNDER-CONSTRUCTION FLYOVER NEAR EXISTING HUDA CITY CENTRE METRO STATION



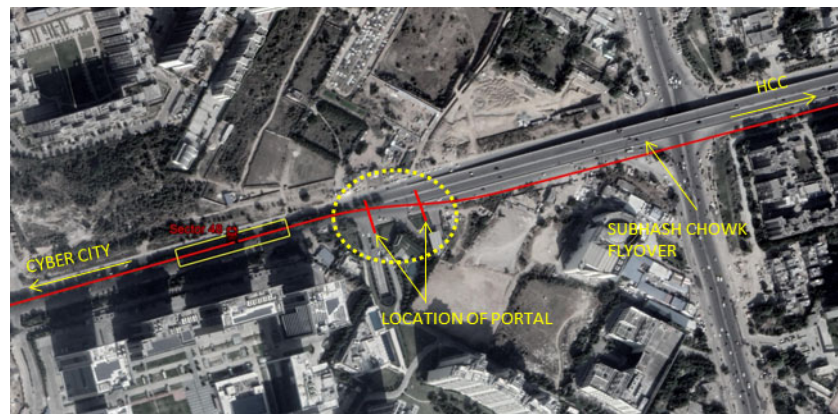
- Earlier, Haryana State Industrial and Infrastructure Development Corporation (HSIIDC) had proposed MRTS corridor from HUDA City Centre to Bawal. This corridor was also proposed to run along Netaji Subhash Marg upto Subhash Chowk, thereafter, it would have turned left towards Sohna Road to continue upto Bawal. For the stretch upto Subhash Chowk, both the Metro Systems (HMRTC and HSIIDC) were proposed to operate on a common viaduct, sharing same Signaling and Telecommunication Systems.
- As per S. No. 5.7, Agenda Item No. 4.3 of Minutes of Fourth Meeting held on 27th May, 2019 (**Annexure 1**) under the chairmanship of Hon'ble Chief Minister of Haryana, the HSIIDC corridor between HUDA City Centre and Subhash Chowk was unlikely to find justification from the ridership estimation. Hence, it was proposed that the new alignment for the HSIIDC Metro could be from Sohna Adda – Rajiv Chowk – Subhash Chowk onwards. Thereafter, Subhash Chowk would be the interchange station for both the MRTS corridors.

FIGURE 5.4: LOCATION OF PORTAL NEAR HUDA CITY CENTRE



FIGURE 5.5: LOCATION OF SPECIAL SPAN AT BAKHTAWAR CHOWK

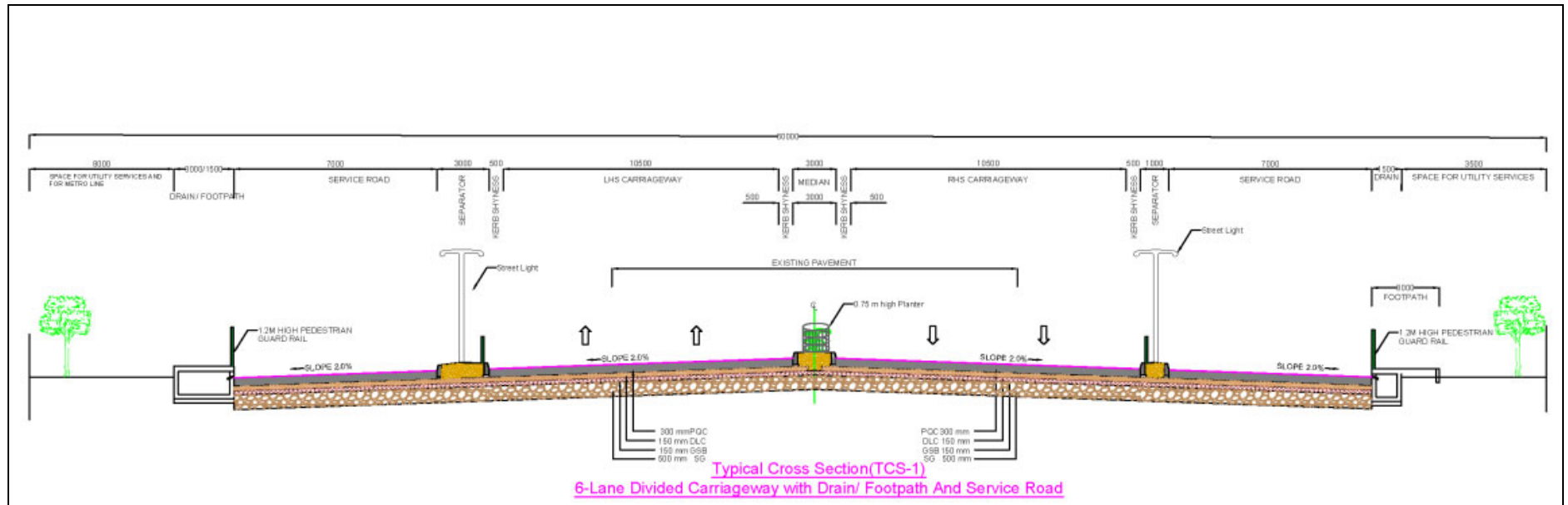


FIGURE 5.6: LOCATION OF PORTAL AT THE START OF SUBHASH CHOWK FLYOVER**FIGURE 5.7: LOCATION OF PORTAL AT THE END OF SUBHASH CHOWK FLYOVER**

ii. Subhash Chowk to Basai Village

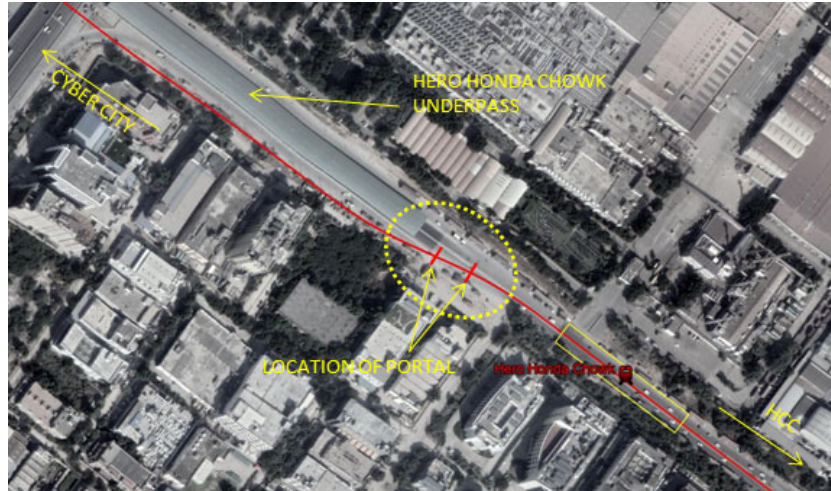
- Total length of the section is about 8 Km and is completely elevated.
- After Subhash Chowk station, the alignment runs to the South of existing Subhash Chowk flyover. The alignment then follows the median of Hero Honda Road and crosses Hero Honda Chowk being to the south of existing underpass and above the existing NH-8 maintaining the necessary clearance.
- NHAI is in process of widening of Hero Honda Road with the proposed RoW of 60m, from the end of underpass upto Umang Bhardwaj Chowk. A flyover is also proposed at Umang Bhardwaj Chowk.
- Thereafter, Gurgaon Metropolitan Development Authority (GMDA) has proposed widening of the existing Basai Road (RoW of 60m) upto Dwarka Expressway with a flyover at Basai Chowk and Railway track crossing. The construction of this section has already started.
- Both the proposed widenings of roads have provision of the Metro corridor on the west, from where the alignment has been proposed to pass. The typical cross-section for the widening is shown in **Figure 5.6**.
- 7 elevated stations namely Sector-48, Sector-72A, Hero Honda Chowk, Udyog Vihar Phase 6, Sector-10, Sector-37 and Basai Village have been proposed in this section.

FIGURE 5.8: PROPOSED CROSS-SECTION FOR WIDENING OF ROAD



- The stations on this section will primarily serve residential and business centre of Sector-48, Hero Motocorp Factory, Manufacturing and business centres of Sector-34, residential area of Sector-10, 37 and Basai Village.
- The Sector-10 station will have passenger integration facilities with Sector-10 Bus Terminal.
- The available 8m width for Metro can accommodate viaduct but the stations and their entry/exit in this section will require land acquisition, out of the available 60m RoW.
- To deviate the alignment from median of the road to the south of underpass at Hero Honda Chowk, portals have been proposed as shown in **FIGURE 5.9**.

FIGURE 5.9: LOCATION OF PORTAL AT START OF HERO HONDA CHOWK UNDERPASS



- The alignment crosses NH-8 flyover and RRTS alignment at Hero Honda Chowk at double height and it will require special span arrangement of (34m + 45m + 75m + 45m + 34m), as shown in **FIGURE 5.10**.

FIGURE 5.10: LOCATION OF SPECIAL SPAN AT HERO HONDA CHOWK



- The alignment crosses Pataudi Road at Umang Bhardwaj Chowk, where a special span arrangement of (34m + 60m + 34m) will be required, as shown in **FIGURE 5.11**.

FIGURE 5.11: LOCATION OF SPECIAL SPAN AT UMANG BHARDWAJ CHOWK



iii. Basai Village (11642m) to Sector-5 (15462m)

- This section is also completely elevated with a length of 3.80 km and consists a total of 4 nos. elevated stations namely Sector-9, Sector-7, Sector-4 and Sector-5.
- After crossing Basai Village station, the alignment turns right on to Neki Ram Marg and then left to Old Railway Road. A spur is proposed to originate at the turn of alignment from Basai Road to Neki Ram Marg, which is discussed in the section **para 5.1.2.2**.
- The RoW of Neki Ram Marg is about 45m, such that all the above mentioned stations along with their entry/exits have been planned without land acquisition. A part of service roads will be acquired for accommodating entry/exits.
- Basai Village station will serve as the interchange station with proposed spur to Dwarka Expressway.

iv. Sector-5 to Udyog Vihar Phase-V

- Total length of the section is about 9 Km and is completely elevated.
- 9 elevated stations namely Ashok Vihar, Sector-3, Bajghera Road, Palam Vihar Extension, Palam Vihar, Sector-23A, Sector-22, Udyog Vihar Ph-IV and Udyog Vihar Ph-V have been proposed in this section.
- Gurgaon Railway Station will get its connectivity with Metro from Sector-5 station. It is proposed to connect the Railway Station using a Skywalk with Travellers.
- The alignment in this section has been proposed along Carterpuri Road upto Rezangla chowk, Major Sushil Aima Marg upto Sector-22 and along Jwala Mill Road upto NH-8.
- The existing Major Sushil Aima Road is without median. The piers of the Metro corridor will act as the median for the road. About 2.0m of the road width (at the centre) will be occupied

by the piers. Widening of the existing road for a 4-lane divided carriageway will be required. Sufficient road width is available for road widening without any land acquisition.

- The Jwala Mill road is presently 10-12m wide and is having undivided carriageway. GMDA has proposal to widen the road to 30m. Accordingly, the alignment has been planned along the proposed median of the road.
- A number of HT towers are being erected along Carterpuri Road. The HT lines run along and across the road, which will required to be shifted prior to the construction of Metro.
- At Sector-22 station, the alignment integrates with Udyog Vihar station of proposed Regional Rapid Transit System (RRTS) corridor from Sarai Kale Khan (Delhi) to Alwar (Rajasthan) by NCRTC.
- The Udyog Vihar station (RRTS) is proposed at the junction of Old Delhi-Gurgaon Road and Major Sushil Aima Marg. The metro viaduct if passes above the Udyog Vihar station would greatly increase the height of metro viaduct and also the cost of the project. Consequently, it is recommended to propose the shifting of the RRTS station further to the South for about 300m along their alignment.
- During the meeting chaired by CEO, GMDA held on 14th March, 2019, it was conveyed to NCRTC to shift the Udyog Vihar RRTS station towards south, so that the height of the metro corridor can be restricted. Accordingly, NCRTC has shifted the location of the Udyog Vihar RRTS station. The rail level of the proposed RRTS corridor at the point of crossing is 238m i.e. about 13.0m above the existing ground level of 225m. The rail level of the Metro corridor has accordingly, been kept as 248m, so as to provide clearance of 10m above the rail level of the RRTS corridor.
- After crossing RRTS alignment, the alignment runs on Jwala Mill Road to reach Udyog Vihar Phase-V station.
- Entry to Phase-V Stabling Depot (3.1 Ha) has been planned in the IDPL land. Proposed layout and connectivity to the Phase-V Depot is shown in Error! Reference source not found..
- Since, track integration with the Rapid Metro has been proposed and existing infrastructure facilities are to be used. The existing maintenance depot of Rapid Metro will be used as primary depot. To meet the balance requirement, one stabling depot in State Government land (IDPL) has been proposed with an area of 3.10 Hectare. Entry to Udyog Vihar stabling depot-1 has been planned from Udyog Vihar Ph-IV station. Error! Reference source not found. shows proposed entry and depot layout.

v. Udyog Vihar Phase-V to Cyber City

- During the meeting chaired by CEO, GMDA held on 14th March, 2019, it was proposed by the CEO to check the feasibility of track integration with Rapid Metro to avoid interchange between proposed Gurgaon Metro and existing Rapid and Delhi Metros.
- Several rounds of meetings were held between RITES and Rapid Metro officials and the following issues were found:
 - The stations of Rapid Metro are designed for 3-car system whereas Gurgaon Metro is proposed for 6-car system.

- The traction system for Delhi Metro and proposed Gurgaon Metro is 25 kV AC OHE whereas, in Rapid Metro, the traction system is 750V DC 3rd rail.
- The issues were discussed in detail and the track integration with Rapid Metro was found feasible. Accordingly, the same was informed to the HMRTC.
- During meeting chaired by Hon'ble Chief Minister of Haryana on 27th May, 2019, as per point No. 5.3, Agenda Item No. 4.3, "DPR for Metro Connectivity in Gurgaon", after detailed deliberations, it was decided to have seamless track integration between the Rapid Metro and the proposed Metro corridor.
- RITES informed the officials of Govt. of Haryana that the integration with the Rapid Metro is technically feasible after adopting some measures like, having 750V DC 3rd rail traction system and modification of existing Rapid metro stations for 6-car system (when the requirement comes). The same was approved during the meeting.
- Thus, Gurgaon Metro is now proposed to have its connectivity with Rapid Metro through track integration. The advantage would be a seamless connectivity between the proposed Metro and Delhi Metro with interchange at Sikandarpur Metro Station.
- The alignment in this section would utilize the existing tracks of Rapid Metro.
- Metro train coming from HUDA City Centre, after crossing Udyog Vihar Ph-V station, reaches Shyam Chowk and then turns left on Green Belt, running parallel to NH-8 upto Shankar Chowk. A station, Cyber City, is proposed on the green belt with one side platform only.
- At Shankar Chowk, the alignment turns right crossing NH-8 at second level. Rapid metro has kept provision for extra track on one side of Micromax Mousari Avenue station (as shown in **Figure 5.12**), where the merging of proposed metro would take place with Rapid Metro after crossing NH-8.

FIGURE 5.12: MICROMAX MOULSARI AVENUE RAPID METRO STATION



- The metro is then proposed to follow Rapid metro route upto Sector-56 via Micromax Mousari Avenue station, DLF Phase-III, DLF Phase-II and Sikandarpur metro station upto Sector-56 station.
- Rapid Metro has left provision of additional track after Vodafone Belvedere Towers Rapid Metro station also (as shown in **Figure 5.13**). The metro coming from Sector-56 would reach Vodafone Belvedere Towers Rapid Metro station via Sikandarpur and DLF Phase-II Rapid Metro stations. Thereafter, it would reach Shyam Chowk crossing NH-8 at second level and then connect with the Gurgaon metro corridor to go upto HUDA City Centre.

FIGURE 5.13: VODAFONE BELVEDERE TOWERS RAPID METRO STATION



- Stabling depot with an area of 5.50 hectare has been proposed in the private land at Sector-101. The land is low lying area and may require permission from Environment department. Provision for future stabling lines has been made in the depot. These future stabling lines can be constructed once the requirements of stabling lines for the rolling stock cannot be met by main depot at Sector-55 and stabling lines already constructed in Sector-101 depot.
- The route/movement of the metro is described in **Table 5.4** and is shown in

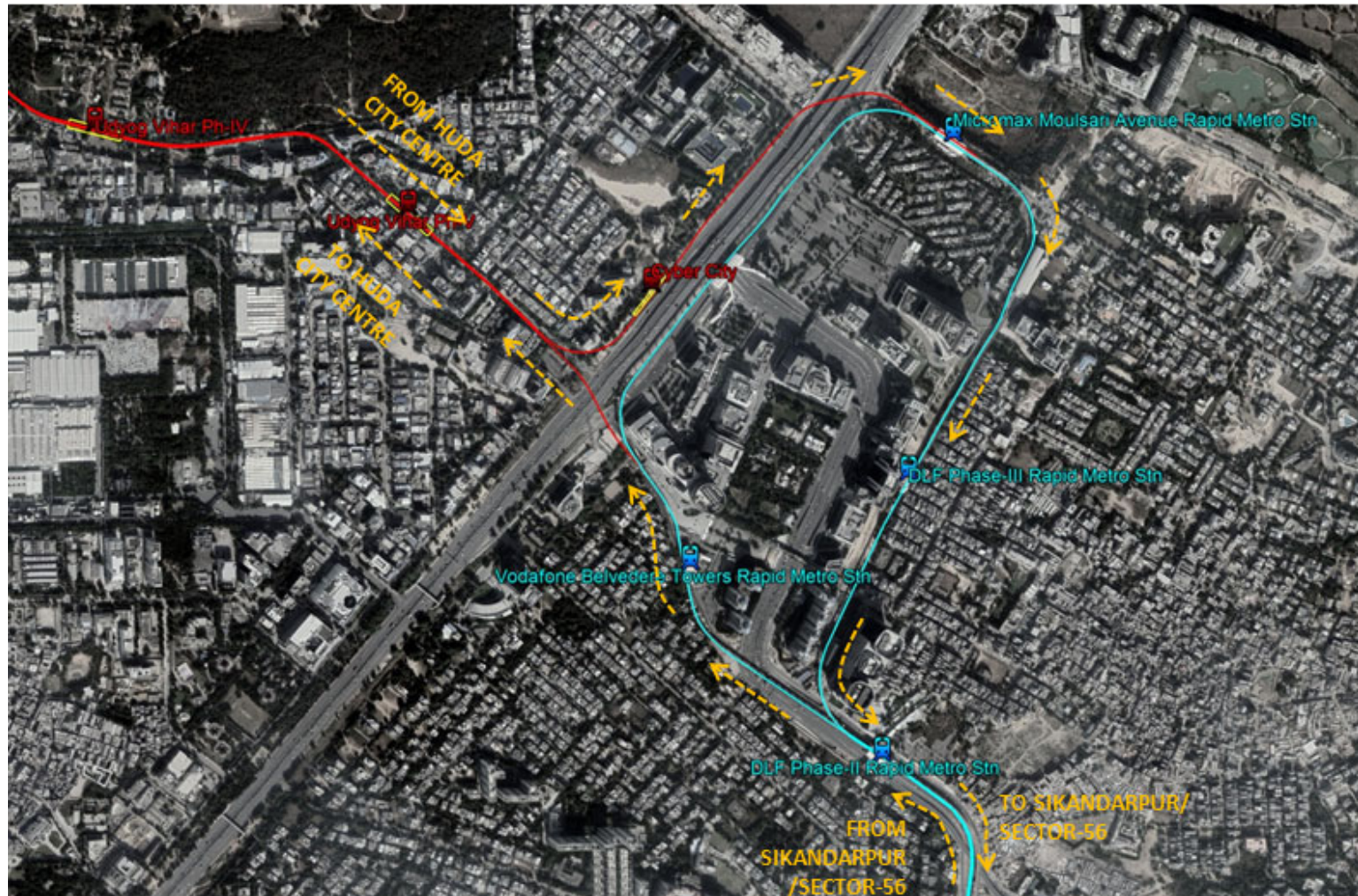
- FIGURE 5.14.

TABLE 5.4: MOVEMENT OF METRO TRAIN UP/DOWN LINE

Direction	Route/Movement	Description
UP	HUDA City Centre to Sector 56	HUDA City Centre (GM) – Udyog Vihar Ph V (GM) – Cyber City (GM) – Mousari Avenue (RM) – DLF Phase III (RM) – DLF Phase II (RM) – Sikandarpur (RM/DMRC) – Sector 56 (RM)
DOWN	Sector 56 to HUDA City Centre	Sector 56 (RM) – Sikandarpur (RM/DMRC) - DLF Phase II (RM) – Belvedere Towers (RM) - Udyog Vihar Ph V (GM) - HUDA City Centre (GM)

**GM = Gurgaon Metro; RM = Rapid Metro; RM/DMRC = Inter-change Station of DMRC Yellow Line & Rapid Metro*

FIGURE 5.14: INTEGRATION/CONNECTIVITY WITH RAPID METRO & METRO MOVEMENT

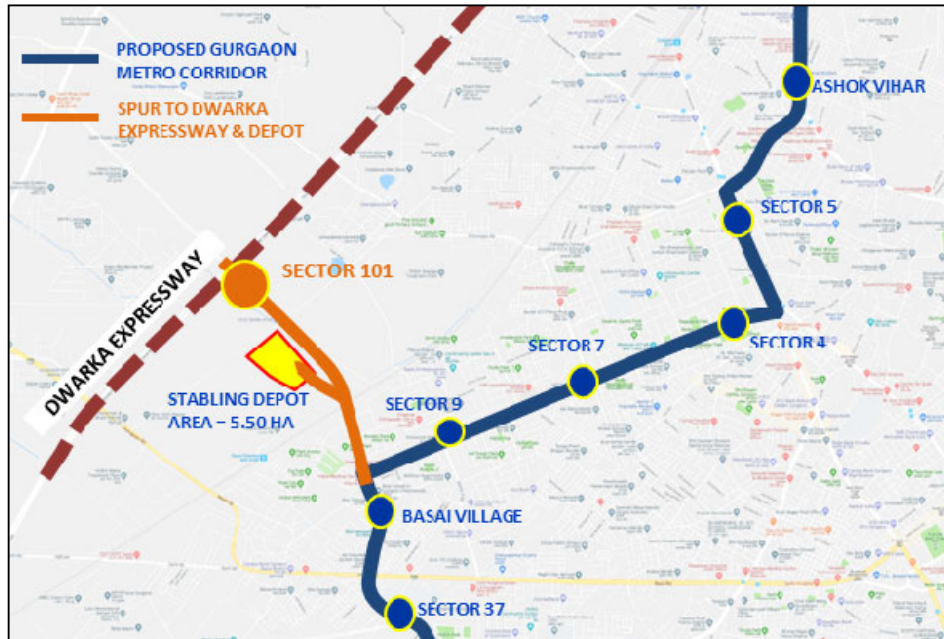


5.1.2.2 Spur to Dwarka Expressway

Alignment Description

The spur takes off from Ch: 11700m after crossing Basai Village station and terminates at Dwarka Expressway (Sector 101). The spur consists of completely elevated stretch as detailed in **Figure 5.15**.

FIGURE 5.15: PROPOSED SPUR TO DWARKA EXPRESSWAY



- Total length of the spur is about 1.85 km. Entry to stabling depot is 300 m long.
- Entry to Sector-101 Stabling Depot (5.50 Ha) has been planned after crossing the railway tracks.
- Proposed layout and connectivity to stabling Depot at Sector 101 is shown in **FIGURE 5.16**.
- The purpose of the spur is to connect Gurgaon Metro with Dwarka Expressway and the proposed MRTS corridor of HSIIDC planned along Dwarka Expressway.
- 1 elevated station namely Sector-101 has been proposed near the junction of Dwarka Expressway. This station will have integration with the station of proposed MRTS Corridor of HSIIDC along Dwarka Expressway.
- The spur crosses existing Railway tracks between Basai Village and Dwarka Expressway. The alignment has been kept on the left edge of the under-construction road, well within the acquired road RoW. Special span is proposed with span configuration of (30m + 45m + 30m). The span arrangement is shown in Error! Reference source not found.

FIGURE 5.16: CONNECTIVITY TO SECTOR 101 STABLING DEPOT

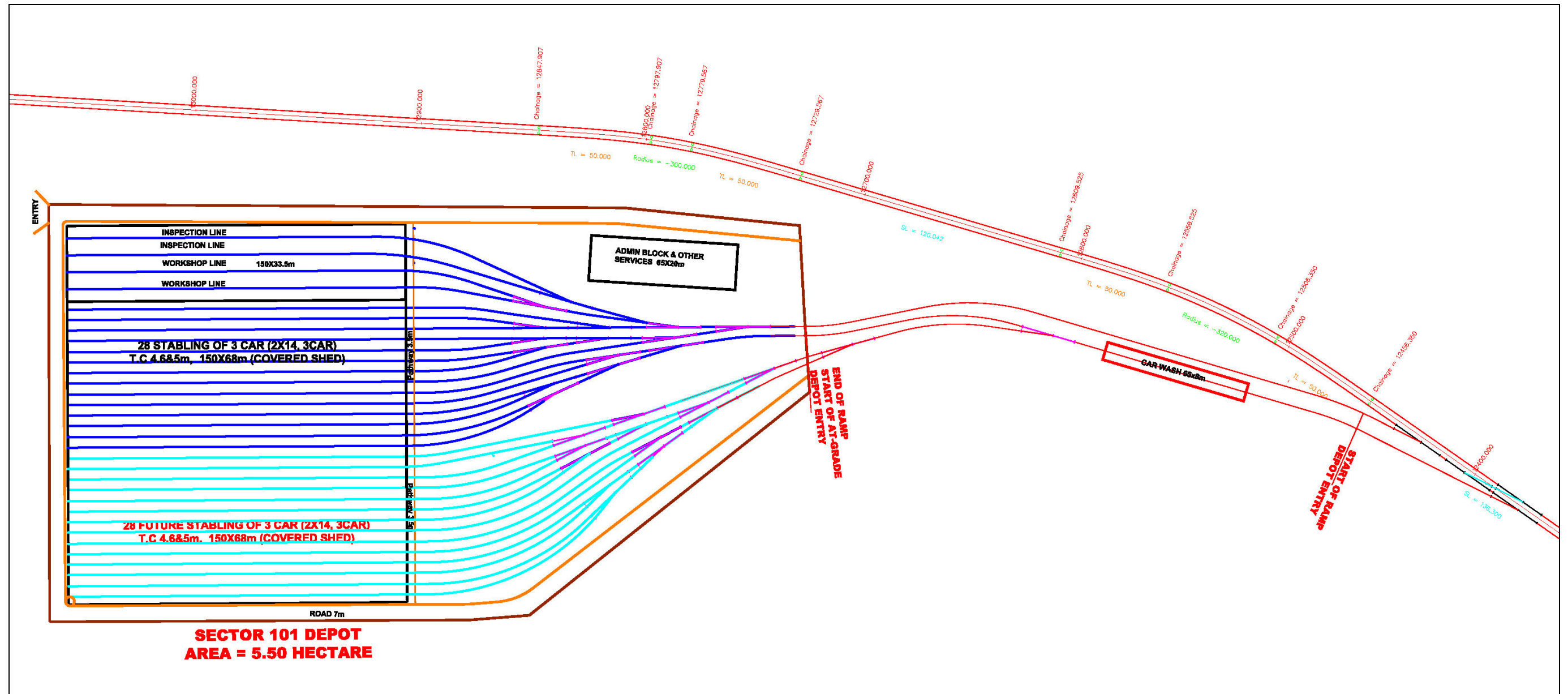


FIGURE 5.17: LOCATION OF SPECIAL SPAN AT RAILWAY TRACKS

5.1.3 Stations

- Stations have been located so as to serve major passenger catchment areas and to enable convenient integration with other modes of transport.
- Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, availability of open land, interchange requirements with other modes of transport, construction feasibility, inter station distance, alignment, utilities, road and pedestrian requirements, future infrastructural developments and joint site visits & consultations with ADA.
- Possibility of Parking space at all the stations has also been explored.
- Considering the track integration with Rapid Metro, the operations of the system will start from existing Sector-56 Rapid Metro station. List of stations along with their chainage and interstation distances (ISD) for Corridor and spur, in the direction from HUDA City Centre to Sector-56 including the existing is given in **Table 5.5** and from Sector-56 to HUDA City Centre is given in **Table 5.6**. Wherever space and site condition permits, portal type arrangement is proposed for elevated stations. However, due to limited ROW and narrow roads, most of the elevated stations are proposed with Cantilever type arrangement, which is also used extensively in Jaipur Metro and for specific stations in LMRC as well as DMRC.
- Names of the stations have been discussed and agreed with GMDA and HMRTC and can be changed during implementation.
- Schematic diagram for Gurgaon Metro corridors is shown in **Figure 5.18**.

TABLE 5.5: LIST OF STATIONS FOR CORRIDOR FOR HUDA CITY CENTRE TO SECTOR-56 DIRECTION

S.No.	Station Name	Chainage (m)	Inter Station Distance (m)	Ground Level (m)	Proposed Rail Level (m)	Station Height (m)	Proposed Length (m)	Proposed Width (m)
Huda City Centre to Mousari Avenue								
1	HUDA City Centre	0	0	236.06	252.5	16.44	130	20
2	Sector 45	1000	1000	232.03	244.8	12.77	130	20
3	Cyber Park	2200	1200	229.1	241.6	12.5	130	20
4	District Shopping Centre, Sector 47	3665	1465	228.15	240.8	12.65	130	20
5	Subhash Chowk	4480	815	225.89	238.5	12.61	130	20
6	Sector 48	5500	1020	223.87	236	12.13	130	20
7	Sector 72A	6370	870	223.07	235.2	12.13	130	20
8	Hero Honda Chowk	7400	1030	221.47	234	12.53	130	20
9	Udyog Vihar Phase 6	8659	1259	219.04	232	12.96	130	20
10	Sector 10	9535	876	217.71	232	14.29	130	20
11	Sector 37	10815	1280	216.38	229	12.62	130	20
12	Basai Village	11645	830	215.17	228	12.83	130	20
13	Sector 9	12438	793	214.85	227.5	12.65	130	20
14	Sector 7	13215	777	215.35	228	12.65	130	20
15	Sector 4	14480	1265	217.03	229.5	12.47	130	20
16	Sector 5	15465	985	216.85	229.5	12.65	130	20
17	Ashok Vihar	16510	1045	216.79	229.3	12.51	130	20
18	Sector 3	17510	1000	216.15	228.7	12.55	130	20
19	Bajghera Road	18435	925	216.42	229	12.58	130	20
20	Palam Vihar Extension	19591	1156	217.56	230.2	12.64	130	20

S.No.	Station Name	Chainage (m)	Inter Station Distance (m)	Ground Level (m)	Proposed Rail Level (m)	Station Height (m)	Proposed Length (m)	Proposed Width (m)
21	Palam Vihar	20400	809	220.07	232.8	12.73	130	20
22	Sector 23A	21491	1091	223.23	235.7	12.47	130	20
23	Sector 22	22773	1282	228.06	248	19.94	130	20
24	Udyog Vihar Phase-IV	23653	880	230.38	242.5	12.12	130	20
25	Udyog Vihar Phase-V	24476	823	233.8	246	12.2	130	20
26	Cyber City	25235	759	238.14	246	7.86	130	11
Existing Rapid Metro: Moulisari Avenue to Sector 56								
27	Moulisari Avenue	26175	940	240.748	255	14.26	75	15
28	Dlf Phase-3	27147	972	242.95	252.208	9.258	65	11
29	Dlf Phase-2	27916	769	241.768	255.608	13.84	75	15
30	Sikanderpur	28762	846	246.1	253.5	7.4	90	15
31	Dlf Phase-1	29822	1060	247.56	261.2	13.64	75	15
32	Sector 42-43	31397	1575	248.95	261.2	12.25	75	15
33	Sector 53-54	32662	1265	250.22	261.2	10.98	75	15
34	Sector 54 Chowk	34232	1570	248.21	261.2	12.99	75	15
35	Sector 55-56	35292	1060					
Metro Spur: Basai Village to Dwarka Expressway								
13	Sector 101	13431	1786	214.36	226.5	12.14	130	20

TABLE 5.6: LIST OF STATIONS FOR CORRIDOR FOR SECTOR-56 TO HUDA CITY CENTRE DIRECTION

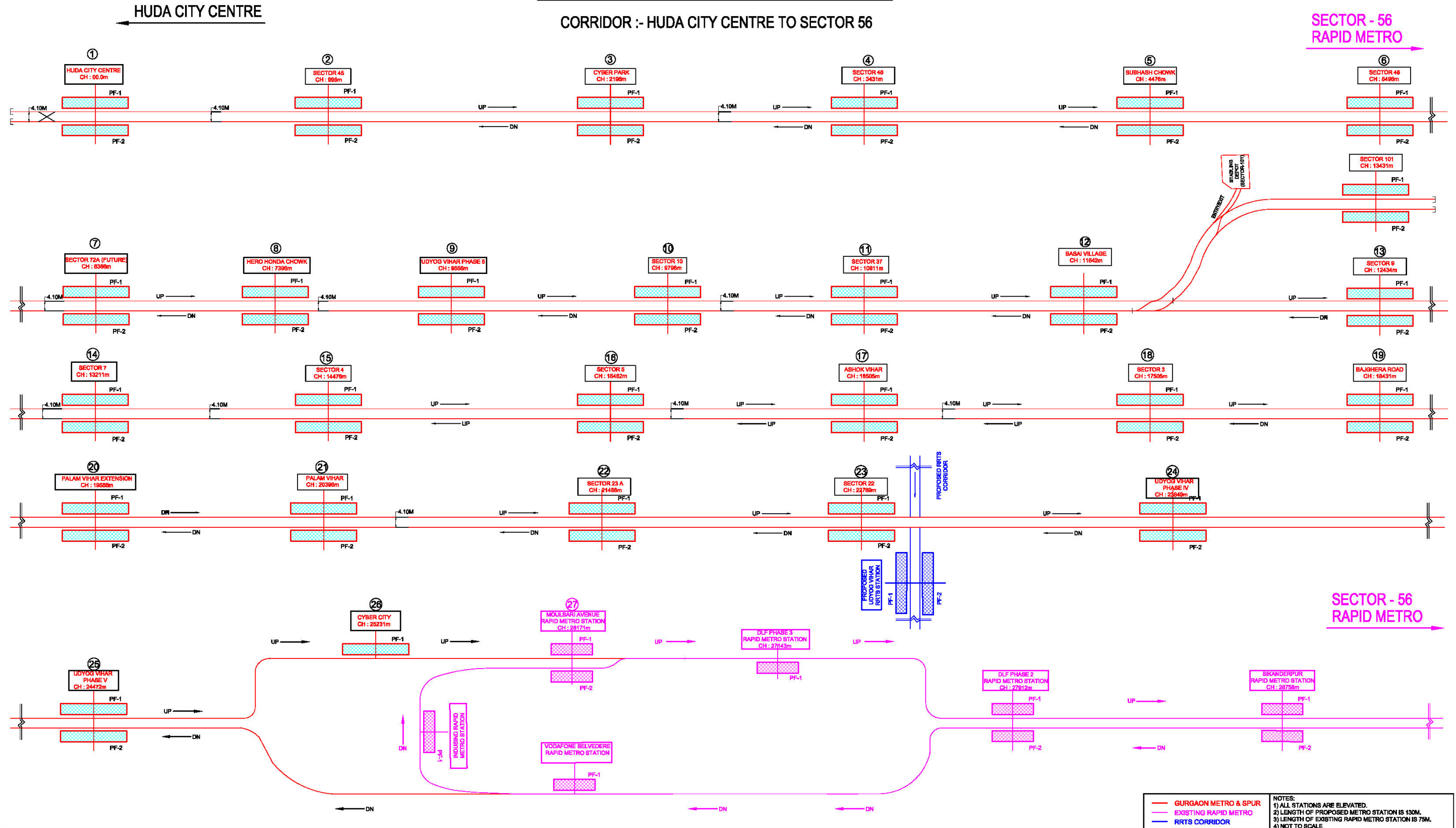
S.No.	Station Name	Chainage (m)	Inter Station Distance (m)	Ground Level (m)	Proposed Rail Level (m)	Station Height (m)	Proposed Length (m)	Proposed Width (m)
Sector 56 to Belvedere Towers								
1	Sector 55-56	0	-					
2	Sector 54 Chowk	1060	1060	248.21	261.2	12.99	75	15
3	Sector 53-54	2630	1570	250.22	261.2	10.98	75	15
4	Sector 42-43	3895	1265	248.95	261.2	12.25	75	15
5	Dlf Phase-1	5470	1575	247.56	261.2	13.64	75	15
6	Sikanderpur	6530	1060	246.1	253.5	7.4	90	15
7	Dlf Phase-2	7376	846	241.768	255.608	13.84	75	15
8	Belvedere Towers	8058	682	237.148	252.208	15.06	75	11
Belvedere Towers to Huda City Centre								
9	Udyog Vihar Phase-V	9130	1072	233.8	246	12.2	130	20
10	Udyog Vihar Phase-IV	9953	823	230.38	242.5	12.12	130	20
11	Sector 22	10833	880	228.06	248	19.94	130	20
12	Sector 23A	12115	1282	223.23	235.7	12.47	130	20
13	Palam Vihar	13206	1091	220.07	232.8	12.73	130	20
14	Palam Vihar Extension	14015	809	217.56	230.2	12.64	130	20
15	Bajghera Road	15171	1156	216.42	229	12.58	130	20
16	Sector 3	16096	925	216.15	228.7	12.55	130	20
17	Ashok Vihar	17096	1000	216.79	229.3	12.51	130	20
18	Sector 5	18141	1045	216.85	229.5	12.65	130	20
19	Sector 4	19126	985	217.03	229.5	12.47	130	20

S.No.	Station Name	Chainage (m)	Inter Station Distance (m)	Ground Level (m)	Proposed Rail Level (m)	Station Height (m)	Proposed Length (m)	Proposed Width (m)
20	Sector 7	20391	1265	215.35	228	12.65	130	20
21	Sector 9	21168	777	214.85	227.5	12.65	130	20
22	Basai Village	21961	793	215.17	228	12.83	130	20
23	Sector 37	22791	830	216.38	229	12.62	130	20
24	Sector 10	24071	1280	217.71	232	14.29	130	20
25	Udyog Vihar Phase 6	24947	876	219.04	232	12.96	130	20
26	Hero Honda Chowk	26206	1259	221.47	234	12.53	130	20
27	Sector 72A	27236	1030	223.07	235.2	12.13	130	20
28	Sector 48	28106	870	223.87	236	12.13	130	20
29	Subhash Chowk	29126	1020	225.89	238.5	12.61	130	20
30	District Shopping Centre, Sector 47	29941	815	228.15	240.8	12.65	130	20
31	Cyber Park	31406	1465	229.1	241.6	12.5	130	20
32	Sector 45	32606	1200	232.03	244.8	12.77	130	20
33	HUDA City Centre	33606	1000	236.06	252.5	16.44	130	20
Spur: Basai Village to Dwarka Expressway								
13	Sector 101	13431	1786	214.36	226.5	12.14	130	20

FIGURE 5.18: SCHEMATIC DIAGRAM OF GURGAON METRO

SCHEMATIC TRACK DIAGRAM

CORRIDOR :- HUDA CITY CENTRE TO SECTOR 56



5.2 ANALYSIS OF CORRIDOR OPTIONS TO BE ELEVATED, UNDERGROUND OR AT GRADE

5.2.1 Corridor Selection

5.2.1.1 Feasibility Report (DMRC)

The Feasibility Report was prepared in September, 2016 by Delhi Metro Rail Corporation (DMRC) for the Gurgaon city area.

The report proposes two route alignment tabulated below:

Type	Alignment	Km
Shorter	HUDA City Centre - Sector 45 - Sector 46 - Sector 47 - Sector 32 (Subhash Chowk) - Rajiv Chowk - Roshanpura - HUDA Road - Sector 4 & 5 - Gurgaon Railway Station	12.28
Longer	HUDA City Centre -Sector 45- Sector 46-Sector 47-SubhashChowk – Behrampur - Hero Honda Cross-Udyog Vihar Ph 6-Sector 37 (Pataudi Road) - Sector 10 (Basai Road) - Sector 9 (Dhankot Railway Station)-Sector 7- HUDA Road - Sector 4&5 - Ashok Vihar – Palam Vihar – Palam Vihar Sector 1 – PalamVihar Sector 23-Sector 111(G) - Bijwasan Border - Bijwasan Railway Station – Barthal - Dwarka Sector 21 Metro Station	27.48
	Total Length for Study	39.76

5.2.1.2 Site Reconnaissance

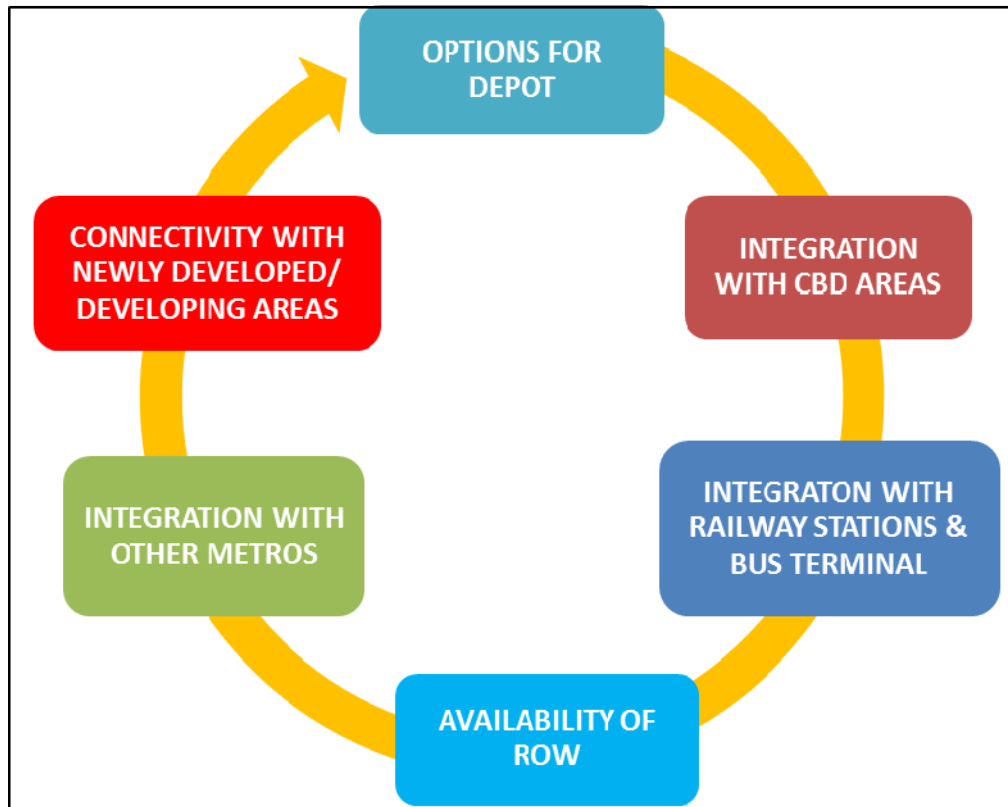
To select the high density corridors based on the Feasibility Report by DMRC, major residential and industrial areas and upcoming developments, a site reconnaissance survey was carried out by RITES in 2018 on the above shorter and longer routes to finalise the MRTS corridor. Based on the site reconnaissance and various meetings with HMRTC, MRTS corridor alongwith a spur was agreed as under:

- **Corridor:** HUDA City Centre Metro Station – Netaji Subhash Marg – Subhash Chowk – Hero Honda Chowk – Basai Road – Neki Ram Marg – Railway Road – Ashok Vihar – Bajghera Chowk via Carterpuri Road – Rezangla Chowk – Sector 22 via Major Sushil Aima Marg – Udyog Vihar Phase 4 & 5 via Jwala Mill Road – Cyber City (approx. 27 Kms)
- **Spur:** Basai Road – Sector 101 – Dwarka Expressway (approx. 2 Kms)

5.2.1.3 Alignment Options Parameters

The consultant studied the various alignment options for the priority MRTS corridors based on the planning parameters shown in **FIGURE 5.19**.

FIGURE 5.19: ALIGNMENT OPTIONS PARAMETERS



MRTS corridor, as discussed in meeting chaired by CEO/GMDA on 19th September 2018, is presented in **Annexure 1** and is briefly discussed as under.

5.2.1.4 Alternatives for HUDA City Centre Station

A) Option - 1: On Dividing Road of HUDA City Centre Metro Station and Sector 45

Description

- In this option, the station is proposed south of existing Delhi Metro's HUDA City Centre (HCC) metro station, on the road dividing the HCC station and Sector 45.
- The location can be identified in the **FIGURE 5.20**.

FIGURE 5.20: LOCATION OF PROPOSED HUDA CITY CENTRE STATION - OPTION 1

- The pros and cons of the option are listed below;

Pros:

- Station is proposed adjacent to the existing HUDA City Centre Metro station of Delhi Metro yellow line.
- Better integration with existing HUDA City Centre Metro station.
- No acquisition, as the station is proposed on the road.
- Direct connection to the platform of existing Metro station can be planned.
- Sufficient space available for movement of construction equipment.
- The future extension of the corridor upto Golf Course road and integration with Rapid Metro station is possible.

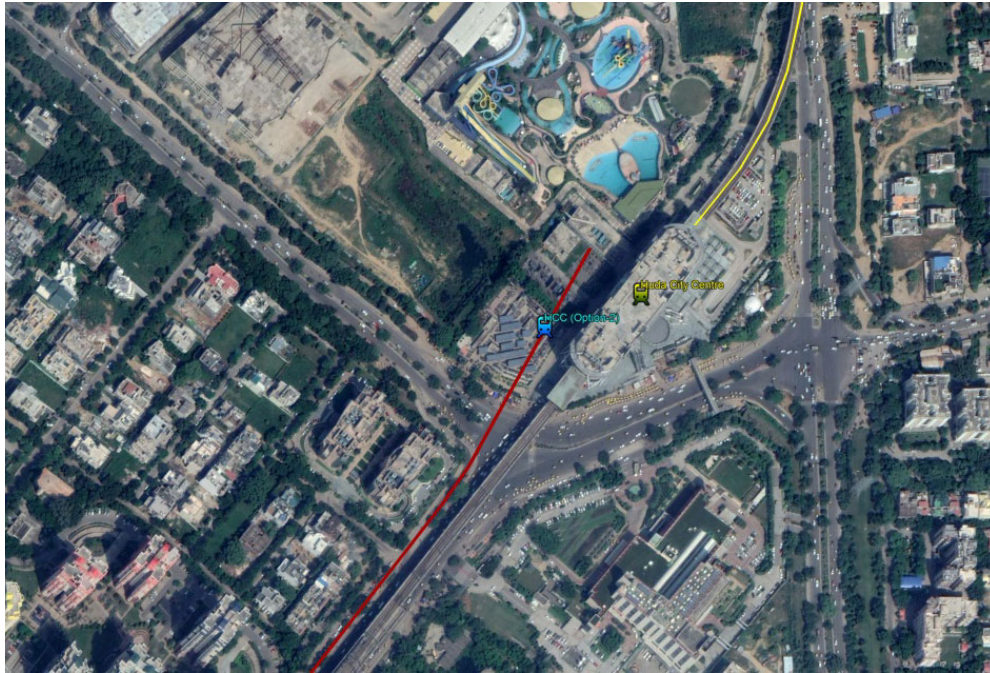
Cons:

- A low height flyover is proposed by GMDA on the same location. Planning of metro station above the flyover will increase the height of the former. Thereby increasing the construction cost.

B) Option - 2: On HUDA City Centre's Parking and Sub-station

Description

- In this option, the station is proposed west of existing Delhi Metro's HUDA City Centre (HCC) metro station, in the parking and sub-station area.
- The location can be identified in **Figure 5.21**.

FIGURE 5.21: LOCATION OF PROPOSED HUDA CITY CENTRE STATION - OPTION 2

- The pros and cons of the option are listed below;

Pros:

- The station location will be nearest to the existing HCC station; reducing the interchange time for the passengers.
- Direct connection to platform of existing Metro station can be provided.
- There will be no impact due to the proposed flyover by GMDA.

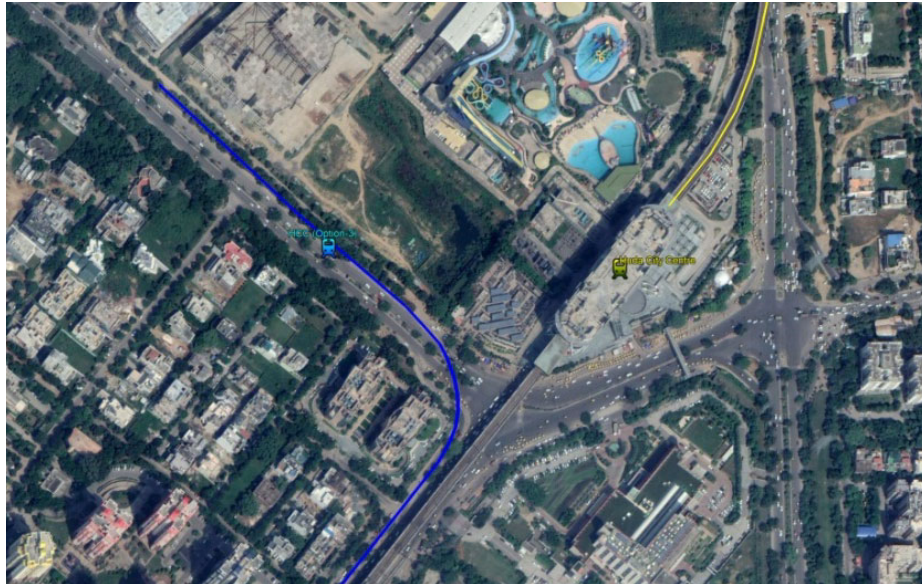
Cons:

- Land acquisition of Parking and Sub-station area of DMRC will have to be done to some extent.
- Acquisition will lead to increase in cost.
- Acquisition will also reduce the parking area of two-wheelers at Metro station.
- Some portion of viaduct will over hang in private land (Appu Ghar water Park), which may require acquisition of land.
- Construction of station building so close to the existing Metro station will be very difficult.
- Space available for construction equipment movement is not adequate.

C) Option - 3: On HUDA City Centre's Parking and Sub-station

Description

- In this option, the station is proposed west of existing Delhi Metro's HUDA City Centre (HCC) Metro station, along the green belt adjacent to the Sector Road.
- The location can be identified in the **Figure 5.22**.

FIGURE 5.22: LOCATION OF PROPOSED HUDA CITY CENTRE STATION - OPTION 3

- The pros and cons of the option are listed below;

Pros:

- The location of this option is partially off the road, such that some acquisition for entry/exit might take place.

Cons:

- The commuters will have to travel longer for interchange with the existing HCC Metro station.
- For the alignment to align on Netaji Subhash Marg, a right hand curve will be negotiated. The curve will require acquisition of some land of Unitech Business Park.

In the view of the above, it is recommended that Option-3 i.e. Location of HUDA City Centre Station on Dividing Road of existing HUDA City Centre Metro Station and Sector 45, may be adopted.

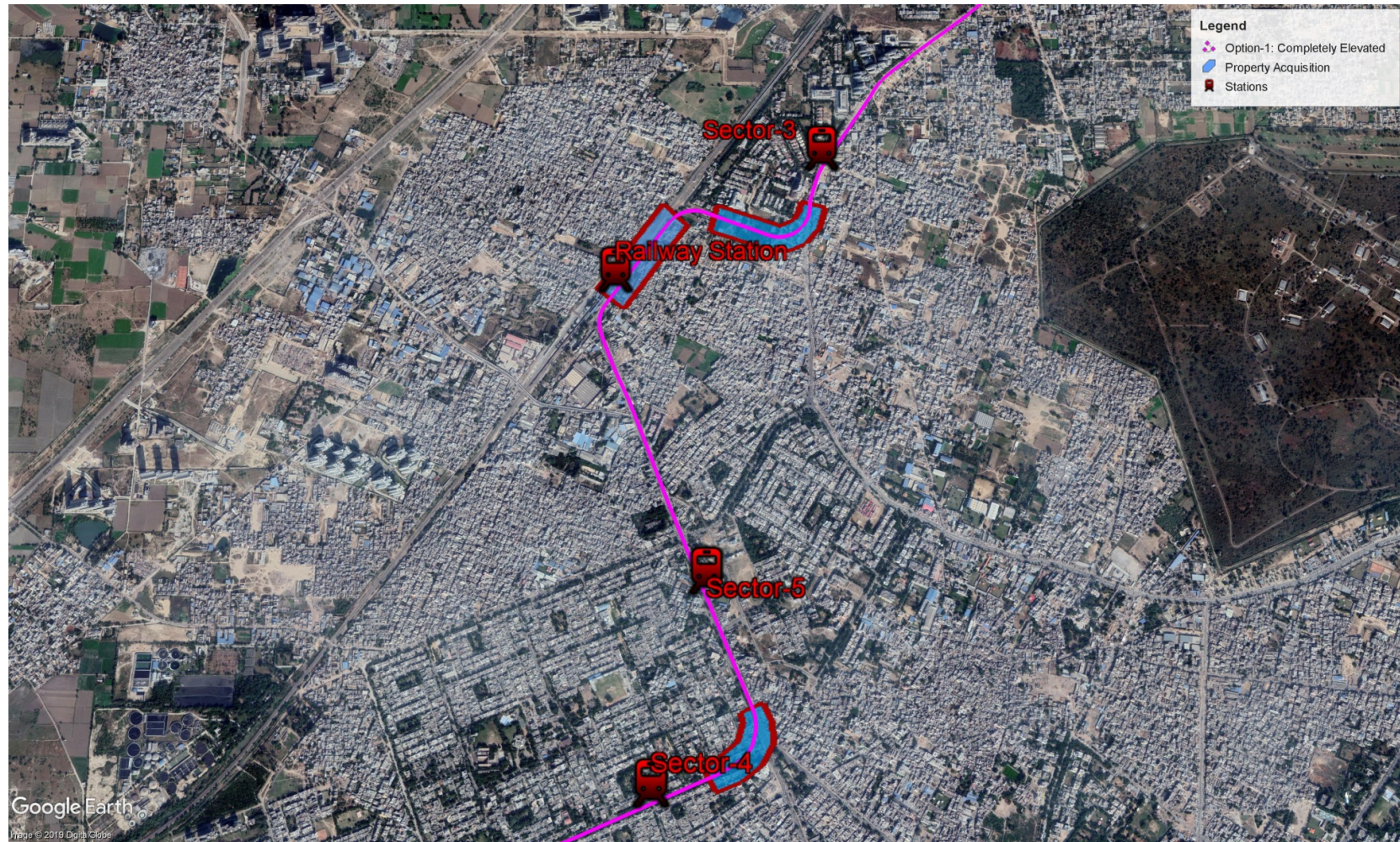
5.2.1.5 Alignment Options for the Corridor from Sector-5 to Sector-3

The consultant studied the following alignment options for the Corridor from Sector-5 to Sector-3:

A) Option – 1: Continuous Corridor from HCC to Cyber City – Completely Elevated**Alignment Description**

- The corridor will continue to run elevated along Neki Ram Marg, Railway Road upto Gurgaon Railway Station. Further, the alignment will pass through the area adjacent to Gurgaon Railway station Platform No. 1. Thereafter, the alignment will pass through open private land and align along Carterpuri Road, as shown in **Figure 5.23**.

FIGURE 5.23: OPTION 1 – COMPLETELY ELEVATED



- The pros and cons of the option are listed below;

Pros:

- Cost of project will be lesser.
- More number of stations is possible which will serve more catchment.
- Lesser inconvenience to the traffic movement during construction.
- Continuous services upto Rapid Metro Station.

Cons:

- Acquisition of private properties (residential houses) at junction of Neki Ram Marg and Railway Road.
- Acquisition of private properties (residential houses) adjacent to Maruti Stock Yard will be required.
- Land acquisition for piers of viaduct on the play-ground of GEMS International School.
- Land acquisition of vacant Private Land for viaduct and pier location.
- Land acquisition of commercial/residential properties near Carterpuri Road.
- Maruti Udyog's Stock Yard will require shifting.
- Major residential and commercial areas of Sector-3 and Sector-5 will remain uncatered.

B) Option – 2: Continuous Corridor from HCC to Cyber City with Gurgaon Railway Station as Underground.

Alignment Description

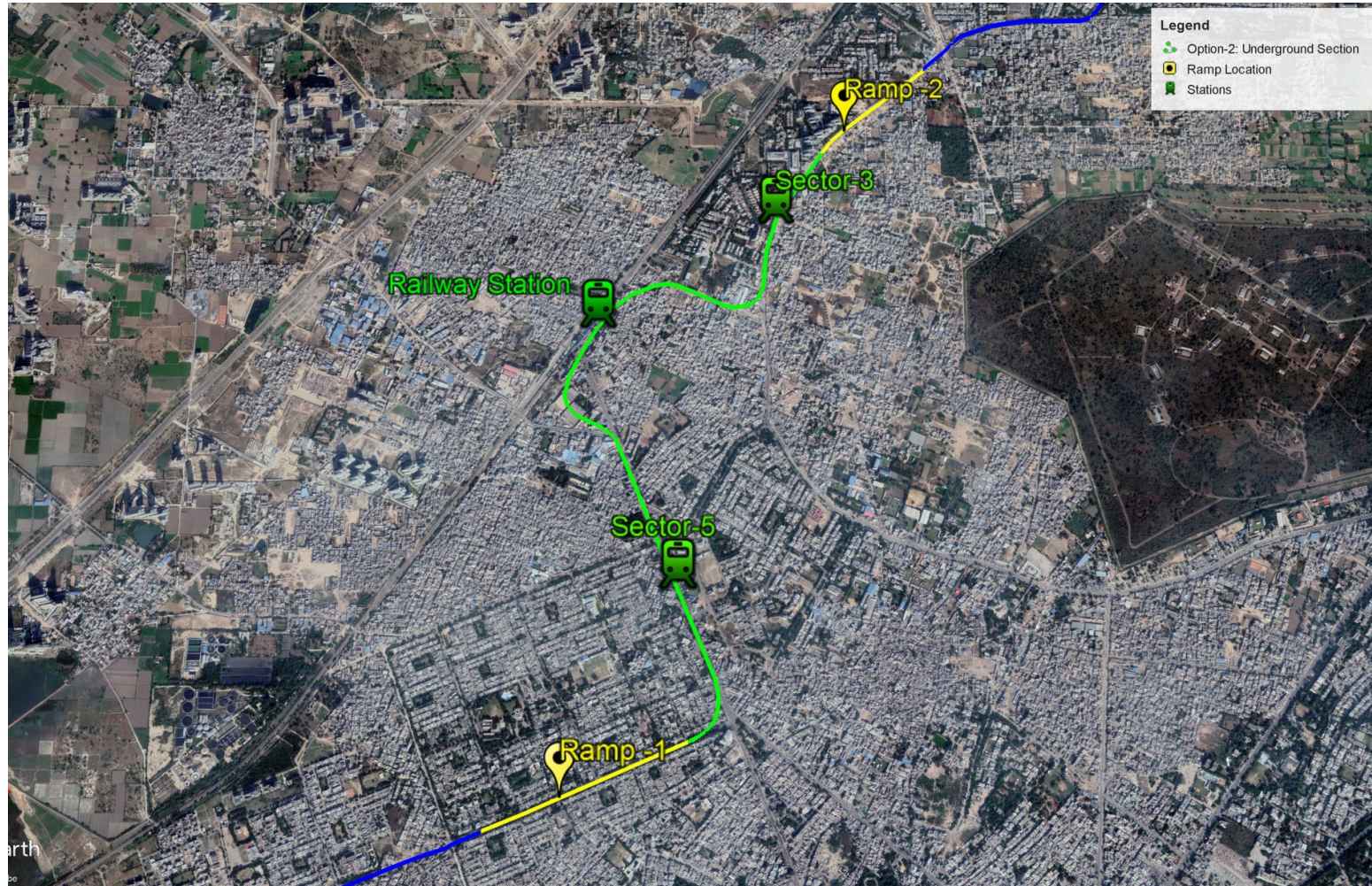
- After crossing Sector-7 Metro Station, due to non-availability of sufficient space to take the alignment underground near the Railway station and along Railway Road, the ramp down (elevated to underground) is proposed along Neki Ram Marg, thereafter, the corridor aligns along Railway Road. Further, the alignment runs through Gurgaon Railway Station and aligns through Carterpuri Road at Sector-3. Further, ramp up (underground to elevated) has been proposed on the left side of road after Park View Residency. The alignment will run along Carterpuri Road upto Rezang La Chowk and then towards Major Sushil Aima Marg and terminates at Old Delhi Road junction, Sector-22, as shown in **FIGURE 5.24**.

- The pros and cons of the option are listed below;

Pros:

- No acquisition of private property required.
- Continuous services upto Sector-22.
- No reduction in road ROW along Railway Road.

FIGURE 5.24: OPTION 2 – RAILWAY STATION AS UNDERGROUND



Cons:

- Acquisition of land for ramps along Neki Ram Marg and Carterpuri Road.
- Cost of the entire project would increase by about Rs. 1200 Crore due to underground length of about 4.7 kms and 3 underground stations.
- During the construction of stations, the area of about 300m x 30m will have to be blocked on the road which will require traffic diversion.
- At Railway Station location, parking area will require closure during construction phase. Moreover, the entry to Railway station will have restricted movement space.
- It would not be feasible to provide Sector-4 Metro station.
- The alignment will have to pass below private properties.

C) Option - 3: Continuous Corridor from HCC to Cyber City with a spur to Gurgaon
Railway station from Sector-5 Metro station - Completely Elevated

Alignment Description

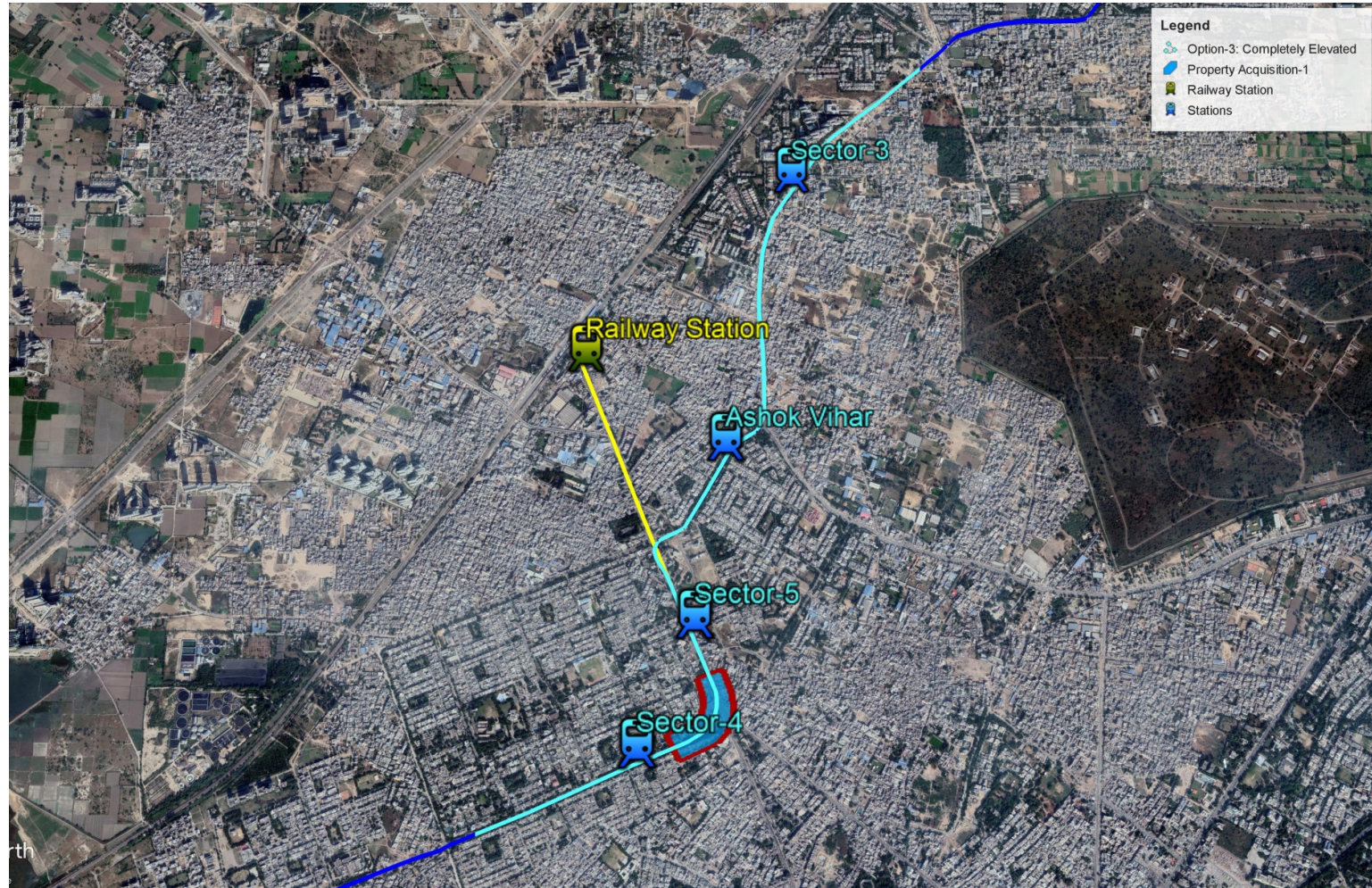
- In this option, the alignment will continue to run elevated along Neki Ram Marg, Railway Road upto Sant Baba Prakash Puri Chowk, thereafter, alignment will run along Lt. Atul Katariya Marg (dividing road of Sector-3 and Sector-5). Further, the alignment will run along Carterpuri Road after Sector-5 Chowk. The alignment will run along Carterpuri Road upto Rezag La Chowk, thereafter, it runs along Major Sushil Aima Marg and terminates at Sector-22 i.e. Old Delhi Road junction, as shown in **FIGURE 5.25**.
- In addition to above, a spur of a length of 1.2 km from Sector-5 will be taken to connect the Gurgaon Railway station. The Train Operation Plan will be adjusted accordingly to this. Few trains will directly go to Gurgaon Railway station and rest towards Cyber City.
- The pros and cons of the option are listed below;

Pros:

- Minimal property acquisition out of all the three options.
- Connectivity to more catchment.
- More stations are possible which will provide more ridership.
- Cost of project will be lesser as compared to other options.
- Lesser inconvenience to traffic movement during construction.

Cons:

- No direct connectivity to Gurgaon Railway station for passengers coming from Cyber City and vice-versa. Passengers will have to change the train at Sector-5 station.
- Acquisition of private property (residential houses) at junction of Neki Ram Marg and Railway Road.

FIGURE 5.25: OPTION 3 – COMPLETELY ELEVATED WITH A SPUR TO RAILWAY STATION

5.2.1.6 Selection of Corridors

- i. Haryana Mass Rapid Transport Corporation (HMRTC) Ltd. Awarded the work of “Preparation of DPR for Metro Rail connection from HUDA City Centre (HCC) to Railway Station Gurgaon” vide their letter No. HMRTC/2017/FO/356 Dt. 22.12.17, covering a stretch of 17 km (approx). Further, HMRTC vide their letter No. HMRTC/2018/FO/409 Dt. 05.07.18, extended the study corridor upto Sector – 22 i.e. for a stretch of 8 km.
- ii. A preliminary discussion on the tentative route of the proposed extension was held with Advisor (Planning), HMRTC on 16th July, 2018. Consequent to the suggestions received during preliminary discussion and findings of the site visit, three options were worked out for the corridor as discussed in **5.2.1.5**.
- iii. A meeting chaired by CEO/GMDA, held on 19th September, 2018 regarding extension of Metro from HUDA City Centre (HCC) to Railway Station, Gurgaon. Out of the three options, the one with **“Completely Elevated Continuous Corridor from HCC to Sector-22, connecting Gurgaon Railway station by a skywalk with travelator from Sector-5 Metro station”** was finalized. Minutes of Meeting vide letter No. HMRTC/2018/FO/610-611 Dt. 24.09.18, were issued by HMRTC. During the meeting, RITES Ltd. also suggested to extend the corridor upto Rapid Metro.
- iv. A presentation was also made to Chief Secretary, Haryana and other senior officials at Panchkula on 4th October, 2018. The alignment connectivity with Sector - 22 (Option – 3) was approved and RITES was advised to look for alignment options for extending the corridor upto Cyber City (Rapid Metro).
- v. A meeting was held on 27th May, 2019, at Haryana Civil Secretariat, Chandigarh under the chairmanship of Hon’ble Chief Minister of Haryana (Minutes of Meeting attached as **Annexure 1**). The proposed Gurgaon Metro alignment alongwith all issues were discussed and the following decisions were taken:
 - a) Metro connectivity at Cyber City with Rapid Metro route may be through track integration for seamless integration between the new Metro route and the existing Rapid Metro route as track integration may be the best way ahead so that Sikanderpur Metro station becomes the nodal Station linking the DMRC and Rapid Metro routes with the proposed Metro route for the benefit of easy interchange at Sikanderpur Metro station.
 - b) Stations for the proposed Metro corridor are designed for 6-car train whereas the existing Rapid Metro stations can accommodate 3-car train. It was then decided to redesign the Sikanderpur Rapid Metro station as per the 6-car system based on technical assessments.
 - c) Traction system in proposed Metro to be adopted same as that of the Rapid Metro i.e. 3rd Rail system.
 - d) The stations to be located, to the extent possible, at the proximity of junctions.

- e) Feasibility of a spur from Rezangla Chowk, Gurgaon to Sector-21, Dwarka is to be explored by HMRTC.
- f) Earlier the proposed HSIIDC Metro and Gurgaon Metro alignment run on the common track from HUDA City Centre upto Subhash Chowk. But in the meeting it was decided that, the new alignment of HSIIDC Metro to be from Sohna Adda – Rajiv Chowk – Subhash Chowk onwards.

5.3 DESIGN NORMS

5.3.1 Track Geometry

The geometric design norms presented in subsequent paragraphs have been worked out based on detailed evaluation of passenger comfort, safety, experience and internationally accepted practices being followed in currently operating rapid transit and rail systems. Since, track integration has been planned with Rapid Metro, the design norms/geometric design parameters of Rapid Metro have been used.

5.3.1.1 Principles for Metro Corridor

While fixing the alternatives on proposed corridor, following requirements/constraints have been kept in view:

- i. To remain on the CL of the existing road or Government premises/land to the extent feasible.
- ii. To utilize the existing road Right of Way (ROW) to the maximum extent in order to minimise the land acquisition and also length of diversions.
- iii. To avoid dismantling of existing structures/Buildings etc. to the extent feasible.
- iv. To avoid private built up areas, villages, habitation and religious structures etc. to the extent feasible.
- v. To provide adequate clearance from existing Railway/ Highway structures.
- vi. To satisfy the requirements of sound economic engineering practices
- vii. To rationalise the location of proposed stations and underground ramps

5.3.1.2 Geometric Design Parameters

A. Alignment Considerations: As far as possible-

- Tangent alignment has been maximized.
- Flattest possible curves have been proposed.
- Number of curves has been minimized.
- Maximum possible transition lengths, commensurate to operating speed have been proposed.
- Elevated alignment has been maximized.
- Number of gradients has been minimized.
- Flattest possible vertical curve have been proposed.

- Cants of appropriate values, commensurate to operating speed at specific locations have been proposed to counter the effect of centrifugal force.
- Vertical curves and transition curves of horizontal alignment do not overlap.

B. General Criteria

General Criteria used for the design purpose are given in **TABLE 5.7**.

TABLE 5.7: DESIGN CRITERIA

S. NO.	CRITERIA	DIMENSION
1	Gauge	1435 mm
2	Design Speed	80Kmph
3	Maximum Axle Load	16T
4	Electric Power Collection	3 rd Rail, 750 V D.C.

C. Horizontal Alignment

Horizontal alignment gives the details of curves in horizontal plane as the entire alignment can-not be on straight. The alignment on mainline track shall consist of tangent sections connected to circular curves by spiral transitions.

i. Circular Curves

Circular curves shall be defined by their radii in meters. Larger radii shall be used whenever possible to improve the riding quality. The minimum radius of curvature for mainline track shall be governed by the design speeds and by the limits for cant but shall not be less than 120m. The horizontal curve parameters are tabulated below in **Table 5.8**.

TABLE 5.8: HORIZONTAL CURVE PARAMETERS

Description	Elevated Section
Minimum radius on main running lines other than stations	125 m with check rail*
Minimum curve radius at Depot & other lines	100m with check rail
Minimum curve radius at passenger stations	1000 m
Maximum permissible cant (Ca)	110 mm
Maximum cant deficiency (Cd)	85 mm
* Check rails are to be provided on circular curves of less than 190m radius including their transition curves	

ii. Reverse Curves

The use of reverse curves is discouraged but where necessary, the two curves have been separated by minimum 25 m. If provision of 25 m straight length is restricted by physical constraints, the two curves have provided without any straight in between.

iii. Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth transition from straight section to curved section and vice-versa. **Table 5.9** shows required Length of transitions for Horizontal curves.

TABLE 5.9: LENGTH OF TRANSITIONS OF HORIZONTAL CURVES

Minimum Length	0.44 * actual cant (in mm) 0.44 * cant deficiency (in mm) whichever is higher
Desirable Length	0.72 * actual cant (in mm) 0.72 * cant deficiency (in mm) whichever is higher
Minimum Straight between two transition curves	25 m or NIL
Minimum horizontal curve length between two transition curves	25 m
No Overlap is allowed between transition curves and vertical curves	

D. Vertical Alignment

The purpose of this section is to establish criteria for use in all design stages of the vertical alignment and track centre of the viaduct, tunnel, station and depot area.

Elevated Section

As per para 2.12.2 of IRC: SP-73, "Minimum 5.50 m vertical clearance shall be provided from all points of the carriageway of project Highways to the nearest surface of the overpass structure". However, it is recommended to keep suitable margin for future raising of road by resurfacing etc. Rail level will also depend upon the type and detailed design of pier cap and super-structure elements.

Rail levels at elevated station locations have been proposed by providing minimum vertical clearance and con-course of 4.00 m. Structural design of con-course floor slabs and viaduct will also govern the final rail level. **TABLE 5.10** shows required Track centres and height for elevated station.

TABLE 5.10: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.10 m*	7.50 m**
Station	4.10 m	12.50 m
Note: * Track centre in elevated section can be modified as per the choice of girder/super structure. For Double U-girder minimum 4.60 m track centre will be provided. ** For I-girder and Box-girder, Minimum Rail Level above Ground Level shall be 8.50 m		

E. Gradients**i. Mid-Section**

The grade on the mid-sections shall not be generally steeper than 2.0%. However, there is a situation, where steeper gradients are unavoidable, such as:

- Where the existing road gradient is more than 2% as the elevated section is kept parallel to the road surface to minimise the rail level (to reduce the pier height).

Suitable longitudinal grades with drains at the low point are proposed for assuring proper drainage.

ii. Stations

Preferably, the stations shall be on level stretch with suitable provision for drainage by way of cross slope and slope of longitudinal drains. However, maximum grade shall not exceed 1 in 400. There shall be no change of grade on turnouts on ballastless track.

iii. Depot

For connectivity to track depot, maximum 4% (compensated) gradient is proposed. For other portions of depot, gradient as flat as possible with adequate track drainage shall be designed to suit the actual ground slope. All shop tracks shall be at level. Sidings shall be level or shall fall away from the main line connection at a gradient not exceeding 0.25%. There shall be no change of grade within 30 m of any points and crossing on ballasted track. **TABLE 5.11** shows gradient parameters.

TABLE 5.11: GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 2%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

F. Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%. However, it is recommended that all changes in grade shall be connected by a circular curve or by a parabolic curve.

It is proposed that vertical curves and transition curves of horizontal alignment do not overlap. Minimum radius and length of vertical curves are shown in **TABLE 5.12**.

TABLE 5.12: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

5.3.1.3 Design Speed

The maximum sectional speed will be 80 km/h, subject to further restriction by radius of horizontal curves, cant and cant deficiency. The parameters of radius of horizontal curve, cant and permitted speed are summarized below. **Table 5.13** shows Radius, Cant and Permitted Speed.

TABLE 5.13: RADIUS, CANT AND PERMITTED SPEED

Radius	Actual Cant (Ca)	Permitted Speed
(m)	(mm)	(km/h)
5000	15	80
3000	15	80
2800	15	80
2400	20	80
2000	20	80
1500	30	80
1200	35	80
1000	40	80
900	50	80
800	55	80
700	65	80
600	70	80
500	80	80
450	85	80
400	85	75
350	95	72
300	100	68
250	105	63
200	110	57
175	110	53
160	110	50
150	110	49
140	110	47
130	110	46
120	110	44

5.3.2 Fixed Structure Clearance & Construction Methodology

Construction of elevated alignment involves following type of constructions:-

- Sub-structure - Columns on Open/Pile foundations with pier cap at top of columns. Alternatively, Portal arrangement is provided at certain locations.

- Superstructure by segmental construction of whole unit construction. Box segments are most common type of segmental construction. I-Girder and U-girder are most common type of non-segmental construction methods where the structural element for whole span length is pre casted and launched in position.

5.3.2.1 Cast in-situ and Pre-Cast Construction

A. Cast in-situ Construction

In cast in-situ construction method, structure is cast at its final location of use. This involves erection of temporary shuttering, scaffolding and support system for casting the structure. The temporary supports and shuttering is removed when the concrete is set and structure attains the strength to bear its dead weight and other loads. This method involves longer construction time and interference to road users for longer period. This method is restricted to casting of substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures.

B. Pre – Cast Construction

In this method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are casted by pre-cast technique. Pre cast construction may be segmental or non-segmental type.

Casting yard is required for casting of precast structural segments and other precast units like U-girder, I-Girder etc. The construction depot has arrangement for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.5 Ha to 3 Ha is required for each construction depot.

Pre-cast construction has following advantages:-

- Reduction in construction period due to concurrent working for substructure and superstructure.
- For segmental, pre-cast element (of generally 3.0m length), transportation from construction depot to site is easy and economical. For other type of construction i.e. I-Girder, U-Girder etc. longer trailer and straighter roads are required but erection can be done by using road cranes in comparatively less time.
- As the pre-cast elements are cast on production line in a construction depot, better and uniform quality control can be exercised.
- This method reduces the interference to road users to minimum.

For casting of segments, both long line and short line method can be adopted. However the long line method is more suitable for spans curved in plan while short line method is good for straight spans. A high degree of accuracy is required for setting out the curves on long line method for which pre calculation of offsets is

necessary. Match casting of segments is required in either method. The cast segments are cured on the bed as well as in stacking yard. Ends of the segments are to be made rough through sand blasting so that gluing of segments can be effective.

The segmental construction has following advantages.

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Segmental construction permits a reduction of construction time as segments are manufactured in a casting yard while substructure work is in progress, and erected rapidly thereafter.
- Better quality control is possible in the casting yard.
- It is easier to transport smaller segments by road trailers on city roads.
- Interference to the traffic during construction is significantly reduced.

5.3.2.2 Structural System of Viaduct

A. Sub-structure

Two broad categories of sub-structure i.e Pile Foundation and Open foundation are considered for Metro Systems. For heavy/medium loads and loose/soft/filled up upper strata, Pile foundation systems are proposed. This requires lesser space and time for excavation. Pile load bearing capacity is calculated as per IS 2911 Part 2 & IRC-78. At locations where hard strata/rock is available close to ground level, open foundations may be adopted.

The viaduct superstructure will be supported on single cast-in-place RC pier. The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs. Circular pier of dia in the range of 1-5-1.7 m are commonly used as it occupies the minimum space at ground/road level where the alignment often follows the central verge of existing roads.

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0m height above existing road level has been proposed all around the pier. A gap of 25mm has been also provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that the required minimum clearance of 5.5m is always available on road side beyond vertical plane drawn on outer face of crash barrier. In such a situation, the minimum height of rail above the existing road is 8.5m. The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8m.

The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will

be provided at pier top for the drainage due to spilling of rainwater, if any. The transverse spacing between bearings would be about 3.0m. The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be selected to ensure minimum footprint at ground/road level traffic. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

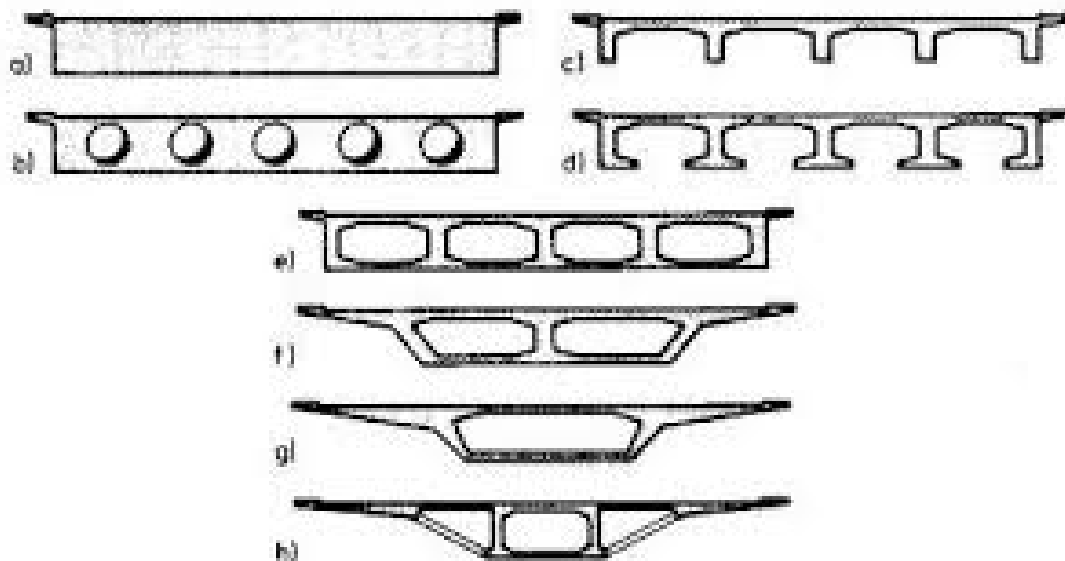
Pile caps are casted over the columns to support the superstructure. Soffit width of superstructure governs the width of pile cap. While box girder requires less width of pile, I-girder and U-girders require larger width of pile caps to support the full width of soffit of such superstructures. At locations where elevated alignment moves from central verge of the road to side of the road and vice versa, Portal arrangement is made instead of column and pile cap. Also at locations where elevated alignment takes a perpendicular left or right turn, portal type arrangement is provided to provide support to superstructure.

B. Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability, maximum safety, least disturbance and inconvenience to road users and maximum standardization of the form-work for wide span ranges. Following types of superstructure may be considered.

- i) Precast segmental box girder using external unbonded tendon.
- ii) Precast U-Channel superstructure with internal pre-stressing.
- iii) Precast U-Channel segmental superstructure using external unbonded tendon.
- iv) I-Girder with internal pre-stressing.
- v) Special spans

FIGURE 5.26: TYPES OF SUPERSTRUCTURE



Three types of superstructures are further deliberated as under:-

C. Precast Segmental Box Girder using External Unbonded Tendon

The superstructure shall be constructed “span by span” sequentially, starting at one end of a continuous stretch and finishing at the other end. A number of launching girders will be required so as to work on different stretches simultaneously to enable completion of the project in time.



For Box girder segmental construction, normally span of 31m is kept by providing 9 segments of 3m length and two end segments of 2m length each. The other standard spans (c/c of pier) comprises of 25m, 28 m, 22m, 19m & 16m, which shall be made by removing/adding standard segments of 3.0m each from the center of the span.

The number of “breaks” in the stretch can be identified by number of continuous units. The suggested method of erection will be detailed in the construction drawings. The launching girder (or, more accurately, the “assembly truss”) is capable of supporting the entire dead load of one span and transferring it to the temporary brackets attached to the pier. The governing weight of the segments will be of the order of 55 M.T. The launching girder is slightly greater than two span lengths. It must be able to negotiate sharp curves in conjunction with temporary brackets.

Transportation of segments from casting yard to the sites of erection will be effected by appropriately designed low-bedded trailers (tyre-mounted). The segments can be lifted and erected using erection portal gantry moving on launching girder.

FIGURE 5.27: LAUNCHING OF BOX GIRDER SEGMENTS



In such construction, the pre-stressing is placed outside the structural concrete (inside the box section) and protected with high density polyethylene tubes which are

grouted with special wax or cement. The match cast joints at the interface of two segments are provided with shear keys as in traditional segmental construction.

The main advantages of externally pre-stressed pre-cast segmental construction can be summarized as follows:-

- Simplification of all post-tensioning operations, especially installation of tendons.
- Reduction in structural concrete thickness as no space is occupied by the tendons inside the concrete.
- Good corrosion protection due to tendons in polyethylene ducts; the grout inspection is easier and leaks, if any, can be identified during the grouting process.
- Simplified segment casting. There is no concern about alignment of tendons. Increased speed of construction.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facilitates inspection and monitoring of tendons during the entire service life of the structure.

However, higher depth and higher construction-transportation- erection cycle time are disadvantages of Box Girder.

D. Precast U-Channel Superstructure with Internal Pre-stressing

The single/Double U type of viaduct structure is also a pre-cast construction with internal pre-stressing. Double U-Girders are provided for 25-28m span. For shorter spans, Single U girders may be provided.

FIGURE 5.28: PRECAST U-CHANNEL SUPERSTRUCTURE



The main advantages for this type of structural configuration of superstructure are:-

- Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
- Saving in construction and erection cycle time.
- Built in structural elements capable to maintain the coaches on the bridge in case of derailment (a standard barrier design allows this).

- Built in cable support and system function.
- Built in maintenance and evacuation path on either side of the track.
- Built in sound barrier.

However, Single U- girder has weight in the range of 300 MT per unit and it is difficult to transport girder of such length and weight. To reduce the weight per girder, double U- girder may be used, but it results into wider track center of 4.6m to accommodate the two inside walls of the two girders.

FIGURE 5.29: LAUNCHING OF U-CHANNEL GIRDER



E. Precast U-Channel segmental Superstructure with Internal Pre-stressing

In this arrangement, superstructure consists of U-shape segments. These are to be launched in a similar way as box segments. This type of superstructure results in shallow depth of superstructure in comparison to box type segments.



F. Precast I-Girder Superstructure with Internal Pre-stressing

Pre cast I-Girders for various span ranges 20-34 m can be designed. At locations with restricted head room, I-Girder with span range of 20m may be used. Precast, pre-stressed I- Girders are casted in casting yard, transported to site and erected as 3/4 I-girders per span (depending upon Detailed design) by using road cranes, connected together at site by casting diaphragm wall and thereafter top slab is casted at site.



The depth of I-girder is comparable to Box girder. Since unit length of I-Girder is for full span, their transportation is not possible for all locations. However, the unit weight of I-Girder is approximately in the range of 70 MT, which is almost half when compared to Double U-girder and hence can be launched with lower capacity road cranes. Deck Slab of I-Girder can easily be planned to accommodate curved alignment. I-Girders are most suitable for station locations, where Box and 'U' Girders are not continued.

FIGURE 5.30: LAUNCHING OF I-GIRDER



G. Special span configuration

Regular spans upto 31m span are not suitable for crossing large openings like road over bridges, wide surface road crossings, railway tracks, wide canals, Rivers etc. Cantilever construction Method using PSC spans are used in such situation. Some of common span arrangements are suggested as under:-

- 34m + 45m + 34m
- 34m + 60m + 34m
- 75m + 105m + 75m

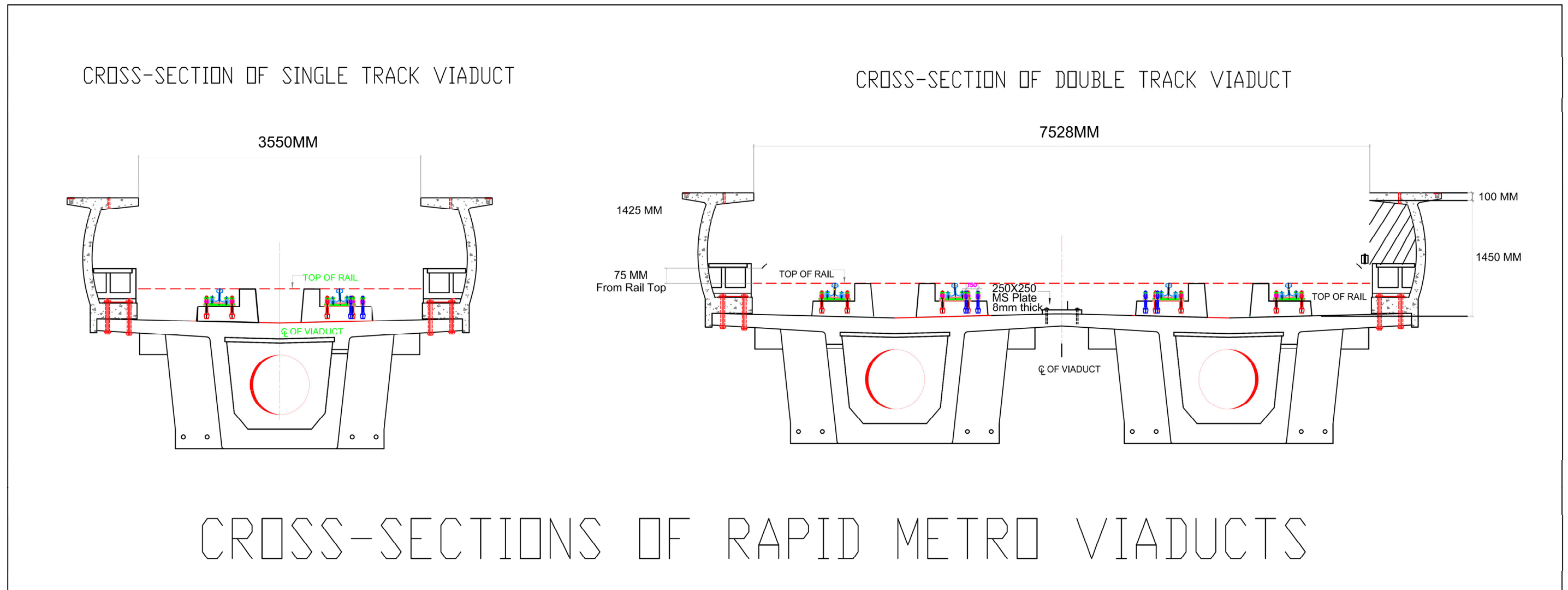
Other span configurations may also be designed as per specific site requirement.

Other alternative is to use steel span. Steel span of upto 60m have been used in Metro systems in India.

FIGURE 5.31: CLC SPAN 75M + 105M + 75M AND STEEL SPAN 60M



FIGURE 5.32: TYPICAL CROSS-SECTIONS OF RAPID METRO VIADUCTS



Recommendation

The Design and Build Contractor may choose any type of super structure keeping in view site conditions, availability of construction time and other resources i.e. road cranes/launching girders/shuttering etc. Combination of above type of superstructure may also be chosen. Appropriate special spans may be provided for specific locations.

5.3.2.3 Construction of Elevated Stations

Elevated stations with elevated concourse over the road are proposed for elevated stretch of alignment. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus a separate structural configuration is required, with shorter spans and lower depth of superstructure, although this may necessitate the break in the launching operations at each station location.

Sub-structure for the station portion will also be similar to that of viaduct and will be carried out in the same manner. Two configurations as under are available for elevated station super-structure:-

- Three legged portal structure supporting concourse and platform level decks through series of Precast I girders resting on the Portal beam ledge.
- Cantilever structure with single centre pier with the arms extending in transverse direction at concourse level and platform level.- Concourse and Platform decks are supported by I girders resting on extended pier arms.

Comparative analysis of above two types of structural arrangements is shown in **TABLE 5.14.**

TABLE 5.14: COMPARATIVE ANALYSIS OF TYPES OF STRUCTURAL ARRANGEMENTS

Item	Three legged portal structure	Cantilever Structure
General	Three legged portal structure is best suited for stations having high traffic load requiring more width. Central median of 3.0 m can be created to position the Central leg of the portal. This median can also divide the road traffic into two carriageways on either side of the median. Entry structures can be built beyond the carriageway on either side.	Cantilever station is more suitable for densely populated downtown areas having narrow ROW. The main elevated superstructure is already supported on cantilever pier caps and to accommodate the platform width (approx. 4m each), total 8m additional width of cantilever is required to support the comparatively lighter load of platform and passengers. The station rooms, entry/exit staircases etc. may be planned by providing more width at these locations only and such wider width can be supported on portal.

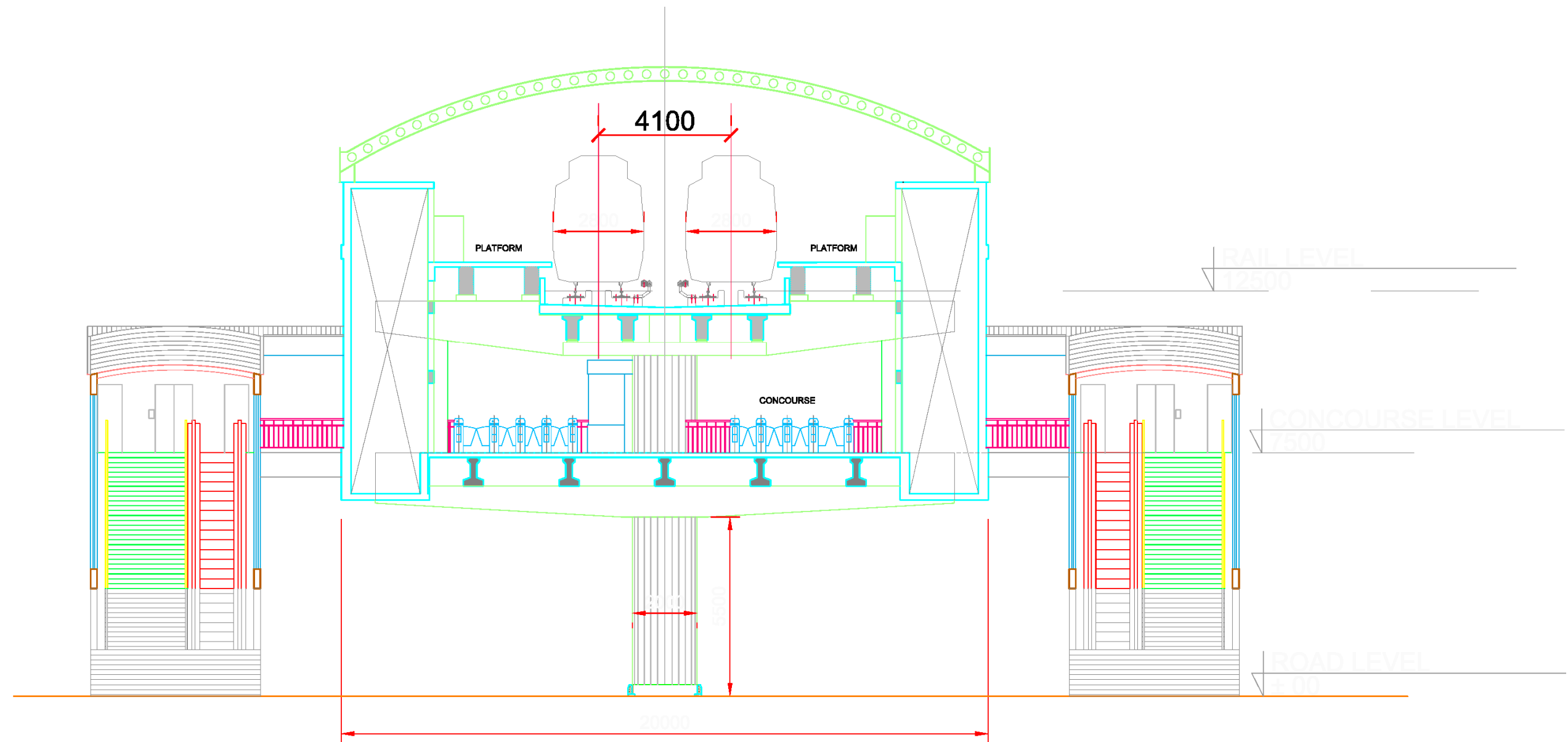
Item	Three legged portal structure	Cantilever Structure
Merit	- Three legged portal is a better structural arrangement with respect to vibration induced by the train loads, long term deflections of the concrete members etc., - The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are effectively transferred to the ground through portal legs in the shortest path. - Need for Bus bays, drop/pick up points is avoided as the outmost lane can be used for this purpose.	- Station structure will be compact and economical. Cantilever arrangement may be properly designed to withstand all dead loads, live loads, seismic and wind loads as well as train induced vibrations. - No need to provide Service road to access adjoining properties. - The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are to be transferred to the ground through portal arrangement.
Demerit	- Cost of the station structure will be more due to large built up area. Wherever there is scope of property development, same may be planned at Concourse level to use the available space. - Service lane need to be provided to ensure access to adjoining properties.	There is need for Bus bays, drop/pick up points.

Typical Elevated Station

The elevated station is generally located on the road median 85 m long and 19.20 m wide and is a three level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid zone, after accommodating the passenger movement and other station facilities is earmarked for commercial utilization.

Since the stations are planned generally in the middle of the road, minimum vertical clearance of 5.50 m has been provided under the concourse. Concourse floor level is about 7.0 m above the road. Consequently, platforms are at a level of about 13.0 m from the road. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. **FIGURE 5.33** shows a typical cross section of elevated station.

FIGURE 5.33: TYPICAL ELEVATED STATION



5.3.2.4 Grade of Concrete

It is proposed to carry out construction work with design mix concrete. Computerized Automatic Batching Plants will be installed. Following grades of concrete are proposed for various members as per design requirement/durability considerations.

- i. Piles : M-35
- ii. Pile cap and open foundation : M-35
- iii. Piers : M-40/M-50
- iv. All pre-cast elements for viaduct and stations: M-45
- v. Tunnel segments : M-45
- vi. Cantilever piers and portals: M-45 /M-50/M-60
- vii. Other miscellaneous structures: M-30

For all main structures, permeability test of concrete is recommended to ensure impermeable concrete.

5.3.2.5 Reinforcement and Pre-stressed Steel

It is proposed to use HYSD 500 or TMT steel as reinforcement bars. For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 T 13 and or 19 K 15 is recommended (confirming to IS:14268).

5.3.3 Geo-Technical Details with New Innovative Techniques to be used for Implementation in Civil Works, Track System

5.3.3.1 Introduction

In total 24 boreholes were drilled from Subhash Chowk to Cyber City including spur to Dwarka Expressway. This Report contains Geotechnical Investigation data for 24 boreholes drilled at an interval of about 1000m c/c distance or at change of strata. 10 boreholes data for the Huda City Centre to Subhash Chowk section has been utilized from the DPR of HUDA City Centre to Bawal MRTS Corridor.

The geotechnical investigation was carried out by RITES with the following objectives:

- To determine the required strength characteristics of the underlying soil/rock strata to design the foundation of the structure proposed to be constructed at various locations.
- To determine the subsurface profile of the underlying strata.

The present geotechnical report includes the field investigation, the laboratory test results of the soil samples to evaluate the soil parameters and recommendations with regard to competency of strata for the design of foundations of proposed structures.

5.3.3.2 Physiography & Climate

Gurgaon district, situated on South eastern part of Haryana state, has an area of about 1200 sq.km. In the North, it is bordered by the Union Territory of Delhi, in the east by

Faridabad, in the North west by Jhajjar and Rewari districts of Haryana and in the west by the Alwar district of Rajasthan state and south by the Mewat district of Haryana state. The study area is largely occupied by alluvial plains, traversed by elongated ridges of Delhi quartzites. The area is well connected by roads and railways. National Highway No. 8 connecting Dehi with Jaipur passes through the district. Major state highways are – No. 13, No 28, No 26 and No. 15A connecting Gurgaon – Alwar, Palwal – Sohna, Gurgaon – Rewari – Narnaul – Singhana road and Jhajjar – Farrukhnagar – Gurgaon respectively. Almost all the villages are connected by metalled roads. Northern Railway Broad gauge main line Delhi – Gurgaon – Rewari and branch line Garhi – Harsaru – Farrukhnagar meter gauge branch line was constructed as far back as in 1883 for the salt traffic of that area. Administratively, the district is divided into four Blocks, namely, Gurgaon, Pataudi, Farrukhnagar, Sohna, and one sub – divisions, Gurgaon. Gurgaon town is the headquarter of the district.

5.3.3.3 Hydrometeorology

The climate of the district can be classified as tropical steppe, semi-arid and hot which is mainly characterized by the extreme dryness of the Air except during monsoon months, intensely hot summers and cold winters. During three months of south west monsoon from last week of June to September, the moist air of oceanic origin penetrate into the district and causes high humidity, cloudiness and monsoon rainfall. The period from October to December constitutes post monsoon season. The cold weather season prevails from January to the beginning of March and followed by the hot weather or summer season which prevails up to the last week of June.

5.3.3.4 Rainfalls and Climate

RAINFALL: The normal annual rainfall in Gurgaon district is about 596 mm spread over 28 days. The south west monsoon sets in the last week of June and withdraws towards the end of September and contributes about 85% of the annual rainfall. July and August are the wettest months. 15% of the annual rainfall occurs during the non-monsoon months in the wake of thunder storms and western disturbances.

5.3.3.5 Geomorphology and Soil Types

The area is conspicuously flat topography, however, in the north-eastern part small isolated hillocks of Precambrian rocks are exposed. The alluvial plain is formed by the Sahibi river which is tributary of River Yamuna. Soils of the Gurgaon district are classified as tropical and brown soils, existing in the north western extreme, northern and north eastern parts of the district and water logged and salt affected soils in the southern parts of the district. The soils are medium textured loamy sand is the average texture in Gurgaon and Sohna blocks. In Pataudi and Sohna blocks the organic content of soils is lowest, just up to 0.20 per cent (very low category). In the rest of the district, organic content is 0.2 to 0.40 percent and falls in low category.

5.3.3.6 General Geology

The Gurgaon district is occupied by Quaternary alluvium and Pre-Cambrian meta-sediments of Delhi Super Group. The alluvium comprises of thick beds of fine to coarse-grained sand with alternating layers of thin clays. The generalised geological formation met within the area and their water bearing characteristics are given in **TABLE 5.15**.

TABLE 5.15: GENERALISED GEOLOGICAL SUCCESSION, GURGAON DISTRICT

Geological Age	Stratigraphic Units	Lithological characters
Recent	Wind-blown sand	Medium to fine grained sand buff coloured over the alluvium
Pleistocene	Newer alluvium	Stream laid sand , silt, clay and gravel
	Older alluvium	Semi-consolidated, poorly sorted fine to medium grained sand, silt and caly occasionally mixed with kankar
-----UNCONFORMITY-----		
Delhi	Ajabgarh	Slates,Phyllites, Quartzites. Mica-schists, with intrusive pagmatites
	Alwar	Quartzites,mica-schists with intrusive pagmatites
-----U n c o n f o r m i t y-----		
Archeans	Aravalli	Mica-schists, crystalline limestone, Quartzites and schistose conglomerates

5.3.3.7 Seismic Zonation of Gurgaon, Haryana

The Haryana falls in the seismic zone IV, III, & II and therefore, the region is vulnerable to earthquakes. Although, in recent past, no major earthquakes have occurred in Haryana, yet tremors have been felt whenever there is an earthquake in the Himalayan foot-hills.

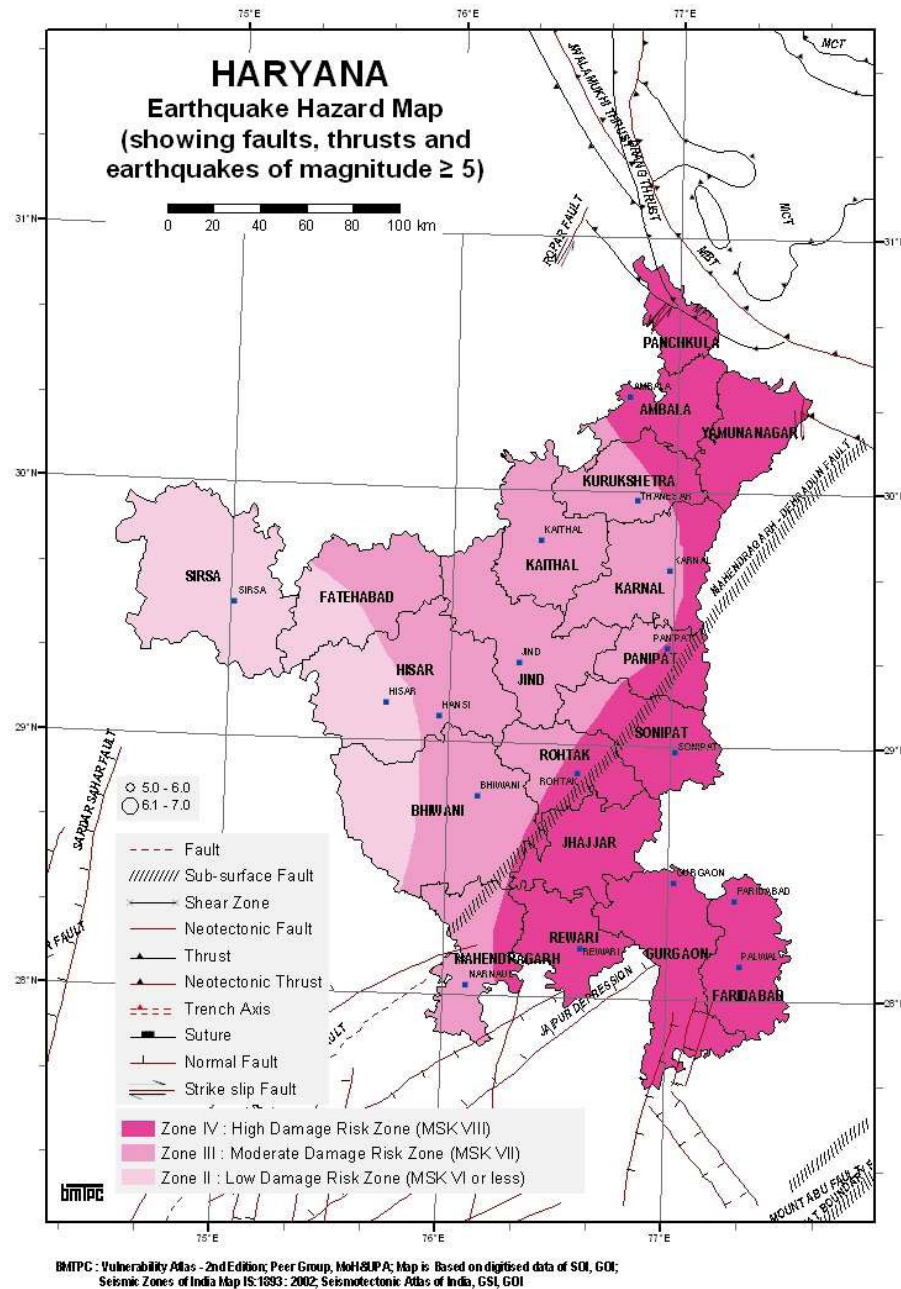
The feet remains that the region is not free from potential affecting the region are:-

- The hidden Moradabad fault.
- The Sohna fault.
- Junction of Aravalli and Alluvium near Delhi.
- Mathura fault.
- Delhi Haridwar fault.

Earthquakes which have occurred during 1820-1988 with their epicenter between latitude 26.00 to 33.00 North and longitude 73.00 to 79.00 East with in which the state of Haryana falls are around 125 of magnitude varying between 4.0 – 8 .0 on Richter Scale. In the last decade, towns of Faridabad and Gurgaon being its proximity of Delhi have grown up in the major residential-industrial towns whereas the town of Panchkula has emerged as a major residential city of the state. And all of them are falling in earthquake zone IV. As a result of this, an unplanned development which is not corrected and mainstreamed by means of preparedness /prevention/mitigation

measures will pose a greater challenge if an event occurs. The combination of moderate to high hazard, high vulnerability and high exposure results in high level of disaster risk. It is understood that a majority of inhabitants in Haryana and sectoral agencies involved in mainstream development are not aware of the existing studies, hazards, risk and vulnerability and therefore are not in a position to undertake suitable measures for preparedness and mitigation. In addition there is a lack of sharing of information amongst stakeholders and at times the existing maps are not available for public use. Earthquake Hazard map is shown in **FIGURE 5.34**.

FIGURE 5.34: EARTHQUAKE HAZARD MAP



5.3.3.8 Scope of Investigations

Field Investigation at the site were planned to determine the required strength characteristics of the underlying soil/rock to design the foundations of the proposed structure to be constructed. The Geotechnical investigation work includes:

- Drilling of 150mm diameter boreholes in all kind of soil including gravels and cobbles, up to depth of 30m. These bore holes have been drilled at an interval of about 1000m c/c distance along the alignment or at change of strata.
- Conducting Standard Penetration test (SPT) at every 3.0 m interval upto Borehole termination depth.
- Collection of disturbed & undisturbed soil samples as per IS: 2132, IS: 1892.

Following laboratory tests were conducted on collected soil samples shown in **TABLE 5.16**.

TABLE 5.16: LABORATORY TESTS

S. NO.	PARTICULARS OF PROPERTIES	RELEVANT IS CODE	DISTURBED SAMPLES	UNDISTURBED SAMPLES
1.	Sieve Analysis	IS 2720 (part IV)	✓	✓
2.	Natural Moisture Content	IS 2720 (part II)		✓
3.	Bulk/Dry Density	IS 2720 (part II)		✓
4.	Specific Gravity	IS 2720 (part III)		✓
5.	Atterberg's Limit	IS 2720 (part V)	✓	✓
6.	Direct Shear test	IS 2720 (part XIII)		✓
7.	Triaxial Shear Test	IS 2720 (part XI)		✓

5.3.3.9 Details of Geotechnical Investigation

A. General

In total, **24 BHs** have been drilled upto a maximum 30.00 m depth each for all along the length of proposed Metro alignment. Details of Boreholes drilled are given below in **Table 5.17**.

TABLE 5.17: SUMMARY OF BORE HOLES UTILIZED FROM HSIIDC METRO

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH - 1	Near HUDA City Centre Metro Station	Not met with	30.00	0
BH - 2	Infront of Taj City Centre, Gurgaon	Not met with	30.00	400
BH - 3	Near Sector-45 Metro Station	Not met with	30.00	800
BH - 4	Between Sector-45 & Cyber Park Metro Stations	Not met with	30.00	1300
BH - 5	Before Cyber Park Metro Station	Not met with	30.00	1800
BH - 6	Near Cyber Park Metro Station	Not met with	30.00	2300
BH - 7	Between Cyber Park & District Shopping Centre, Sector 47 Metro Stations	Not met with	30.00	2800
BH - 8	Near District Shopping Centre, Sector 47 Metro Station	Not met with	30.00	3300
BH - 9	Between District Shopping Centre, Sector 47 & Subhash Chowk Metro	Not met with	30.00	3800
BH - 10	Near Subhash Chowk Metro Station	Not met with	30.00	4400

TABLE 5.18: SUMMARY OF BORE HOLES DRILLED ALONG THE CORRIDOR

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH - 1	Near Subhash Chowk	Not met with	30.00	4925
BH - 2	Near sector-48 Metro Station	Not met with	30.00	5940
BH - 3	Technology Park Metro Station	Not met with	30.00	6910
BH - 4	Near Hero Honda Chowk	Not met with	30.00	7930
BH - 5	Near Udyog Vihar 6 Metro Station	Not met with	30.00	8990
BH - 6	Sector-10 Metro Station Near Kadipur Chowk	Not met with	30.00	10058
BH - 7	In between Sector-37 and Basai Village Metro Station	Not met with	30.00	10980

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH – 8	Near Vidya medical centre Neki Ram Marg	Not met with	30.00	11915
BH – 9	Near Sector 9 Metro Station	Not met with	30.00	12608
BH – 10	Near, Sector 7 Metro Station	15.00 m	30.00	13320
BH – 11	Near sector 4 Metro Station	14.00 m	30.00	14365
BH – 12	Near Sector-5 Metro Station	14.00 m	30.00	15323
BH – 13	851 m from BH-12 along railway road towards Gurgaon Railway station	9.50 m	30.00	851
BH – 14	Near Gurgaon Railway station	13.50 m	30.00	551
BH – 15	Ashok Vihar Phase III, Near Mata Sheetla Fuel Station	Not met with	30.00	16947
BH –16	Near Sector-3 Metro Station	Not met with	30.00	17430
BH –17	Near Bajghera Road Metro Station	Not met with	30.00	18575
BH–18	Near Palam Vihar Extn Metro Station	Not met with	30.00	19518
BH–19	Near Palam Vihar Metro Station	Not met with	30.00	20700
BH–20	Near Sector-23A, Metro Station	Not met with	30.00	21900
BH–21	Near Sector-22, Metro Station	Not met with	30.00	22852
BH–22	Dhanwarpur Village, Near Dwarka Expressway	2.50	30.00	13500
BH–23	Near ASF Centre, Gurgaon	Not met with	30.00	23927
BH–24	Near HSIIDC Office, Gurgaon	Not met with	30.00	25477

B. Standard Penetration Test (SPT)

SPT was conducted in the boreholes at every 3.0 m interval and change of strata as per specifications. Standard split spoon sampler attached to lower end of drill rods was driven in the boreholes by means of standard hammer of 63.50 kg falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications and number of blows required for each 15 cm penetration was recorded. The number of blows for the first 15 cm penetration was not taken into account as it is considered seating drive. The number of blows for next 30 cm penetration was designated as SPT 'N' value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed Soil samples obtained from standard split spoon sampler were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to laboratory for testing.

C. Undisturbed Soil Samples (UDS)

UDS were collected from the boreholes at every 3.0 m interval & change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia. and 450 mm length. These sampling tubes after retrieval from the boreholes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing.

The depth of **Ground Water Table** was measured in all bore holes.

The location plan of boreholes drilled is given in **Figure 5.36** to **Figure 5.38**.

5.3.3.10 Engineering Parameters of Each Layer

Sub Soil Profile

The sub-soil strata at proposed metro sites are generally homogeneous and comprises of mainly three types of layers (based on field tests & laboratory test result data). Description of engineering parameters of each layer met is as under;

LAYER TYPE – I, Yellowish colour low to medium plastic silty clay. (CL/CI,CL-CI)

LAYER TYPE– II, Yellowish colour non plastic sandy silt. (ML)

LAYER TYPE - III, Greyish colour non plastic silty sand. (SM/SP-SM)

FIGURE 5.35: LOCATION PLAN OF BOREHOLES UTILIZED FROM HSIIDC METRO (BH 01 – BH 05)

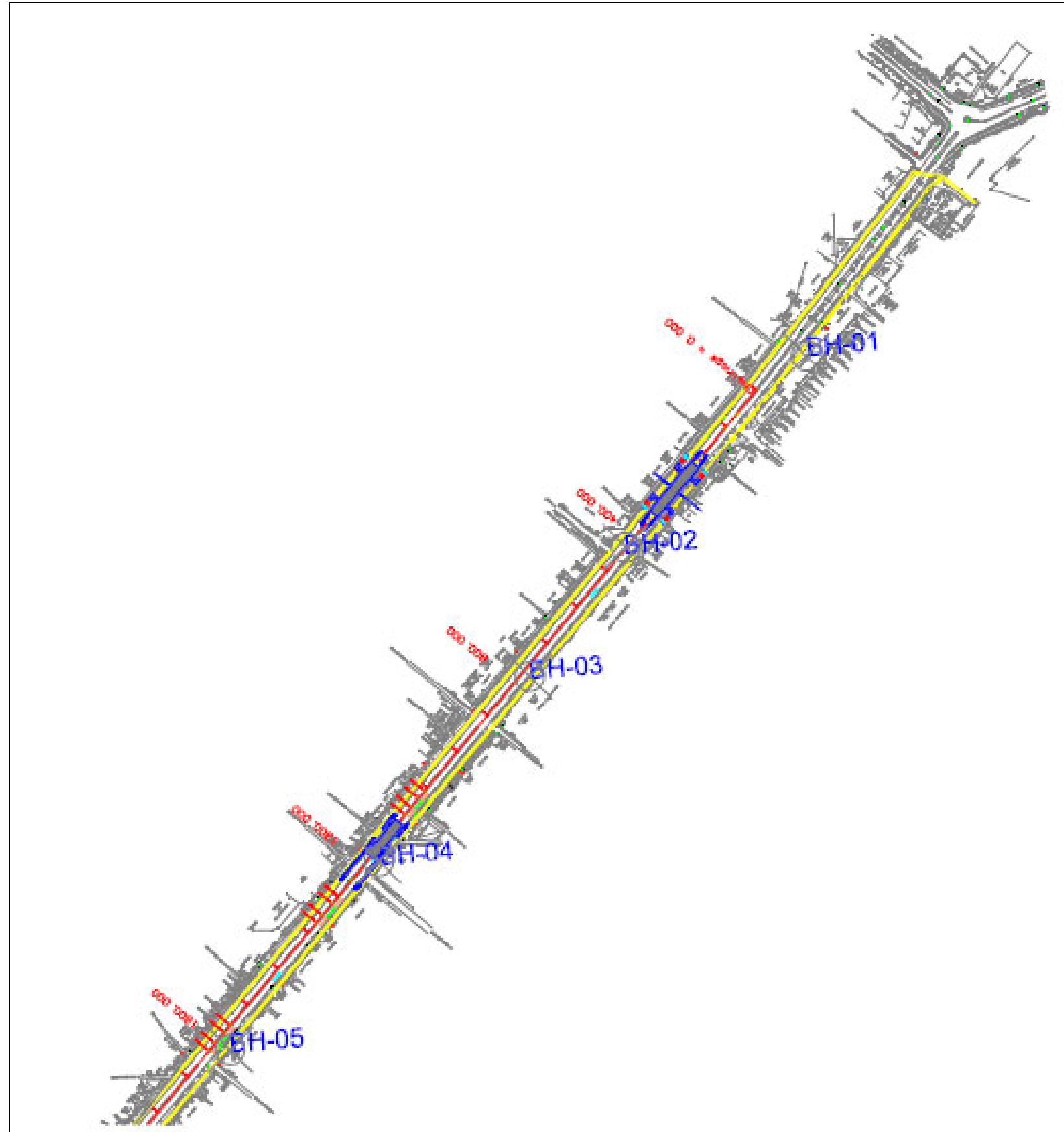


FIGURE 5.36: LOCATION PLAN OF BOREHOLES UTILIZED FROM HSIIDC METRO (BH 06 – BH 10)

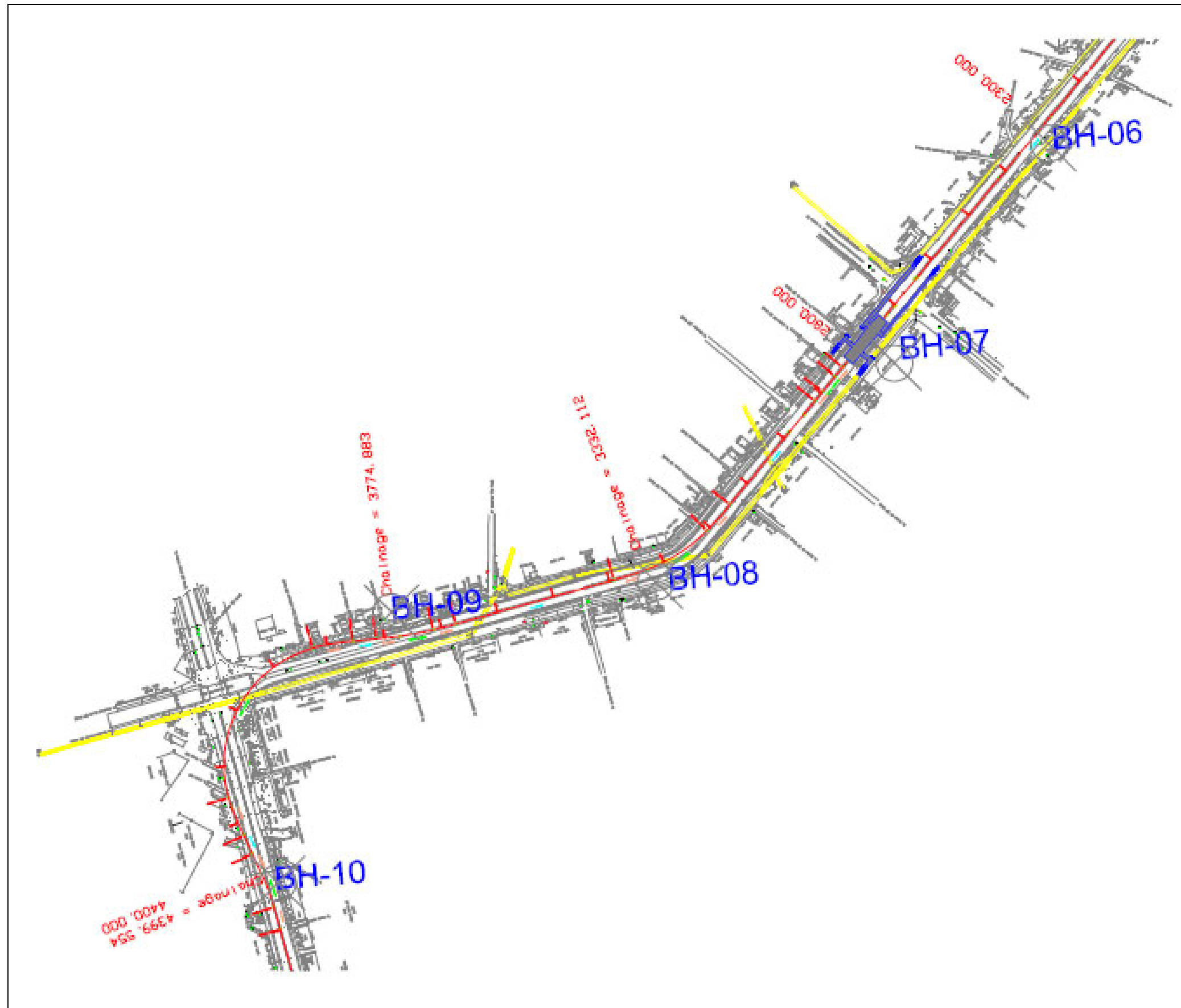
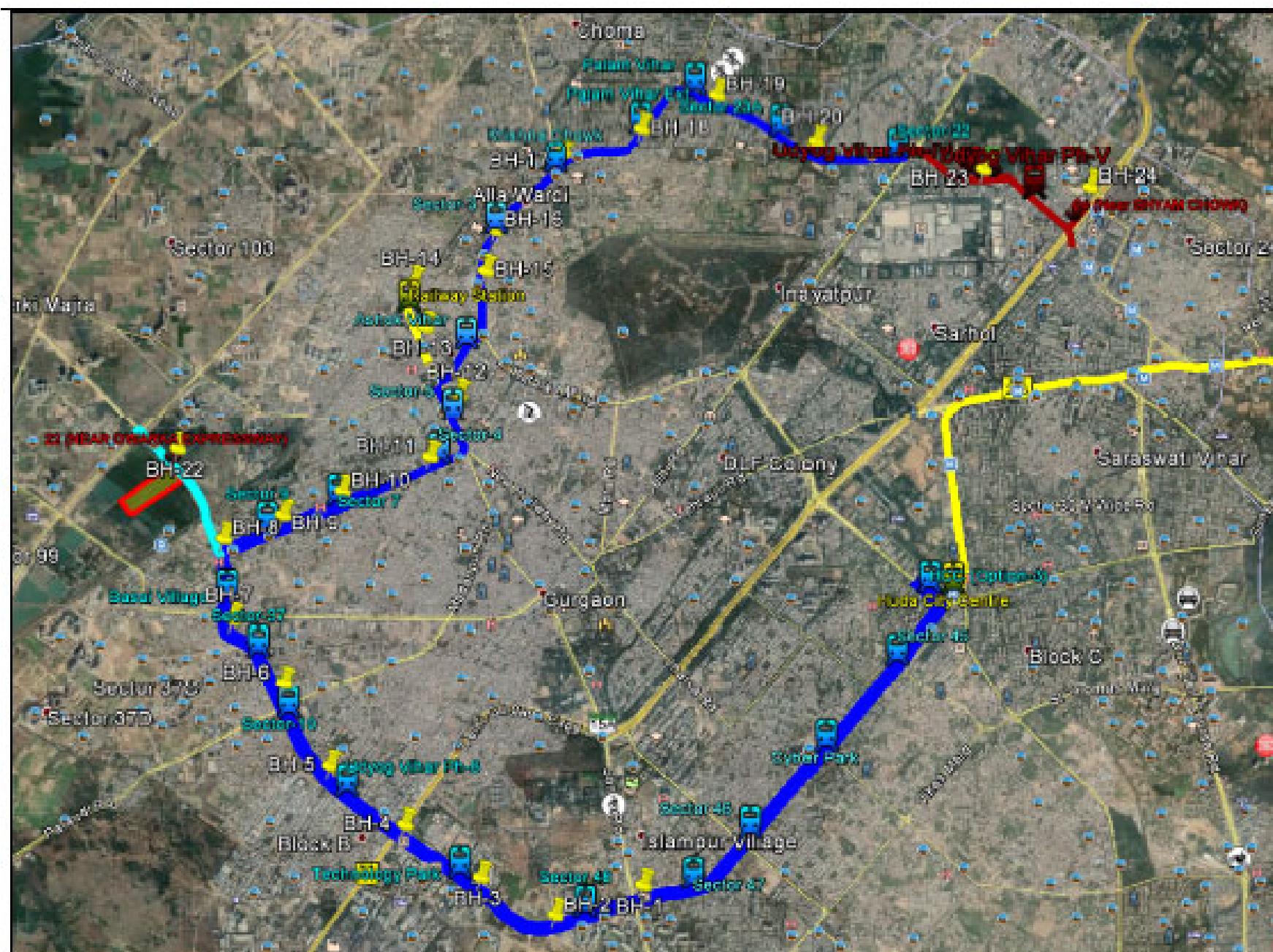


FIGURE 5.37: LOCATION PLAN OF BOREHOLES DRILLED



**TABLE 5.19: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG THE CORRIDOR
(UTILIZED FROM HSIIDC)**

DEPTH (m)	SOIL TYPE	DESIGN 'N' VALUE	DESIGN PARAMETERS			
			$\gamma_{\text{bulk}} / \gamma_{\text{sat}}$ (T/m ³)	$\gamma_{\text{submerged}}$ (T/m ³)	C_u , T/m ²	ϕ°
			BH – 1			
0.00 – 1.00	ML-SM	--	1.60	0.90	--	--
1.00 – 2.00	ML-CL	12	1.60	0.90	0.5	27
2.00 – 4.00	CL	22	1.67	0.98	0.5	30
4.00 – 8.00	CL	35	1.90	1.04	1.0	30
8.00 – 13.00	ML-CL	45	1.90	1.04	0.5	31
13.00 – 24.00	CL	50	2.00	1.05	1.0	31
24.00 – 25.00	ML	40	2.05	1.05	0	32
25.00 – 30.00	CL	75	2.05	1.05	1.0	31
			BH – 2			
0.00 – 2.00	ML-SM	15	1.70	0.90	--	--
2.00 – 5.00	CL	17	1.77	0.97	0.5	28
5.00 – 8.00	CL	40	1.80	0.99	1.0	30
8.50 – 9.00	ML	--	1.84	1.02	0	32
9.00 – 13.00	CL	45	1.90	1.02	0.5	31
13.00 – 18.00	CL	50	1.90	1.05	0.5	31
18.00 – 26.00	CL	60	2.00	1.05	1.0	31
26.00 – 30.00	CL	75	2.00	1.06	1.5	30
			BH – 3			
0.00 – 2.00	ML-SM	20	1.70	0.90	--	--
2.00 – 4.00	CL	25	1.80	1.00	0.5	30
4.00 – 5.00	ML-SM	22	1.80	1.00	0.5	30
5.00 – 9.00	CL	30	1.81	1.01	0.5	31
9.00 – 15.00	CL	40	1.83	1.02	1.0	31
15.00 – 18.00	SM-ML	34	1.90	1.02	0	33
18.00 – 21.00	GC-CL	50	2.00	1.05	0.5	32
21.00 – 24.00	CL	42	2.00	1.03	0.5	31
24.00 – 30.00	ML-SM	38	2.00	1.03	0.5	31.5
			BH – 4			
0.00 – 1.00	ML-SM	--	1.60	0.90	--	--
1.00 – 2.00	CL	9	1.64	0.94	--	--
2.00 – 4.00	ML-SM	12	1.64	0.94	0	28
4.00 – 6.00	GM	19	1.70	0.94	0	31
6.00 – 11.00	CL	24	1.90	1.01	0.5	30
11.00 – 15.00	SM-ML	22	1.88	1.01	0	32
15.00 – 19.00	CL	40	1.90	1.02	1.0	30

DEPTH (m)	SOIL TYPE	DESIGN 'N' VALUE	DESIGN PARAMETERS			
			$\gamma_{\text{bulk}} / \gamma_{\text{sat}}$ (T/m ³)	$\gamma_{\text{submerged}}$ (T/m ³)	Cu, T/m ²	ϕ°
19.00 – 21.00	SM-ML	40	2.00	1.03	0	33
21.00 – 26.00	CL	45	2.00	1.03	1.0	31
26.00 – 30.00	ML	45	2.00	1.03	0	32
BH – 5						
0.00 – 2.00	ML-CL	8	1.63	0.90	--	--
2.00 – 4.00	ML-CL	12	1.66	0.95	0.5	28
4.00 – 6.00	CL	15	1.81	1.00	0.5	30
6.00 – 11.00	CL	28	1.85	1.01	1.0	31
11.00 – 15.00	SM	35	1.85	1.02	0	33
15.00 – 17.00	CL	45	1.90	1.02	1.0	30
17.00 – 21.00	SM	32	1.90	1.02	0	33
21.00 – 30.00	CL	60	2.05	1.05	0.5	31
BH – 6						
0.00 – 2.00	SM	10	1.60	0.90	--	--
2.00 – 5.00	SM	15	1.65	0.95	0	29
5.00 – 8.00	ML	20	1.73	1.00	0.5	30
8.00 – 13.00	SM	28	1.90	1.01	0	32
13.00 – 18.00	CL	45	1.90	1.03	0.5	30
18.00 – 30.00	CL	60	2.00	1.05	0.5	31
BH – 7						
0.00 – 2.00	ML-CL	9	1.70	0.90	--	--
2.00 – 4.00	CL	12	1.72	0.94	0.5	28
4.00 – 5.00	ML-SM	35	1.81	1.02	0.5	31
5.00 – 10.00	CL	45	1.82	1.02	0.5	30.5
10.00 – 12.00	ML	40	1.90	1.04	0	32
12.00 – 15.00	SM-ML	35	1.90	1.04	0	33
15.00 – 18.00	CL	40	1.90	1.03	0.5	30.5
18.00 – 27.00	CL	60	2.00/2.05	1.05	0.5	31
27.00 – 30.00	ML-SM	26	2.02	1.02	0	32
BH – 8						
0.00 – 2.00	ML	10	1.70	0.90	--	--
2.00 – 3.00	ML-CL	--	1.72	0.94	0.5	28
3.00 – 5.00	ML-SM	18	1.80	0.95	0.5	30
5.00 – 8.00	CL	30	1.81	1.02	1.0	30
8.00 – 10.00	CL	35	1.85	1.02	0.5	31
10.00 – 14.00	CL	50	1.90	1.02	0.5	31
14.00 – 18.00	SM	45	1.90	1.05	0	33
18.00 – 19.00	ML-CL	50	1.90	1.02	0	32
19.00 – 21.00	SM	30	1.90	1.02	0	33

DEPTH (m)	SOIL TYPE	DESIGN 'N' VALUE	DESIGN PARAMETERS			
			$\gamma_{\text{bulk / sat}}$ (T/m ³)	$\gamma_{\text{submerged}}$ (T/m ³)	Cu, T/m ²	ϕ°
21.00 – 30.00	CL	60	2.00/2.06	1.06	0.5	32
			BH – 9			
0.00 – 2.00	CL	12	1.70	0.90	–	–
2.00 – 3.00	ML-CL	–	1.70	0.96	0.5	28
3.00 – 4.00	SM	22	1.80	0.96	0	31
4.00 – 8.00	CL	20	1.88	0.99	1.0	29
8.00 – 12.00	ML-SM	40	1.83	1.01	0.5	31
12.00 – 15.00	ML-CL	30	1.83	1.01	0.5	31
15.00 – 18.00	CL	40	1.90	1.01	0.5	30.5
18.00 – 30.00	CL	50	2.00/2.04	1.04	1.0	31
			BH – 10			
0.00 – 8.00	CL	9	1.70	0.94	0.5	27
8.00 – 12.00	CL	28	1.83	1.02	1.0	30
12.00 – 17.00	CL	40	1.90	1.02	1.0	30.5
17.00 – 21.00	ML	50	2.00	1.03	0.5	32
21.00 – 27.00	CL	60	2.00	1.06	0.5	31
27.00 – 28.00	ML	35	2.00	1.06	0.5	32
28.00 – 29.00	CL	75	2.00	1.06	1.0	31
29.00 – 30.00	ML	34	2.00	1.03	0.5	32

TABLE 5.20: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG THE CORRIDOR (DRILLED BOREHOLES)

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM/SC)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m ²)		Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m ²)		Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m ²)	
1.	13.50-30.00	56- (N>100)	-	-	-	-	-	-	0.00-13.50	17-34	0.6-0.8	30-31
2.	16.50-30.00	50- (N>100)	-	-	-	-	-	-	0.00-16.50	15-36	0.8-1	27-28
3.	13.50-30.00	41-69	-	-	-	-	-	-	0.00-13.50	22-30	0.4-0.6	31-32
4.	10.30-30.00	31- (N>100)	-	-	-	-	-	-	0.00-10.50	20-27	0.4-0.8	29-33
5.	15.00-19.50	45-48	-	-	12.00-15.00	30-30	-	-	0.00-12.00 19.50-30.00	20-26 50-- (N>100)	0.4-0.6 -	29-30 -
6.	9.00-19.50	28-49	1.4-1.4	24-24	-	-	-	-	0.00-9.00 19.50-30.00	20-23 52- (N>100)	0.6-0.6 -	28-28 -
7.	13.50-30.00	39- (N>100)	-	-	-	-	-	-	0.00-13.50	21-33	0.4-0.8	27-29
8.	18.00-30.00	66- (N>100)	-	-	-	-	-	-	0.00-18.00	8-52	0.6-0.8	31-32
9.	-	-	-	-	-	-	-	-	0.00-30.00	11- (N>100)	0.6-0.8	29-30

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM/SC)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m ²)		Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m ²)		Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m ²)	
10.	-	-	-	-	-	-	-	-	0.00-30.00	13- (N>100)	0.6-0.8	27-28
11.	-	-	-	-	-	-	-	-	0.00-30.00	12- (N>100)	0.6-0.8	28-31
12.	0.00- 9.00 18.00-30.00	17-29 58-86	1.2-1.2 -	24-24 -	-	-	-	-	9.00-18.00	38-49	0.6-0.6	30-30
13.	0.00 - 6.00 13.50 -21.00	29-32 58-84	1.4-1.4 -	22-22 -	-	-	-	-	6.00-13.50 21.00-30.00	38-45 91- (N>100)	0.6-0.6 -	30-30 -
14.	0.00-7.50	21-34	1.6-1.6	23-23	-	-	-	-	7.50-30.00	48- (N>100)	0.8-0.8	29-29
15.	10.50-16.50 22.50-30	31-53 55-68	- -	- -	-	-	-	-	0.00-10.50 16.50-22.50	10-26 55-67	6 -	9 -
16.	9.00-16.50 27.00-30.00	34-57 73-82	1 -	26 -	-	-	-	-	0.00-9.00 16.50-27.00	14-31 61- (N>100)	8.8 -	6 -
17.	27.00-30.00	82- (N>100)	-	-	4.50-16.50	17-56	0.8	1.0	0.00-4.50 16.50-27.00	5-14 53- (N>100)	- -	- -
18.	0.00-9.00 16.50-30.00	27-47 68-98	8.4 -	5 -	9.00-16.5	39-64	0.8-27	-	-	-	-	-
19.	0.00-16.50 19.50-30.00	16-46 54-94	1-8 -	5-6 -	-	-	-	-	16.50-19.50	52	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM/SC)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m2)		Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m2)		Depth (m) from - to	SPT N VALUES	Shear Parameters C ϕ (T/m2)	
20.	0.00-21.00 24.00-30.00	21-70 53-66	1.2-9.4 -	6-23 -	-	-	-	-	21.00-24.00	63-65	-	-
21.	0.00-3.00 4.50-12.00 13.50-30	6 31-41 47- (N>100)	- 1 8.4	- 24 5	-	-	-	-	3.00-4.50 12.00-13.50	30 39	- -	- -
22.	1.50-10.50 12.00-15.00 21.00-30.00	20-24 36-39	9.6 - -	6.00	15.00-18.00 10.50-12.50	60-64 24-36	0.4	30.00	0-1.50 10.50-12.00 18.00-21.00	8 24-36 40-42	- - -	- - -
23.	4.50-9.00 9.00-12.00 19.50-22.00 24.00-25.00 27.00-28.50	19-51 33-51 41-46 48 78	- - - - -	- - - - -	9.00-12.00	33-51	-	-	0-4.50 12.00-19.50 22.50-24.00 25.50-27.00 28.50-30.00	18 33-81 46-48 67-74 78-94	- - - - -	- - - - -
24.	0-10.50 16.50-18.00 21.00-24.00 24.00-27.00 27.00-30.00	41-56 59-62 75- N>100 83-100	- - - - -	- - - - -	10.50-13.50 15.00-16.50 24.00-27.00	54-56 59 88-91	- - -	- - -	13.50-15.00 18.00-21.00	58 64-75	- - -	- - -

5.3.3.11 Foundation Analysis

A. Introduction

The structures along the proposed alignment have been explored by drilling of 24 boreholes down to depth ranging upto 30m below ground level.

B. Depth Of Foundation In Soil

A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Depth of foundations in soil shall be decided as per clause 7 of IS: 1904 for special cases like; where volume change is expected / scour is expected / foundations on sloping ground / foundation on made up or filled up ground / frost action is expected etc.

C. Allowable Bearing Capacity Of Shallow Foundations In Soil

It will be taken, as the net intensity of loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding net safe bearing capacity

For satisfactory performance of a foundation, the following criteria must be satisfied;

- i. The foundation must not fail in shear.
- ii. The foundation must not settle by an amount more than the permissible settlement.

TABLE 5.21: SAFE LOAD CARRYING CAPACITY OF PILES (UTILIZED FROM HSIIDC METRO)

Stretch	DIAMETER OF PILE (mm)	LENGTH OF PILE BELOW CUTOFF LEVEL (m)	RECOMMENDED SAFE VERTICAL LOAD CAPACITY (Tonnes)		RECOMMENDED SAFE UPLIFT LOAD CAPACITY (Tonnes)		RECOMMENDED SAFE HORIZONTAL LOAD CAPACITY (Tonnes)	RECOMMENDED DEPTH OF FIXITY BELOW CUTOFF LEVEL (m)
			Normal Condition	**Seismic Condition	Normal Condition	**Seismic Condition	Normal Condition	Normal Condition
0 – 4000m	1000	20.00	328	311	189	173	30	8.30
		21.00	340	323	200	184		
		22.00	352	335	212	195		
		23.00	364	347	223	207		
		24.00	376	359	234	218		
		25.00	388	371	246	229		
		26.00	400	383	257	241		
	1200	20.00	466	434	230	210	50	9.50
		21.00	480	448	243	224		
		22.00	494	462	257	237		
		23.00	508	476	271	251		
		24.00	522	490	284	265		
		25.00	537	504	298	278		
		26.00	551	518	312	292		

Stretch	DIAMETER OF PILE (mm)	LENGTH OF PILE BELOW CUTOFF LEVEL (m)	RECOMMENDED SAFE VERTICAL LOAD CAPACITY (Tonnes)		RECOMMENDED SAFE UPLIFT LOAD CAPACITY (Tonnes)		RECOMMENDED SAFE HORIZONTAL LOAD CAPACITY (Tonnes)	RECOMMENDED DEPTH OF FIXITY BELOW CUTOFF LEVEL (m)
			Normal Condition	**Seismic Condition	Normal Condition	**Seismic Condition	Normal Condition	Normal Condition
4000 – 4700m	1000	20.00	319	281	183	151	20	13.00
		21.00	331	293	194	162		
		22.00	343	305	205	174		
		23.00	355	317	217	185		
		24.00	367	329	228	196		
		25.00	379	341	239	208		
		26.00	403	365	251	219		
	1200	22.00	484	424	249	211	30	14.00
		23.00	498	438	263	225		
		24.00	512	452	277	239		
		25.00	526	467	290	252		
		26.00	557	497	304	266		

TABLE 5.22: SAFE LOAD CARRYING CAPACITY OF PILES (DRILLED BOREHOLES)

S. No.	Location	Chainage (m)	Bore hole No	Dimension of pile		Safe load (Tonnes)
				Length (m)	Diameter (m)	
1.	Near Subhash Chowk	4925	BH-1	24	1.0	184
					1.2	233
				20	1.0	148
					1.2	188
2.	Near sector-48 Metro Station	5940	BH-2	24	1.0	170
					1.2	217
				21	1.0	147
					1.2	188
3.	Technology Park Metro Station	6910	BH-3	24	1.0	201
					1.2	255
				20	1.0	166
					1.2	211
4.	Near Hero Honda Chowk	7930	BH-4	24	1.0	176
					1.2	224
				17	1.0	117
					1.2	150
5.	Near Udyog Vihar 6 Metro Station	8990	BH-5	24	1.0	196
					1.2	241
				20	1.0	157
					1.2	200
6.	Sector-10 Metro Station Near Kadipur Chowk	10058	BH-6	24	1.0	210
					1.2	300
				20	1.0	134
					1.2	175

S. No.	Location	Chainage (m)	Bore hole No	Dimension of pile		Safe load (Tonnes)
				Length (m)	Diameter (m)	
7.	In between sector-37 and Barai Village Metro Station	10980	BH-7	24	1.0	170
					1.2	215
				20	1.0	137
					1.2	175
8.	Near Vidya medical centre neki ram marg	11915	BH-8	24	1.0	204
					1.2	256
				12	1.0	152
					1.2	207
9.	Near Sector 9 Metro Station	12608	BH-9	24	1.0	274
					1.2	395
				18	1.0	210
					1.2	304
10.	Near, Sector 7 Metro Station	13320	BH-10	24	1.0	217
					1.2	304
				18	1.0	163
					1.2	226
11.	Near sector 4 Metro Station	14365	BH-11	24	1.0	235
					1.2	331
				18	1.0	177
					1.2	250
12.	Near Sector-5 Metro Station	15323	BH-12	24	1.0	220
					1.2	277
				12	1.0	167
					1.2	217
13.	851 m from BH-12 along railway road towards Gurgaon Railway station	851	BH-13	24	1.0	243
					1.2	348
				21	1.0	251
					1.2	192
14.	Near Gurgaon Railway station	551	BH-14	24	1.0	357
					1.2	506
				18	1.0	275
					1.2	391
15.	Ashok Vihar Phase III, Near Mata Sheetla Fuel Station	16947	BH-15	24	1.0	154
					1.2	193
				18	1.0	113
					1.2	143
16.	Near Sector-3 Metro Station	17430	BH-16	24	1.0	204
					1.2	291
				18	1.0	114
					1.2	145
17.	Near Krishna Chowk, Metro Station	18575	BH-17	24	1.0	187
					1.2	269
				18	1.0	104
					1.2	132

S. No.	Location	Chainage (m)	Bore hole No	Dimension of pile		Safe load (Tonnes)
				Length (m)	Diameter (m)	
18.	Near Palam Vihar Extn Metro Station	19518	BH-18	24	1.0	192
					1.2	240
				18	1.0	176
					1.2	239
19.	Near Palam Vihar Metro Station	20700	BH-19	24	1.0	188
					1.2	236
				18	1.0	146
					1.2	183
20.	Near Sector-23A, Metro Station	21900	BH-20	24	1.0	203
					1.2	290
				18	1.0	126
					1.2	159
21.	Near Sector-22, Metro Station	22852	BH-21	24	1.0	163
					1.2	205
				18	1.0	122
					1.2	154
22.	Near Dwarka Expressway	N.A	22	18.00	1.0	177
					1.2	239
				24.00	1.0	199
					1.2	251
23.	Near ASF Centre, Gurgaon	23927	23	18.00	1.0	194
					1.2	269
				24.00	1.0	248
					1.2	344
24.	Near HSIDC Office, Gurgaon	25477	24	18.00	1.0	149
					1.2	188
				24.00	1.0	192
					1.2	242

FIGURE 5.38: LITHOLOGICAL SECTION ALONG THE CORRIDOR (UTILIZED FROM HSIIDC METRO)

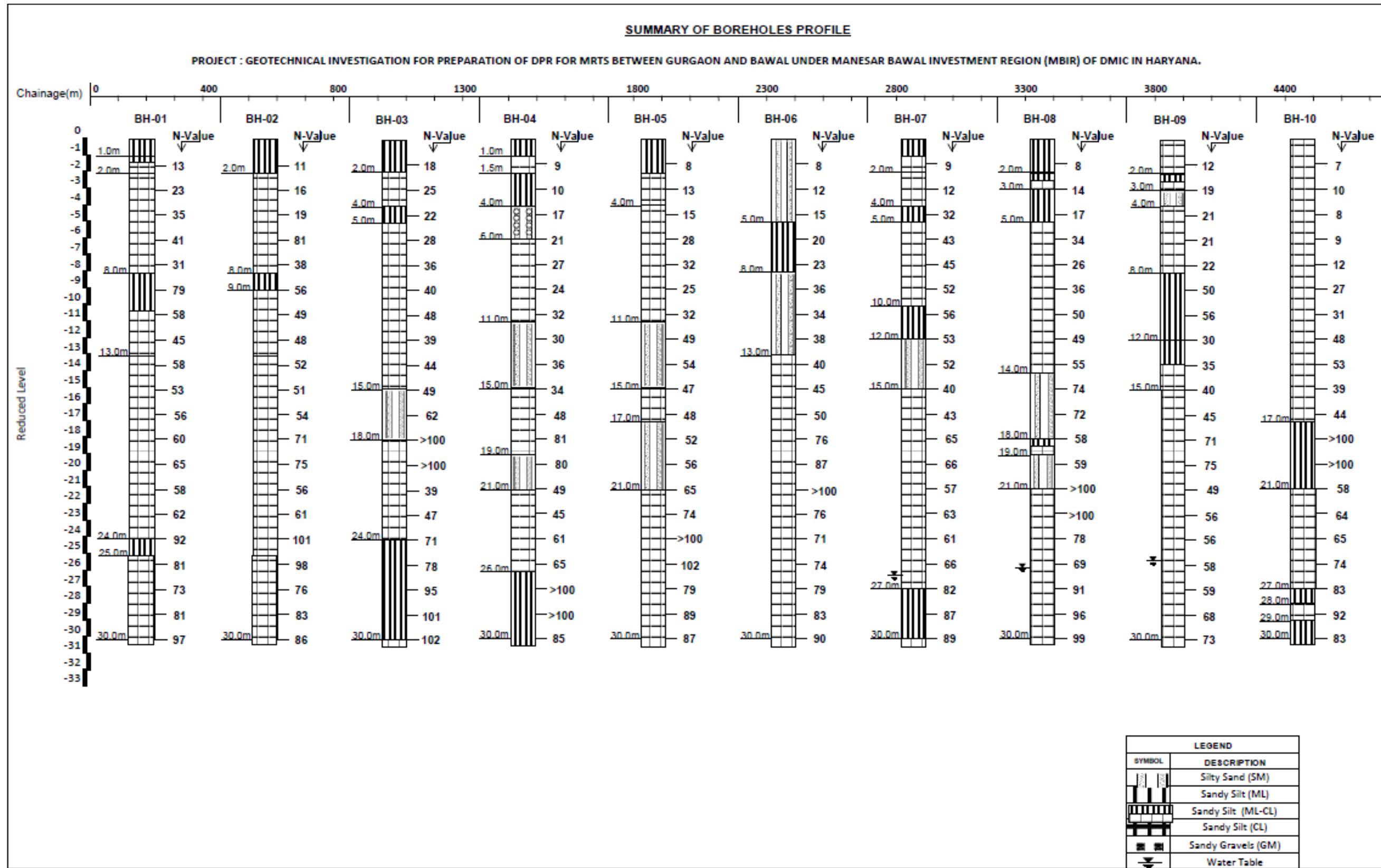


FIGURE 5.39: LITHOLOGICAL SECTION ALONG THE CORRIDOR (DRILLED SECTION)

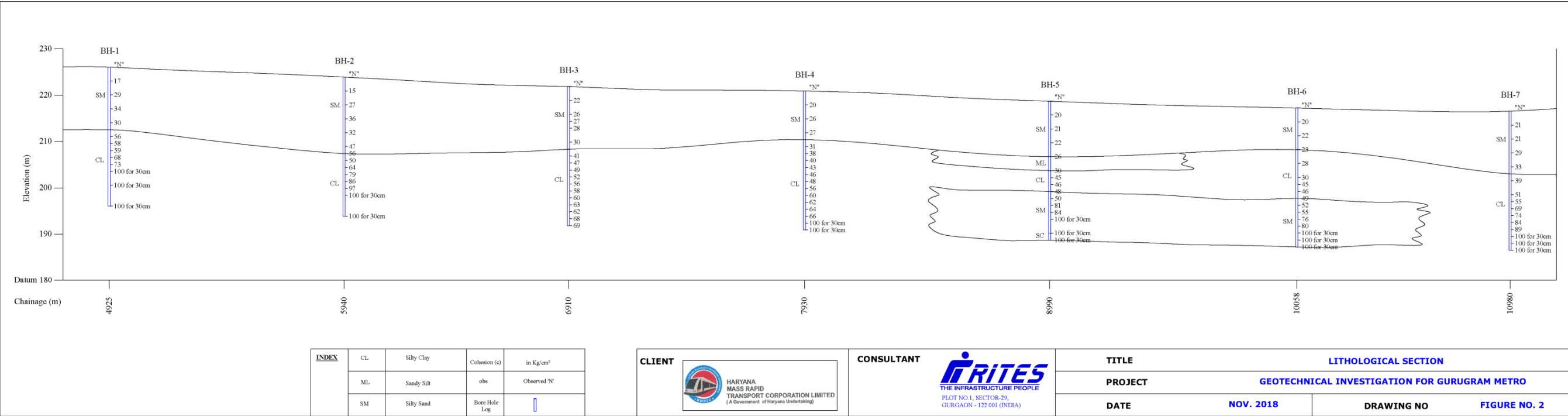


FIGURE 5.40: LITHOLOGICAL SECTION ALONG THE CORRIDOR

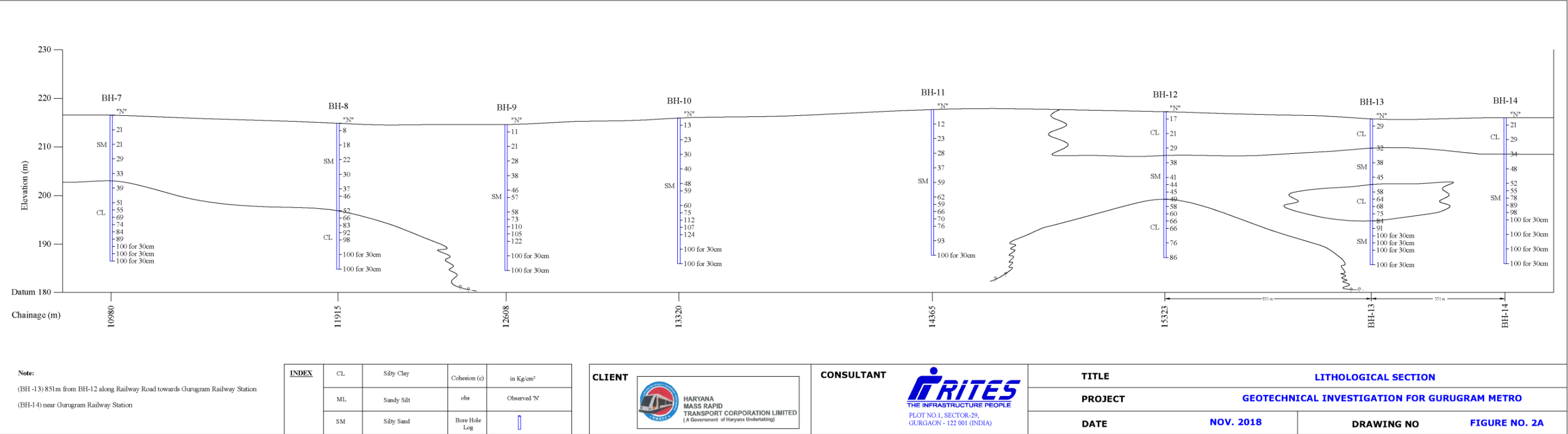
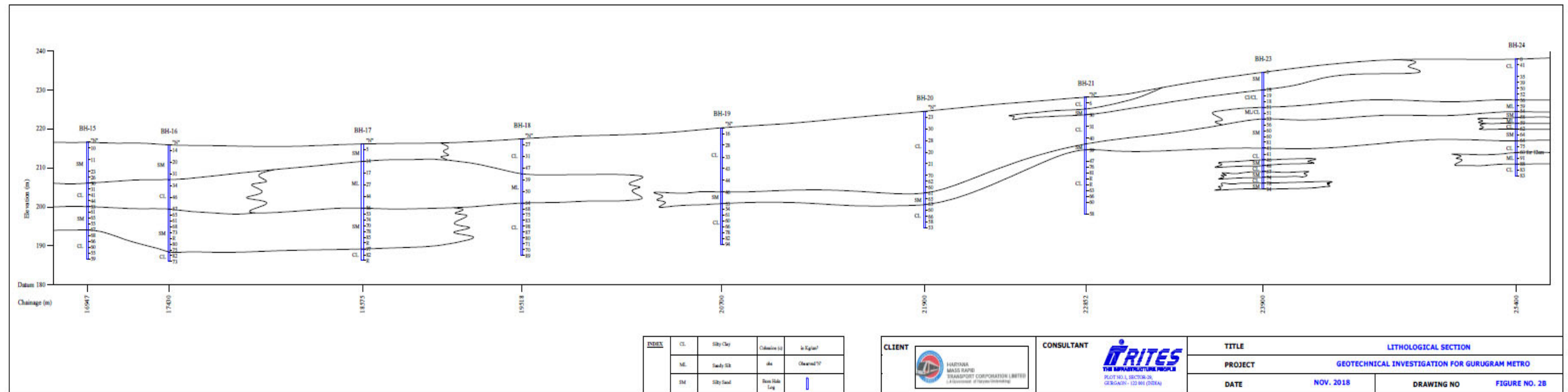


FIGURE 5.41: LITHOLOGICAL SECTION ALONG THE CORRIDOR



5.3.3.12 Conclusions & Recommendations

Twenty four bore holes have been drilled down to maximum depth of 30.00 m below ground level and data of ten boreholes have been utilized from the Geotechnical Study of HSIIDC Metro for sub soil exploration. Following is recommended for different type of foundations:

- a) Since heavy loads are to be transferred to sub soil strata at viaduct part of alignment therefore **Pile Foundations** have been recommended for the proposed viaduct
- b) The design safe load carrying capacity of Pile Foundation has been given in **Table 5.21** and **Table 5.22**.
- c) The load capacities of piles are based on empirical correlation's and should be confirmed by conducting **pile load test as per IS: 2911 (Part 4)** on test piles before execution of working piles.
- d) Since the proposed site is situated in seismic **Zone IV** of the seismic zonation map of India, suitable seismic coefficient commensurate to seismic Zone IV (IS: 1893) should be adopted in the design of the structures.
- e) Wherever Undisturbed samples (UDS) could not be obtained due to stiff soil (SPT value more than 30), cohesion & angle of internal friction values have been obtained from observed SPT N value.

References:

- i. IS 1892:1979 – Code of Practice for Sub-surface investigation for foundations.
- ii. IS 78-2014 (Appendix 5/Method 2): Design and Construction of Pile Foundations.
- iii. IS 2720- Methods of Tests for Soils (Relevant parts).
- iv. IS 2131- Method for Standard Penetration Test for Soils.
- v. Is 6403: 1981 Code for practice for determination of Safe Bearing Capacity of shallow foundation on Soil.

5.4 GEOMETRIC DESIGN OF CORRIDOR INCLUDING PLAN/PROFILE

5.4.1 Alignment Design Considerations

Following considerations have been kept in view, while designing the alignment.

- a. The alignment has been proposed to cover the high density traffic corridors and origination/destination centers.
- b. The elevated alignment has been generally proposed along the median of the road.
- c. Track Centre of 4.10 m has been proposed for elevated section so as to provide flexibility of adopting Double U-shaped Girders for superstructure.

- d. Traffic diversion will be required where elevated stations are proposed along the road.
- e. Effort has been made to minimize disruption to road traffic during construction phase.
- f. Effort has been made to position the ramps and depots on Government land.

5.4.2 Corridor: HUDA City Centre to Cyber City, Gurgaon

A. Horizontal Curvature

The proposed alignment negotiates frequent horizontal curves to follow the existing road median. At some places there are sharp turns and curves along the road and this necessitates provision of sharp curves on metro alignment also.

Total 77 nos. horizontal curves have been provided on the entire length of the alignment. The minimum radius of curves is 125 m in the corridor. About 63% alignment is on straight and about 37% of alignment is on curves. The abstract and details of curves are indicated in **TABLE 5.23** and **TABLE 5.24** respectively.

TABLE 5.23: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤ 200	24	4135.40	42.42
2	$>200 \leq 300$	5	631.16	6.47
3	$>300 \leq 500$	19	2483.95	25.48
4	$>500 \leq 800$	9	878.66	9.01
5	$>800 \leq 1000$	7	864.95	8.87
6	>1000	13	755.11	7.75
	Total	77	9749.24	100.00

TABLE 5.24: DETAILS OF HORIZONTAL CURVES OF THE CORRIDOR

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
HUDA City Centre to Udyog Vihar Ph V													
1	-168.93	-67.45	Left	-400	8	28	57.00	40	40	50.81	21.48	101.48	135
2	67.61	195.14	Left	-140	31	26	1.68	50	50	64.97	27.52	127.52	61
3	256.24	337.16	Right	800	3	23	5.28	30	30	40.47	20.92	80.92	110
4	446.90	508.44	Right	1750	1	18	45.36	15	15	30.77	31.54	61.54	136
5	644.68	754.68	Right	500	8	0	42.48	40	40	55.07	30.00	110.00	18
6	772.43	882.91	Left	-500	8	2	36.60	40	40	55.31	30.48	110.48	1383
7	2266.21	2331.50	Right	7000	0	16	15.24	10	10	32.64	45.29	65.29	684
8	3015.38	3052.89	Left	-7000	0	7	59.16	10	10	18.76	17.51	37.51	1015
9	4068.26	4194.94	Right	125	35	5	24.36	50	50	64.82	26.69	126.69	360
10	4555.44	4682.08	Left	-400	10	35	3.48	50	50	63.46	26.65	126.65	1
11	4683.52	4808.38	Right	400	10	25	57.00	50	50	62.56	24.86	124.86	354
12	5162.51	5285.99	Right	450	10	22	27.48	40	40	61.87	43.48	123.48	1
13	5286.95	5418.39	Left	-450	11	22	59.52	40	40	65.89	51.44	131.44	384
14	5802.16	5860.80	Right	2500	1	0	0.00	15	15	29.32	28.64	58.64	77
15	5937.45	6061.16	Right	255	16	20	2.40	50	50	62.16	23.71	123.71	106
16	6167.39	6294.50	Right	150	29	16	15.60	50	50	64.59	27.11	127.11	147
17	6441.26	6574.82	Right	220	21	27	13.32	50	50	67.37	33.55	133.55	12
18	6586.51	6710.15	Left	-260	16	8	3.48	50	50	62.12	23.64	123.64	759
19	7468.77	7591.54	Left	-350	12	26	6.72	45	45	61.57	32.77	122.77	1
20	7592.70	7714.94	Right	350	12	23	3.84	45	45	61.30	32.25	122.25	31
21	7746.01	7834.58	Left	-2000	2	3	45.72	15	15	44.29	58.57	88.57	49
22	7883.27	7955.08	Right	1000	2	24	19.80	25	25	35.91	21.81	71.81	74
23	8029.18	8137.17	Left	-1000	4	27	6.84	25	25	54.02	58.00	108.00	124
24	8260.98	8289.65	Left	-5000	0	7	30.00	10	10	14.34	8.67	28.67	162
25	8451.43	8553.29	Right	500	7	3	6.84	40	40	50.98	21.86	101.86	373
26	8925.95	9057.83	Right	390	12	0	53.28	50	50	66.12	31.89	131.89	253

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
27	9310.52	9555.04	Right	1000	12	20	38.40	25	25	122.71	194.52	244.52	466
28	10020.85	10111.94	Right	800	4	13	23.52	30	30	45.56	31.09	91.09	2
29	10113.77	10211.42	Left	-800	4	30	15.12	30	30	48.85	37.65	97.65	408
30	10619.81	10745.75	Left	-140	31	2	38.04	50	50	64.11	25.94	125.94	166
31	10912.04	11068.85	Right	200	30	21	19.08	50	50	79.84	56.81	156.81	28
32	11096.74	11308.14	Right	175	52	30	10.44	50	50	112.23	111.40	211.40	109
33	11416.70	11569.75	Left	-125	47	8	25.08	50	50	79.99	53.05	153.05	184
34	11753.44	11999.18	Right	125	89	25	57.00	50	50	150.19	145.75	245.75	1019
35	13017.92	13062.78	Right	13900	0	4	55.92	11	11	22.43	22.86	44.86	223
36	13285.81	13397.11	Right	710	5	27	5.04	40	40	55.68	31.30	111.30	0
37	13397.14	13518.99	Left	-375	10	35	3.12	50	50	61.06	21.85	121.85	0
38	13519.15	13624.60	Right	790	4	26	41.28	40	40	52.75	25.45	105.45	235
39	13859.77	13916.17	Left	-2000	1	10	48.72	11	11	28.20	34.40	56.40	397
40	14312.79	14360.93	Right	3100	0	24	40.32	11	11	24.07	26.15	48.15	193
41	14553.82	14639.15	Right	1000	3	16	20.28	25	25	42.67	35.33	85.33	48
42	14687.02	14953.54	Left	-125	99	8	36.96	50	50	172.93	166.52	266.52	17
43	14970.30	15061.62	Right	700	5	0	38.88	30	30	45.68	31.32	91.32	251
44	15312.43	15372.78	Right	1750	1	17	25.80	15	15	30.18	30.35	60.35	153
45	15526.17	15744.07	Right	125	79	9	4.32	45	45	126.54	127.90	217.90	1
46	15745.05	15864.35	Left	-148.5	26	26	27.24	50	50	60.43	19.30	119.30	240
47	16103.89	16256.65	Right	200	29	15	44.28	50	50	77.67	52.76	152.76	1
48	16257.29	16437.04	Left	-125	59	16	55.92	50	50	96.85	79.75	179.75	208
49	16644.62	16784.47	Left	-850	7	26	34.80	25	25	70.02	89.85	139.85	1
50	16785.43	16887.14	Right	550	6	15	15.84	40	40	50.90	21.71	101.71	45
51	16932.29	17065.56	Right	1000	6	7	16.32	25	25	66.69	83.27	133.27	71
52	17136.23	17301.79	Right	500	14	13	53.76	40	40	83.13	85.56	165.56	3
53	17304.94	17435.79	Right	330	14	1	17.40	50	50	65.66	30.85	130.85	141
54	17576.54	17631.02	Right	2500	0	32	30.48	15	15	27.24	24.49	54.49	138
55	17768.55	17891.59	Right	250	16	26	31.20	50	50	61.83	23.04	123.04	328

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
56	18220.02	18270.32	Left	-1750	1	5	31.56	15	15	25.15	20.31	50.31	236
57	18506.31	18609.31	Left	-600	6	17	36.96	35	35	51.54	33.00	103.00	1
58	18610.26	18747.05	Right	180	27	22	25.32	50	50	69.38	36.79	136.79	45
59	18792.01	18918.65	Right	400	10	35	3.48	50	50	63.46	26.65	126.65	61
60	18980.04	19091.58	Right	500	8	6	54.36	40	40	55.84	31.54	111.54	118
61	19209.13	19400.49	Left	-150	53	35	39.48	50	50	101.75	91.36	191.36	678
62	20078.25	20330.01	Right	155	74	20	44.52	50	50	143.53	151.77	251.77	735
63	21064.80	21208.43	Right	400	13	14	38.04	50	50	72.05	43.62	143.62	720
64	21928.65	22063.54	Left	-135	36	0	52.56	50	50	69.13	34.89	134.89	777
65	22840.75	22979.24	Left	-150	33	28	48.72	50	50	70.76	38.49	138.49	2
66	22981.48	23191.24	Right	125	73	8	3.12	50	50	118.47	109.76	209.76	251
67	23442.44	23575.45	Left	-200	23	27	55.08	50	50	67.21	33.01	133.01	147
68	23722.81	23946.00	Left	-450	22	1	49.08	50	50	112.72	123.19	223.19	147
69	24092.58	24248.11	Right	125	48	13	18.12	50	50	81.48	55.53	155.53	429
70	24677.22	24777.57	Right	1200	3	21	18.72	25	25	50.19	50.35	100.35	-
Udyog Vihar Ph V to Micromax Mousari Avenue Rapid Metro Station													
71	24883.03	25143.74	Left	-125	96	20	44.52	50	50	166.16	160.71	260.71	159
72	25303.15	25385.33	Left	-900	3	22	57.00	25	25	41.10	32.18	82.18	3
73	25387.86	25484.09	Right	600	5	30	17.28	35	35	48.14	26.23	96.23	234
74	25718.18	25874.88	Right	170	35	34	26.04	50	50	80.35	56.70	156.70	25
75	25900.13	26056.05	Right	125	48	19	31.44	50	50	81.71	55.92	155.92	-
Udyog Vihar Ph V to Vodafone Belvedere Tower Rapid Metro Station													
76	25101.63	Right	225	19	23	42.72	50	50	64.065	27.223	127.22	3	25101.63
77	25257.88	Left	-400	15	19	30.72	45	45	77.134	63.544	153.54	-	25257.88

B. Gradients

While designing vertical alignment, efforts have been made to avoid frequent gradients. The number of gradients has been kept to minimum, however, due to ground profile, difference in rail level of viaduct over mid-section and station location, horizontal alignment and gradients are inevitable. Efforts have been made to provide the gradients as flat as possible, subject to ground profile.

A total 114 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided for 36.18% of the alignment. Steepest gradient is 3.03% provided for viaduct between Udyog Vihar Ph VI station and Sector 10 station. The abstract and details of gradients are given in **TABLE 5.25** and **TABLE 5.26** respectively.

TABLE 5.25: ABSTRACT OF GRADIENTS OF CORRIDOR

S. No.	Description	Nos. of Occurrences	Length (m)	Percentage
1	Level (0%)	43	9845	36.18
2	>0% to 1%	19	4982	18.31
3	>1% to 2%	39	9234	33.93
4	>2% to 3%	12	2985	10.97
5	>3%	1	165	0.61
	TOTAL	114	27211	100.00

TABLE 5.26: DETAILS OF GRADIENTS FOR CORRIDOR

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
HUDA City Centre to Udyog Vihar Ph V							
1	-400	131	531	252.5	252.5	0.00	Level
2	131	620	489	252.5	244	-1.74	Fall
3	620	900	280	244	244.8	0.29	Rise
4	900	1100	200	244.8	244.8	0.00	Level
5	1100	1325	225	244.8	240.5	-1.91	Fall
6	1325	1900	575	240.5	238	-0.43	Fall
7	1900	2100	200	238	241.6	1.80	Rise
8	2100	2300	200	241.6	241.6	0.00	Level
9	2300	2500	200	241.6	237.5	-2.05	Fall
10	2500	3100	600	237.5	237	-0.08	Fall
11	3100	3325	225	237	240.8	1.69	Rise
12	3325	3525	200	240.8	240.8	0.00	Level
13	3525	3725	200	240.8	236.1	-2.35	Fall
14	3725	4000	275	236.1	235.2	-0.33	Fall
15	4000	4225	225	235.2	236	0.36	Rise
16	4225	4375	150	236	238.5	1.67	Rise
17	4375	4619	244	238.5	238.5	0.00	Level
18	4619	4850	231	238.5	234.5	-1.73	Fall
19	4850	5000	150	234.5	234.5	0.00	Level
20	5000	5140	140	234.5	233.5	-0.71	Fall
21	5140	5350	210	233.5	236	1.19	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
22	5350	5600	250	236	236	0.00	Level
23	5600	5900	300	236	231	-1.67	Fall
24	5900	6080	180	231	232.5	0.83	Rise
25	6080	6231	151	232.5	235.2	1.79	Rise
26	6231	6507	276	235.2	235.2	0.00	Level
27	6507	6800	293	235.2	230.8	-1.50	Fall
28	6800	7100	300	230.8	230.2	-0.20	Fall
29	7100	7300	200	230.2	234	1.90	Rise
30	7300	7530	230	234	234	0.00	Level
31	7530	7863	333	234	236.7	0.81	Rise
32	7863	8075	212	236.7	236.7	0.00	Level
33	8075	8375	300	236.7	229	-2.57	Fall
34	8375	8570	195	229	232	1.54	Rise
35	8570	8750	180	232	232	0.00	Level
36	8750	9100	350	232	227.2	-1.37	Fall
37	9100	9275	175	227.2	227	-0.11	Fall
38	9275	9440	165	227	232	3.03	Rise
39	9440	9625	185	232	232	0.00	Level
40	9625	9875	250	232	227	-2.00	Fall
41	9875	9975	100	227	227	0.00	Level
42	9975	10250	275	227	225.3	-0.62	Fall
43	10250	10475	225	225.3	225	-0.13	Fall
44	10475	10683	208	225	229	1.92	Rise
45	10683	10895	212	229	229	0.00	Level
46	10895	11175	280	229	225	-1.43	Fall
47	11175	11325	150	225	225	0.00	Level
48	11325	11500	175	225	228	1.71	Rise
49	11500	11850	350	228	228	0.00	Level
50	11850	12100	250	228	223.2	-1.92	Fall
51	12100	12325	225	223.2	227.5	1.91	Rise
52	12325	12525	200	227.5	227.5	0.00	Level
53	12525	12750	225	227.5	223.2	-1.91	Fall
54	12750	12900	150	223.2	223.5	0.20	Rise
55	12900	13100	200	223.5	228	2.25	Rise
56	13100	13342	242	228	228	0.00	Level
57	13342	13675	333	228	224.5	-1.05	Fall
58	13675	13825	150	224.5	225.5	0.67	Rise
59	13825	14150	325	225.5	225.5	0.00	Level
60	14150	14385	235	225.5	229.5	1.70	Rise
61	14385	14597	212	229.5	229.5	0.00	Level
62	14597	14825	228	229.5	226.2	-1.45	Fall
63	14825	15100	275	226.2	226.2	0.00	Level
64	15100	15343	243	226.2	229.5	1.36	Rise
65	15343	15620	277	229.5	229.5	0.00	Level
66	15620	15900	280	229.5	225	-1.61	Fall

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
67	15900	16175	275	225	225	0.00	Level
68	16175	16360	185	225	229.3	2.32	Rise
69	16360	16600	240	229.3	229.3	0.00	Level
70	16600	16910	310	229.3	224.7	-1.48	Fall
71	16910	17100	190	224.7	224.7	0.00	Level
72	17100	17370	270	224.7	228.7	1.48	Rise
73	17370	17650	280	228.7	228.7	0.00	Level
74	17650	17925	275	228.7	225	-1.35	Fall
75	17925	18150	225	225	225	0.00	Level
76	18150	18325	175	225	229	2.29	Rise
77	18325	18567	242	229	229	0.00	Level
78	18567	18760	193	229	225.4	-1.87	Fall
79	18760	19036	276	225.4	225.4	0.00	Level
80	19036	19300	264	225.4	226.3	0.34	Rise
81	19300	19490	190	226.3	230.2	2.05	Rise
82	19490	19675	185	230.2	230.2	0.00	Level
83	19675	19900	225	230.2	226.6	-1.60	Fall
84	19900	20050	150	226.6	227.6	0.67	Rise
85	20050	20250	200	227.6	232.8	2.60	Rise
86	20250	20500	250	232.8	232.8	0.00	Level
87	20500	20750	250	232.8	229	-1.52	Fall
88	20750	20925	175	229	230	0.57	Rise
89	20925	21135	210	230	231	0.48	Rise
90	21135	21390	255	231	235.7	1.84	Rise
91	21390	21600	210	235.7	235.7	0.00	Level
92	21600	21800	200	235.7	233	-1.35	Fall
93	21800	22100	300	233	234	0.33	Rise
94	22100	22650	550	234	248	2.55	Rise
95	22650	23050	400	248	248	0.00	Level
96	23050	23510	460	248	242.5	-1.20	Fall
97	23510	23790	280	242.5	242.5	0.00	Level
98	23790	23875	85	242.5	241.5	-1.18	Fall
99	23875	24175	300	241.5	241.5	0.00	Level
100	24175	24375	200	241.5	246	2.25	Rise
101	24375	24565	190	246	246	0.00	Level
102	24565	24725	160	246	244	-1.25	Fall
103	24725	24850	125	244	244	0.00	Level
Udyog Vihar Ph V to Micromax Mousari Avenue Rapid Metro Station							
104	24800	24930	130	244	244	0.00	Level
105	24930	25075	145	244	246	1.38	Rise
106	25075	25345	270	246	246	0.00	Level
107	25345	25500	155	246	248	1.29	Rise
108	25500	25800	300	248	257	3.00	Rise
109	25800	25975	175	257	257	0.00	Level
110	25975	26075	100	257	255	-1.99	Fall

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
111	26075	26261	186	255	255	0.00	Level
Udyog Vihar Ph V to Vodafone Belvedere Tower Rapid Metro Station							
112	24800	24900	100	244	244	0.00	Level
113	24900	25185	285	244	252.508	2.99	Rise
114	25185	25300	115	252.508	252.508	0.00	Level

* Note : All the change points are provided with Vertical curves

C. Portals and Special Span

For diverting the elevated alignment from centre of road to off the road and vice-versa, portal arrangement will be required with details as per **Table 5.27**.

TABLE 5.27: LOCATION OF PORTALS

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
1	HUDA City Centre	700	850	150	Alignment from off the road to median of the road
2	Subhash Chowk	4600	4760	160	Alignment from median to off the road
3		5250	5400	150	Alignment from off the road to median
4	Hero Honda Chowk	7550	7700	150	Alignment from median to off the road

Special spans have been provided at certain locations along the alignment, with details as per **TABLE 5.28**.

TABLE 5.28: LOCATION OF SPECIAL SPAN

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
1	Bakhtawar Chowk	3510	3570	60	At the crossing of Bakhtawar Chowk
2	Hero Honda Chowk	7950	8115	165	To cross above NH-8 & proposed RRTS alignment
3	Umang Bhardwaj Chowk	9910	9970	60	Over the crossing of Pataudi Road & Hero Honda Road

5.4.3 Spur: Basai Village to Dwarka Expressway

A. Horizontal Curvature

The proposed alignment negotiates frequent horizontal curves to follow the existing road median. At some places like entry to depot, there are sharp turns and curves along the road and this necessitates provision of sharp curves on metro alignment also.

Total 5 nos. horizontal curves have been provided on the entire length of the alignment. The minimum radius of curves is 300 m in elevated section. About 69% alignment is on straight & about 31% of alignment is on curves. The abstract and details of curves are indicated in **TABLE 5.29** and **TABLE 5.33** respectively.

TABLE 5.29: ABSTRACT OF HORIZONTAL CURVES OF SPUR TO DWARKA EXPRESSWAY

S. No.	Curve Radius	No. of Occurrences	Length (m)	Percentage
1	≤ 200	0	0.00	0.00
2	$>200 \leq 300$	1	118.34	19.79
3	$>300 \leq 500$	4	479.75	80.21
4	$>500 \leq 800$	0	0.00	0.00
5	$>800 \leq 1000$	0	0.00	0.00
6	>1000	0	0.00	0.00
	Total	5	598.10	100.00

B. Gradients

A total 8 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided for 50.34% of the alignment. Steepest gradient is 2.23% provided for viaduct after crossing railway line. The abstract and details of gradients are given in **TABLE 5.25** and **TABLE 5.26** respectively.

TABLE 5.30: ABSTRACT OF GRADIENTS OF SPUR TO DWARKA EXPRESSWAY

S. No.	Description	Nos. of Occurrences	Length (m)	Percentage
1	Level (0%)	4	965	50.34
2	$>0\%$ to 1%	2	552	28.79
3	$>1\%$ to 2%	1	225	11.74
4	$>2\%$ to 3%	1	175	9.13
5	$>3\%$	0	0	0.00
	TOTAL	8	1917	100.00

TABLE 5.31: DETAILS OF GRADIENTS FOR SPUR TO DWARKA EXPRESSWAY

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	11700	11883	183	228	228	0.00	Level
2	11883	12260	377	228	226.2	-0.48	Fall
3	12260	12525	265	226.2	226.2	0.00	Level
4	12525	12700	175	226.2	222.3	-2.23	Fall
5	12700	12925	225	222.3	222.3	0.00	Level
6	12925	13100	175	222.3	223	0.40	Rise
7	13100	13325	225	223	226.5	1.56	Rise
8	13325	13617	292	226.5	226.5	0.00	Level

C. Portals and Special Span

Special spans have been provided at certain locations along the alignment, with details as per **Table 5.32**.

TABLE 5.32: LOCATION OF SPECIAL SPAN

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
1	Sector-101	12320	12365	45	Over the Railway Crossing

TABLE 5.33: DETAILS OF HORIZONTAL CURVES OF SPUR TO DWARKA EXPRESSWAY

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	11829.30	11937.13	Left	-500	7	27	42.84	40	40	53.97	27.82	107.82	33
2	11969.79	12078.22	Right	500	7	30	10.44	40	40	54.28	28.43	108.43	127
3	12205.37	12315.70	Right	450	8	34	17.40	40	40	55.25	30.33	110.33	136
4	12452.00	12605.17	Left	-320	18	16	56.64	50	50	77.09	53.17	153.17	120
5	12725.22	12843.56	Left	-300	13	1	50.88	50	50	59.35	18.34	118.34	-

5.5 IDENTIFICATION OF EXISTING SERVICES/ UTILITIES

5.5.1 Introduction

- Large number of sub-surface, surface and overhead utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, Overhead power transmission lines, power cables, traffic signals, etc. exists all along the proposed alignment.
- These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. Therefore, meticulous detailed survey and planning will be required to protect/divert the utility services.
- Accordingly, overhead utilities were identified during physical survey of corridor. Moreover, liaison with concerned utility owners was made for identification and mapping of various underground utilities. No trenching / GPR survey etc. was conducted for underground utilities.

5.5.2 Agencies for Utility Services

For identification of likely utilities in the proposed metro Corridor and spur, liaison was made with following Organizations/Departments **TABLE 5.34.**

TABLE 5.34: UTILITY RESPONSIBILITY DEPARTMENTS

S. No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1	NHAI, Gurgaon	Road Construction and maintenance of State highways, Municipal Roads etc.
2	PWD	City Roads
3	Indian Railways	Railway crossings, subways, signals, railway bridges etc.
4	Gurgaon Municipal Development Authority (GMDA)	Storm water drainage.
5	Gurgaon Municipal Development Authority (GMDA)	Water lines
6	Gurgaon Municipal Development Authority (GMDA)	sewer lines
7	Dakshin Haryana BijliVitrn Nigam Ltd (DHVBN)	HT/other overhead Power lines.
8	Gas Authority of India (GAIL)	Gas Pipelines
9	Haryana City Gas (HCG)	Gas Pipelines

S. No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
10	Powergrid Corporation Of India Ltd (PGCIL)	Telecommunications cables, junction boxes, telephone posts, O.H lines.
11	RAILTEL	Telecommunications cables, junction boxes, telephone posts, O.H lines.
12	BSNL (OFC)	Telecommunications cables, junction boxes, telephone posts, O.H lines.
13	Airtel (OFC)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
14	RELIANCE TELE COMMUNICATION	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
15	JIO COMMUNICATION	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
16	Tata Tele Services (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
17	Vodafone (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
18	Aircel (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
19	North Telecom Region (Long Distance Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
20	Indian Oil Corporation Ltd	Oil Pipe Lines
21	Bharat Oil Corporation Ltd	Oil Pipe Lines
22	Hindustan Oil Corporation Ltd	Oil Pipe Lines
23	Archeological Survey Of India	Protected, Prohibited and Restricted Structures.

5.5.3 Guidelines for Diversion of Underground Utilities

While planning for diversion of underground utility services viz. sewer lines, water pipelines, cables, etc., during construction of MRTS, following guidelines have been adopted:

- Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.

- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.
- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout of piles in the foundation may be suitably adjusted to ensure that no foundation needs be constructed at the location. The utility service can also be encased within the foundation piles.

5.5.4 Sewer Lines, Storm Water Drains and Water Lines

The storm water drains and water pipe lines generally exists either side of under main carriageway or at some places on the central verge, as a result of subsequent road widening. However, majority of sewer lines are running in the centre of the road.

The major sewer, storm water drains and water pipe lines mains running across the alignment and likely to be affected due to location of column foundations, are proposed to be taken care of by relocating the column supports of viaduct by change in span or by suitably adjusting the layout of pile foundations. Where, this is not feasible, lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility service lines. Details of sewer lines & storm water drains and water pipe lines affected are indicated in **TABLE 5.35** and **TABLE 5.36**.

5.5.5 Gas Pipe Lines

Few gas pipe lines with varying diameters belonging to Haryana City Gas and GAIL are running along and across the roads along which the metro alignment is proposed. Though, the alignment is planned almost along the road, en-route few pipelines running across and along the alignment likely to be affected by the alignment are detailed in **TABLE 5.39** and **TABLE 5.40**.

5.5.6 Telecom Cables, OFC, Ducts and Trench

At several places, telecom cables and OFC of Power Grid, BSNL, Airtel, Reliance Communication, Jio Communication, Tata Tele Services, Vodafone and Aircel are also running along and across the proposed corridors and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are shown in **TABLE 5.41** to **TABLE 5.48**.

TABLE 5.35: WATER PIPE LINES OF GMDA

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (DIA -MM)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15600	700	LHS	1600	5.0	Parallel	Elevated	No
2	11900	14900	3000	LHS	1600	5.0	Parallel	Elevated	No
3	3900	11700	7800	LHS	1600	5.0	Parallel	Elevated	No
4	7560	7560	15	CROSSING	1600	5.0	Perpendicular	Elevated	Yes
5	5000	7500	2500	RHS	1600	5.0	Parallel	Elevated	No
6	4950	4950	15	CROSSING	1200	5.0	Perpendicular	Elevated	Yes
7	3900	4900	1000	LHS	1200	5.0	Parallel	Elevated	No
8	5500	8700	3200	LHS	1300	5.0	Parallel	Elevated	No
9	15700	18600	2900	LHS	900	5.0	Parallel	Elevated	No
10	15700	18600	2900	LHS	700	5.0	Parallel	Elevated	No
11	18600	20100	1500	RHS	500	5.0	Parallel	Elevated	No
12	20150	20150	15	CROSSING	500	5.0	Perpendicular	Elevated	Yes
13	20100	23100	3000	RHS	400	5.0	Parallel	Elevated	No

TABLE 5.36: SEWER PIPE LINES OF GMDA

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	DIAMETER IN MM	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15600	700	RHS	400	6	Parallel	Elevated	No
2	11900	14800	2900	RHS	400	6	Parallel	Elevated	No
3	13500	13600	100	RHS	200	6	Parallel	Elevated	No
4	11200	11900	700	RHS	400	6	Parallel	Elevated	No
5	11160	11160	15	CROSSING	400	6	Perpendicular	Elevated	Yes
6	3600	5500	1900	RHS	400	6	Parallel	Elevated	No
7	9950	9950	15	CROSSING	400	6	Perpendicular	Elevated	Yes
8	9440	9440	15	CROSSING	400	6	Perpendicular	Elevated	Yes
9	8455	8455	15	CROSSING	200	6	Perpendicular	Elevated	Yes
10	8250	8350	100	CROSSING	400	6	Perpendicular	Elevated	Yes

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	DIAMETER IN MM	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
11	5760	6160	400	CROSSING	400	6	Perpendicular	Elevated	Yes
12	3400	3500	100	LHS	600	6	Parallel	Elevated	No
13	1400	3400	2000	RHS	600	6	Parallel	Elevated	No
14	16100	17400	1300	LHS	400	6	Parallel	Elevated	No
15	16400	16600	200	RHS	400	6	Parallel	Elevated	No
16	18555	18555	15	CROSSING	400	6	Perpendicular	Elevated	Yes
17	18600	19100	500	LHS	600	6	Parallel	Elevated	No
18	3500	3850	350	RHS	600	6	Parallel	Elevated	No
19	19150	19150	15	CROSSING	600	6	Perpendicular	Elevated	Yes
20	20200	23000	2800	RHS	600	6	Parallel	Elevated	No
21	20300	20600	300	LHS	600	6	Parallel	Elevated	No

TABLE 5.37: ELECTRICITY LINES OF HARYANA VIDYUT PRASARAN NIGAM LIMITED (HVPNL)

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	250	250	15	CROSSING	220KV	Perpendicular	Elevated	Yes
2	300	3500	3200	LHS	66KV	Parallel	Elevated	No
3	300	4100	3800	LHS	66KV	Parallel	Elevated	No
4	4100	4200	100	RHS	66KV	Parallel	Elevated	No
5	4200	6100	1900	RHS	66KV	Parallel	Elevated	No
6	4455	4455	15	CROSSING	66KV	Perpendicular	Elevated	Yes
7	4500	6900	2400	LHS	66KV	Parallel	Elevated	No
8	6860	6860	15	CROSSING	66KV	Perpendicular	Elevated	Yes
9	6655	6655	15	CROSSING	220KV	Perpendicular	Elevated	Yes
10	6350	6350	15	CROSSING	66KV	Perpendicular	Elevated	Yes
11	6040	6040	15	CROSSING	220KV	Perpendicular	Elevated	Yes
12	6700	7900	1200	RHS	66KV	Parallel	Elevated	No
13	7950	7950	15	CROSSING	66KV	Perpendicular	Elevated	Yes

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	POSITION	METRO ALIGNMENT	DIVERSION REQD
14	8100	8400	300	LHS	66KV	Parallel	Elevated	No
15	8460	8460	15	CROSSING	66KV	Perpendicular	Elevated	Yes
16	8500	9400	900	RHS	66KV	Parallel	Elevated	No
17	9460	9460	15	CROSSING	66KV	Perpendicular	Elevated	Yes
18	9600	9900	300	LHS	66KV	Parallel	Elevated	No
19	11650	11650	15	CROSSING	66KV	Perpendicular	Elevated	Yes
20	11700	11800	100	LHS	66KV	Parallel	Elevated	No
21	18645	18645	15	CROSSING	66KV	Perpendicular	Elevated	Yes
22	18755	18755	15	CROSSING	66KV	Perpendicular	Elevated	Yes
23	18800	20100	1300	LHS	66KV	Parallel	Elevated	No
24	20150	20150	15	CROSSING	66KV	Perpendicular	Elevated	Yes
25	20200	21800	1600	RHS	66KV	Parallel	Elevated	No

TABLE 5.38: ELECTRICITY LINES OF DAKSHIN HARYANA BIJLI VITRAN NIGAM VIDYUT (DHVBN)

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	150	500	350	LHS	11 KV	Parallel	Elevated	NO
2	400	3900	3500	LHS	11 KV	Parallel	Elevated	NO
3	50	5400	5350	RHS	11 KV	Parallel	Elevated	NO
4	4000	5500	1500	LHS	11 KV	Parallel	Elevated	NO
5	5800	6000	200	RHS	11 KV	Parallel	Elevated	NO
6	6030	6030	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
7	6030	6750	720	RHS	11 KV	Parallel	Elevated	Yes
8	6750	6750	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
9	6800	7500	700	LHS	11 KV	Parallel	Elevated	NO
10	6900	6900	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
11	6910	6910	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
12	6950	6950	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
13	6960	6960	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
14	6965	6965	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
15	6970	6970	15	CROSSING	11 KV	Perpendicular	Elevated	Yes

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	POSITION	METRO ALIGNMENT	DIVERSION REQD
16	6890	7150	260	RHS	11 KV	Parallel	Elevated	NO
17	6960	7900	940	RHS	11 KV	Parallel	Elevated	NO
18	7920	7920	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
19	7820	7820	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
20	8120	11075	2955	RHS	11 KV	Parallel	Elevated	NO
21	8200	10700	2500	LHS	11 KV	Parallel	Elevated	NO
22	11180	11180	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
23	11200	11200	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
24	11200	11480	280	RHS	11 KV	Parallel	Elevated	NO
25	11400	11700	300	LHS	11 KV	Parallel	Elevated	NO
26	11700	11900	200	LHS	11 KV	Parallel	Elevated	NO
27	11700	14400	2700	RHS	11 KV	Parallel	Elevated	NO
28	14400	14430	30	RHS	33KV UG	Parallel	Elevated	NO
29	11900	13000	1100	LHS	11 KV	Parallel	Elevated	NO
30	13520	13670	150	LHS	11 KV	Parallel	Elevated	NO
31	14100	14130	30	LHS	11 KV	Parallel	Elevated	NO
32	14500	14800	300	RHS	11 KV	Parallel	Elevated	NO
33	14625	15600	975	LHS	11 KV	Parallel	Elevated	NO
34	14900	15150	250	RHS	11 KV	Parallel	Elevated	NO
35	15300	15650	350	RHS	11 KV	Parallel	Elevated	NO
36	15700	16375	675	RHS	11 KV	Parallel	Elevated	NO
37	15800	16375	575	LHS	11 KV	Parallel	Elevated	NO
38	16375	16375	15	CROSSING	11 KV	Perpendicular	Elevated	Yes
39	15750	18580	2830	LHS	11 KV	Parallel	Elevated	NO
40	16400	21500	5100	RHS	11 KV	Parallel	Elevated	NO
41	20300	22575	2275	LHS	11 KV	Parallel	Elevated	NO
42	22685	23000	315	LHS	11 KV	Parallel	Elevated	NO

TABLE 5.39: GAS LINES OF GAS AUTHORITY OF INDIA LTD (GAIL)

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	7580	7580	15	CROSSING	8" STEEL	1.5 TO 2.0	Perpendicular	Elevated	Yes
2	900	7500	6600	LHS	8" STEEL	1.5 TO 3	Parallel	Elevated	No
3	970	970	15	CROSSING	8" STEEL	1.5 TO 2.0	Perpendicular	Elevated	Yes

TABLE 5.40: GAS LINES OF HARYANA CITY GAS (HCG)

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	DIAMETRE (MM)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	11900	14800	2900	RHS	125	2.0	Parallel	Elevated	No
2	11660	11660	15	CROSSING	63	2.0	Perpendicular	Elevated	Yes
3	8500	11700	3200	LHS	125	2.0	Parallel	Elevated	No
4	8200	8500	300	RHS	125	2.0	Parallel	Elevated	No
5	8500	8600	100	RHS	305	2.0	Parallel	Elevated	No
6	8100	8200	100	LHS	305	2.0	Parallel	Elevated	No
7	8045	8045	15	CROSSING	305	2.0	Perpendicular	Elevated	Yes
8	3500	8000	4500	RHS	305	2.0	Parallel	Elevated	No
9	6960	6960	15	CROSSING	153	2.0	Perpendicular	Elevated	Yes
10	6550	6550	15	CROSSING	102	2.0	Perpendicular	Elevated	Yes
11	18500	20100	1600	RHS	125	2.0	Parallel	Elevated	No
12	20140	20140	15	CROSSING	125	2.0	Perpendicular	Elevated	Yes
13	20300	7150	2800	LHS	125	2.0	Parallel	Elevated	No
14	22760	22760	15	CROSSING	125	2.0	Perpendicular	Elevated	Yes

TABLE 5.41: OPTICAL FIBRE CABLE OF POWER GRID CORPORATION OF INDIA LTD (PGCIL)

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	0	1300	1300	LHS	24x1 Cable	3.0	Parallel	Elevated	No

TABLE 5.42: OPTICAL FIBRE CABLE OF BHARAT SANCHAR NIGAM LIMITED (BSNL)

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CEN TRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15600	700	LHS	48x1 Cable 288x1 Cable	2.0	Parallel	Elevated	No
2	14900	15600	700	RHS	24x1 Cable	2.0	Parallel	Elevated	No
3	11900	14800	2900	RHS	48x1 Cable 288x1 Cable	2.0	Parallel	Elevated	No
4	100	14800	14700	LHS	24x1 Cable	2.0	Parallel	Elevated	No
5	13540	13540	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
6	13560	13560	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
7	100	11800	11700	RHS	24x1 Cable 48x1 Cable	2.0	Parallel	Elevated	No
8	9950	9950	15	CROSSING	48x1 Cable	2.0	Perpendicular	Elevated	Yes
9	9960	9960	15	CROSSING	48x1 Cable	2.0	Perpendicular	Elevated	Yes
10	8045	8045	15	CROSSING	48x1 Cable	2.0	Perpendicular	Elevated	Yes
11	7955	7955	15	CROSSING	48x1 Cable	2.0	Perpendicular	Elevated	Yes
12	3560	3560	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
13	3550	3550	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
14	2560	2560	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
15	80	80	15	CROSSING	96x1 Cable	2.0	Perpendicular	Elevated	Yes
16	15700	20200	4500	LHS	288x1 Cable	2.0	Parallel	Elevated	No
17	15700	20200	4500	RHS	288x1 Cable	2.0	Parallel	Elevated	No
18	16440	16440	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
19	16850	16850	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
20	17360	17360	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
21	8560	8560	15	CROSSING	24x1 Cable	2.0	Perpendicular	Elevated	Yes
22	20300	23000	2700	LHS	288x1 Cable	2.0	Parallel	Elevated	No
23	20300	23000	2700	RHS	288x1 Cable	2.0	Parallel	Elevated	No

TABLE 5.43: OPTICAL FIBRE CABLE OF AIRTEL

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15600	700	LHS	96x1 Cable	3.0	Parallel	Elevated	No
2	11900	14800	2900	LHS	96x1 Cable	3.0	Parallel	Elevated	No
3	9900	11900	2000	LHS	96x1 Cable	3.0	Parallel	Elevated	No
4	4300	9900	5600	LHS	96x2 Cable 48x2 Cable	3.0	Parallel	Elevated	No
5	12400	16600	4200	RHS	48x1 Cable 96x1 Cable	3.0	Parallel	Elevated	No
6	11260	11260	15	CROSSING	48x1 Cable	3.0	Perpendicular	Elevated	Yes
7	11150	11150	15	CROSSING	96x1 Cable 48x1 Cable	3.0	Perpendicular	Elevated	Yes
8	8500	9900	1400	RHS	96x1 Cable 48x1 Cable	3.0	Parallel	Elevated	No
9	7945	7945	15	CROSSING	96x2 Cable 48x2 Cable	3.0	Perpendicular	Elevated	Yes
10	7900	8000	100	RHS	96x1 Cable	3.0	Parallel	Elevated	No
11	4300	9900	5600	LHS	96x1 Cable 48x1 Cable	3.0	Parallel	Elevated	No
12	3555	3555	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
13	3560	3560	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
14	50	50	15	CROSSING	96x1 Cable 48x1 Cable	3.0	Perpendicular	Elevated	Yes
15	0	4300	4300	LHS	96x1 Cable	3.0	Parallel	Elevated	No
16	200	4400	4200	RHS	96x1 Cable	3.0	Parallel	Elevated	No
17	15700	20200	4500	RHS	96x1 Cable	3.0	Parallel	Elevated	No
18	15700	20200	4500	LHS	48x1 Cable	3.0	Parallel	Elevated	No
19	20300	22900	2600	LHS	96x2 Cable	3.0	Parallel	Elevated	No
20	20300	22900	2600	RHS	96x1 Cable	3.0	Parallel	Elevated	No
21	2750	2750	15	CROSSING	96x4 Cable	3.0	Perpendicular	Elevated	Yes
22	2760	2760	15	CROSSING	96x3 Cable	3.0	Perpendicular	Elevated	Yes
23	23055	23055	15	CROSSING	96x1 Cable 48x3 Cable	3.0	Perpendicular	Elevated	Yes
24	23045	23045	15	CROSSING	96x3 Cable	3.0	Perpendicular	Elevated	Yes

TABLE 5.44: OPTICAL FIBRE CABLE OF RELIANCE COMMUNICATION

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15700	800	RHS	12x1 Cable	3.0	Parallel	Elevated	No
2	9200	9400	200	RHS	48x2 Cable	3.0	Parallel	Elevated	No
3	9280	9280	15	CROSSING	48x1 Cable	3.0	Perpendicular	Elevated	Yes
4	8100	8500	400	RHS	48x1 Cable	3.0	Parallel	Elevated	No
5	8275	8275	15	CROSSING	48x3 Cable	3.0	Perpendicular	Elevated	Yes
6	8100	8200	100	LHS	48x4 Cable	3.0	Parallel	Elevated	No
7	8490	8490	15	CROSSING	48x2 Cable 12x1 Cable	3.0	Perpendicular	Elevated	Yes
8	8610	8610	15	CROSSING	48x2 Cable 12x1 Cable	4.0	Perpendicular		
9	8630	9220	590	LHS	48x1 Cable 12x2 Cable	3.0	Parallel	Elevated	No
10	9280	9280	15	CROSSING	48x1 Cable 12x2 Cable	3.0	Perpendicular	Elevated	Yes
11	9150	11750	2600	RHS	96x1 Cable	3.0	Parallel	Elevated	No
12	11750	13150	1400	RHS	96x1 Cable	3.0	Parallel	Elevated	No
13	15350	16600	1250	RHS	48x1 Cable	3.0	Parallel	Elevated	No
14	15650	15650	15	CROSSING	48x1 Cable	4.0	Parallel	Elevated	No
15	15700	15700	15	CROSSING	48x1 Cable	5.0	Parallel	Elevated	No
16	200	700	500	RHS	12x2 Cable	3.0	Parallel	Elevated	No
17	650	700	50	CROSSING	12x2 Cable	3.0	Perpendicular	Elevated	Yes
18	15800	16300	500	RHS	12x2 Cable	3.0	Parallel	Elevated	No
19	16300	16300	15	CROSSING	12x2 Cable	3.0	Perpendicular	Elevated	Yes
20	16300	19500	3200	LHS	12x2 Cable	3.0	Parallel	Elevated	No
21	19480	19480	15	CROSSING	12x2 Cable	3.0	Perpendicular	Elevated	Yes
22	19480	20200	720	RHS	12x2 Cable	3.0	Parallel	Elevated	No
23	20180	20180	15	CROSSING	12x2 Cable	3.0	Perpendicular	Elevated	Yes
24	20300	22900	2600	LHS	48x1 Cable 12x1 Cable	3.0	Parallel	Elevated	Yes
25	22450	22450	15	CROSSING	48x1 Cable 12x1 Cable	3.0	Perpendicular	Elevated	Yes

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/ CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
26	22870	22870	15	CROSSING	48x1 Cable 12x1 Cable	3.0	Perpendicular	Elevated	Yes
27	22440	22900	460	RHS	48x1 Cable 12x1 Cable	3.0	Parallel	Elevated	No
28	23100	23100	15	CROSSING	48x1 Cable 12x1 Cable	3.0	Perpendicular	Elevated	Yes

TABLE 5.45: OPTICAL FIBRE CABLE OF JIO COMMUNICATION

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/ CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	850	1270	420	LHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
2	14850	14850	15	CROSSING	48x1 Cable 96x1 Cable 288x1 Cable	3.0	Perpendicular	Elevated	Yes
3	14860	14860	15	CROSSING	48x1 Cable 96x1 Cable 288x1 Cable	4.0	Perpendicular	Elevated	Yes
4	11900	14300	2400	LHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
5	9200	11700	2500	RHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
6	2200	8900	6700	RHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
7	5000	8800	3800	LHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
8	3670	3670	15	CROSSING	96x1 Cable 288x1 Cable	3.0	Perpendicular	Elevated	No
9	2200	3600	1400	RHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
10	200	3200	3000	RHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
11	0	1100	1100	LHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/ CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
12	15700	18600	2900	LHS	96x1 Cable 288x1 Cable	3.0	Parallel	Elevated	No
13	8650	8650	15	CROSSING	48x1 Cable 96x1 Cable 288x1 Cable	3.0	Perpendicular	Elevated	No
14	8600	19900	11300	RHS	96x1 Cable	3.0	Parallel	Elevated	No
15	20000	21000	1000	RHS	96x1 Cable	3.0	Parallel	Elevated	No
16	20300	21300	1000	LHS	96x1 Cable	3.0	Parallel	Elevated	No
17	22400	22800	400	LHS	96x1 Cable	3.0	Parallel	Elevated	No

TABLE 5.46: OPTICAL FIBRE CABLE OF TATA TELE SERVICES COMMUNICATION

S.NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/ CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15600	700	RHS	96x1 Cable	2.0	Parallel	Elevated	No
2	13600	14800	1200	LHS	96x1 Cable	2.0	Parallel	Elevated	No
3	13550	13550	15	CROSSING	96x1 Cable	2.0	Perpendicular	Elevated	Yes
4	9960	9960	15	CROSSING	96x1 Cable	2.0	Perpendicular	Elevated	Yes
5	6000	9900	3900	LHS	96x1 Cable	2.0	Parallel	Elevated	No
6	5945	5945	15	CROSSING	96x1 Cable	2.0	Perpendicular	Elevated	Yes
7	900	5900	5000	RHS	96x1 Cable	2.0	Parallel	Elevated	No
8	800	900	100	RHS	48x1 Cable 96x1 Cable	2.0	Parallel	Elevated	No
9	3560	3560	15	CROSSING	96x1 Cable	2.0	Perpendicular	Elevated	Yes
10	3300	3500	200	RHS	96x1 Cable	2.0	Parallel	Elevated	No
11	100	200	100	LHS	96x1 Cable	2.0	Parallel	Elevated	No
12	15640	15640	15	CROSSING	96x1 Cable	2.0	Perpendicular	Elevated	Yes
13	15700	20200	4500	LHS	96x1 Cable	2.0	Parallel	Elevated	No
14	20100	20200	100	RHS	96x1 Cable	2.0	Parallel	Elevated	No
15	20300	23000	2700	LHS	96x1 Cable	2.0	Parallel	Elevated	No

TABLE 5.47: OPTICAL FIBRE CABLE OF VODAFONE

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	14900	15600	700	RHS	96x1 Cable	3.0	Parallel	Elevated	No
2	11900	14800	2900	RHS	96x1 Cable	3.0	Parallel	Elevated	No
3	10200	11900	1700	RHS	96x1 Cable	3.0	Parallel	Elevated	No
4	10150	10150	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
5	8500	10200	1700	LHS	96x1 Cable	3.0	Parallel	Elevated	No
6	8500	9900	1400	LHS	96x1 Cable	3.0	Parallel	Elevated	No
7	5000	7900	2900	LHS	96x1 Cable	3.0	Parallel	Elevated	No
8	8500	9900	1400	RHS	96x1 Cable	3.0	Parallel	Elevated	No
9	200	7900	7700	LHS	96x1 Cable	3.0	Parallel	Elevated	No
10	4950	4950	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
11	950	950	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
12	15700	20200	4500	RHS	48x1 Cable	3.0	Parallel	Elevated	No
13	15700	20200	4500	LHS	96x2 Cable	3.0	Parallel	Elevated	No
14	16450	16450	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
15	8560	8560	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
16	19350	19350	15	CROSSING	96x1 Cable	3.0	Perpendicular	Elevated	Yes
17	20300	22900	2600	LHS	48x1Cable	3.0	Parallel	Elevated	No
18	20300	22900	2600	RHS	96x1Cable	3.0	Parallel	Elevated	No
19	22945	22945	15	CROSSING	48x1Cable	3.0	Perpendicular	Elevated	Yes

TABLE 5.48: OPTICAL FIBRE CABLE OF AIRCEL

S. NO.	CHAINAGE FROM (M)	CHAINAGE TO (M)	LENGTH (MTR)	LHS/RHS/CENTRE	SIZE/QTY. (PAIR)	DEPTH (BGL) IN MTR	POSITION	METRO ALIGNMENT	DIVERSION REQD
1	0	2400	2400	LHS	48x1 Cable	3.0	Parallel	Elevated	NO
2	2380	2380	15	CROSSING	48x1 Cable	3	Perpendicular	Elevated	Yes
3	2400	4900	2500	LHS	48x1 Cable	3.0	Parallel	Elevated	NO
4	4950	4950	15	CROSSING	48x1 Cable	3.0	Perpendicular	Elevated	Yes
5	5060	5060	15	CROSSING	48x1 Cable	3.0	Perpendicular	Elevated	Yes
6	5200	5500	300	LHS	48x1 Cable	3.0	Parallel	Elevated	NO
7	5000	5700	700	RHS	48x1 Cable	3.0	Parallel	Elevated	NO
8	8700	8900	200	LHS	48x1 Cable	3.0	Parallel	Elevated	NO
9	23060	23060	15	CROSSING	48x1 Cable	3.0	Perpendicular	Elevated	Yes

5.6 LAND REQUIREMENT FOR THE CORRIDOR, DEPOTS STATIONS, PARKING, MULTI MODEL STATIONS

5.6.1 Main Components

Land will be required for the following main components:

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Temporary Construction Depots and work sites.

5.6.2 Land for Elevated stretches

No land at surface is required permanently for elevated section, except for small areas for entry/exit structures, traffic integration and other maintenance utilities at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road. Wherever stations are proposed off the road, land for station building is also required permanently.

5.6.3 Land for Traffic integration

Govt. land has been proposed for integration with Rail system, Metro corridors and Bus system.

5.6.4 Land for Maintenance Depot

Since, track integration with the Rapid Metro has been proposed and existing infrastructure facilities are to be used. The existing maintenance depot of Rapid Metro at Sector 56 will be used as primary depot. To meet the balance requirement stabling depot with an area of 5.50 hectare has been proposed in the private land at Sector-101.

5.6.5 Land for TSS, RSS, ASS and DG Sets

Total of two RSS have been proposed on the corridor at Gurgaon Water Works near Fortis Hospital (near HUDA City Centre) and at IDPL Land, near Sector 22. An area of 3000 sqm has been proposed for each RSS. ASS and DG Sets are required at some stations.

5.6.6 Summary of Land Requirement

Abstract of land requirements for different components of corridors are given in **Table 5.49**.

TABLE 5.49: LAND & STRUCTURES REQUIREMENT (IN SQM)

Ownership	Purpose	Permanent Land (Sqm)	Temporary Land (Sqm)	Structures (Floor Area) (Sqm)
Central Govt.	Alignment / Stations, ancillary buildings & Misc.	1047	0	118
	Sub-Total	1047	0	118
State Govt.	Alignment / Stations, ancillary buildings & Misc.	41919	0	1221
	TSS	3000	0	0
	Construction Yards	0	45000	0
	Sub-Total	44919	45000	1221
Private	Alignment / Stations, ancillary buildings & Misc.	10291	0	1767
	Stabling Depot	55000	0	0
	Sub-Total	65291	0	1767
TOTAL		111257	45000	3106

5.7 OWNERSHIPS DETAILS OF THE LAND REQUIRED FOR THE CORRIDOR

5.7.1 Permanent Land Requirement

Land is required permanently for entry/exit, Viaduct, stations and ramps etc. Permanent requirement of Land for stations is tabulated in **Table 5.50**. Permanent requirement of Land for running section is tabulated in **TABLE 5.51**.

5.7.2 Temporary Land Requirement

No Land is required temporarily at the time of construction of viaduct, etc.

5.7.3 Temporary Construction Depot

During construction period, huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored and sufficient land is required for storage of these materials.

Also, large numbers of pre-cast tunnel segments are required for construction of tunnels for which a large Open area is required for setting up of casting yard. As far as possible, this area will be in temporary construction depot.

Since the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose is identified throughout the corridor, in the vicinity of the stations on temporary acquisition basis. These sites will be obtained on lease temporarily for the construction period. After completion of construction, these will be handed over back to the land owning agency.

About **4.5 Ha** land has been proposed for construction depots along the corridor. At the time of construction, depending upon the need, area requirements, the location and size can be reassessed and temporary land acquisitions can be made accordingly. Land is required Temporary Construction Depot is tabulated in **TABLE 5.52**.

TABLE 5.50: PERMANENT LAND REQUIREMENT FOR STATIONS

S. No.	Station Name	Plot No.	Chainage (m)		Area (Sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area (Sqm)
			From	To						
1	Huda City Centre	ST-01	-40	5	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-01A	-30	10	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
2	Sector -45	ST-02	930	940	201	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-02A	1000	1050	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-02B	1000	1050	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
3	Cyber Park	ST-03	2200	2260	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-03A	2200	2260	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
4	Sector -46	ST-04	3420	3460	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-04A	3580	3620	181	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-04B	3420	3460	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
5	Subhash Chowk	ST-05	4490	4550	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-05A	4490	4550	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
6	Sector -48	ST-06	5480	5550	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-06A	5480	5550	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
7	Sector 72A (Future)	ST-07	6320	6380	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-07A	6320	6380	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
8	Hero Honda Chowk	ST-08	7385	7450	199	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-08A	7385	7450	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
9	Udyog Vihar Phase-6 Station	ST-09	8632	8772	64	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-09A	8570	8670	99	Private	Station Building	2 Tin Shed	4	47
								1 G+2		81
								1 G+0		30
		ST-09B	8625	8730	637	Govt (State)	Station Construction	Nil	0	0
								Nil	0	0
								Nil	0	0
		ST-09C	8600	8640	198	Govt. (Central)	Entry/Exit, Lift etc	Nil	0	0
10	Sector 10 station	ST-10	9470	9605	902	Govt (State)	station Construction	1 G+0	1	344

S. No.	Station Name	Plot No.	Chainage (m)		Area (Sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area (Sqm)
			From	To						
11	Sector 37 Station	ST-10A	9505	9545	364	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-10B	9505	9545	200	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-11	10785	10825	449	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-11A	10765	10810	113	Govt. (Central)	Entry/Exit, Lift etc	Nil	0	0
		ST-11B	10765	10810	256	Private	Entry/Exit, Lift etc	Nil	0	0
		ST-11C	10650	10750	6330	Govt (State)	Parking	1 (G+0) Tinshed	1 3	366 255
12	Basai Village	ST-12	11615	11665	186	Govt. (Central)	Entry/Exit, Lift etc	Nil	0	0
		ST-12A	11615	11665	186	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-12B	11580	11610	45	Govt (State)	Station Construction	Nil	0	0
		ST-12C	11697	11715	61	Govt (State)	Station Construction	Nil	0	0
		ST-12D	11615	11660	143	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-12E	11615	11660	237	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
13	Sector 09	ST-13	12390	12455	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-13A	12390	12455	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
14	Sector 07	ST-14	13160	13210	180	Govt. (Central)	Entry/Exit, Lift etc	Nil	0	0
		ST-14A			206	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-14 B	13150	13210	499	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
15	Sector 04	ST-15	14490	14530	488	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-15 A	14480	15515	181	Govt (State)	Entry/Exit	Nil	0	0
16	Sector 05	ST-16	15475	15530	389	Private	Entry/Exit, Lift etc	Shops (G+0)	1	107
		ST-16 A	15450	15490	182	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-16 B	-		370	Rly Govt. (Central)	Entry/Exit, Lift etc	Toilet (G+0)	1	118
17	Ashok Vihar	ST-17	16490	16535	141	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-17A			214	Private	Entry/Exit, Lift etc	Bldg (G+0)2	2	46
		ST-17B	16520	16565	216	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
18	Sector-3	ST-18	17510	17550	240	Govt (State)	Entry/Exit, Lift etc	Nil	0	0

S. No.	Station Name	Plot No.	Chainage (m)		Area (Sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area (Sqm)
			From	To						
		ST-18A	17475	17520	359	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
19	BAJGHERA ROAD	ST-19	18405	18445	323	Private	Entry/Exit, Lift etc	G+0,	1	7
		ST-19A	18380	18420	288	Private	Entry/Exit, Lift etc	Nil	0	0
20	Palam Vihar Extension	ST-20	19555	19600	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-20A	19555	19600	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
21	Palam Vihar	ST-21	20350	20390	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-21A	20350	20390	361	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
22	Sector 23 A	ST-22	21460	21500	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-22A	21460	21500	361	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
23	Sector 22	ST-23	22750	22800	361	Private	Entry/Exit, Lift etc	Nil	0	0
		ST-23A	22780	22825	361	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
24	Udyog Vihar Phase-IV	ST-24	23635	23680	199	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-24A	23635	23675	355	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
25	Udyog Vihar Phase-V	ST-25	25425	24467	335	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-25A	25425	24467	198	Govt (State)	Entry/Exit, lift and stations facilities	Nil	0	0
26	Cyber City station	ST-26	25165	25300	2400	Govt (State)	Entry/Exit, lift and stations facilities	Nil	0	0
27	Dwarka Expressway station	ST-26	13400	13450	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
		ST-26A	13400	13450	198	Govt (State)	Entry/Exit, Lift etc	Nil	0	0
	Total				24812				14	1401
Summary										
	Private Land				1930				8	318
	State Govt. Land				21835				5	965
	Central Govt. Land				1047				1	118
1	All dimensions shown in the drawing are tentative & may change during Detailed Design stage.									
2	Minimum Land Area has been considered for Station Entry /Exit Structures to minimize the land & property acquisition.									
Notes:-	Actual land boundaries should be verified from Revenue records at the time of preparation of land schedule before acquisition.									

TABLE 5.51: PERMANENT LAND REQUIREMENT FOR RUNNING SECTION

S. No.	Location	Plot No.	Chainage (m)		Area (Sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area (Sqm)
			From	To						
1	Near Hero Honda Chowk	RS-01	8080	8100	79	Private	Viaduct construction	G+0	1	79
2	Near Pace Hotel Hero Honda Road	RS-02	8322	8400	110	Govt. (State)	Viaduct construction	Nil	0	0
3	Near Pace Hotel, Hero Honda Road	RS-03	8400	8475	166	Private	Viaduct construction	G+3 (Hotel Pace) Partly affected	1	280
								Welding shop, Tin shed	1	13
4	Near Vikas Nagar Chowk	RS-04	10200	10716	888	Govt. (State)	Viaduct construction	Balaji G+O and Tin Shed	2	90
5	Before Basai Chowk	RS-05	11060	11120	109	Private	Viaduct construction	Ciara Industry and 4nos G+1 Partially affected	5	212
6	Before Basai Chowk	RS-06	11130	11140	15	Private	Viaduct construction	Tin Shed	1	15
7	Basai Village	RS-07	11205	11240	79	Private	Viaduct construction	Nil	0	0
8	Basai Village	RS-08	11240	11315	112	Govt. (State)	Viaduct construction	Nil	0	0
9	Basai Village	RS-09	11350	11370	28	Private	Viaduct construction	Shyam International (G+3)	1	84
10	After Basai Village station	RS-10	11710	11780	545	Govt. (State)	Viaduct construction	Nil	0	0
11	After Basai Village station	RS-11	11790	11835	257	Private	Viaduct construction	Nil	0	0
12	After Basai Village on Neki Ram Marg	RS-12	11880	11915	208	Private	Viaduct construction	House (G+0)	1	15
13	After Sector -7 station	RS-13	13375	13390	6	Private	Viaduct construction	Nil	0	0

S. No.	Location	Plot No.	Chainage (m)		Area (Sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area (Sqm)
			From	To						
14	After Sector -7 station	RS-14	13445	13455	6	Private	Viaduct construction	2G+1 Corner affected	2	10
15	Sector 4-7 chowk	RS-15	14780	14830	423	Private	Viaduct construction	No 949/4 & 950/4, G+0, Partly affected	2	440
16	Near Sant Baba Prakash Puri Chowk	RS-17	15695	15720	51	Govt. (State)	Viaduct construction	Nil	0	0
17	Near Carterpuri Chowk	RS-18	19315	19325	5	Govt. (State)	Viaduct construction	Nil	0	0
18	Rezang La chowk	RS-19	20180	20210	54	Govt. (State)	Viaduct construction	Corner of discovery wines G+0	1	5
19	After Sector 22 station	RS-20	23035	23085	432	Govt. (State)	Viaduct construction	Kishan Mandi Shed	1	40
20	After Udyog Vihar Ph- V Station	RS-21	24850	24890	51	Private	Viaduct construction	Gaurd Room	1	8
21	After Udyog Vihar Ph- V Station	RS-22	24890	24925	134	Govt. (State)	Viaduct construction	Nil	0	0
22	After Udyog Vihar Ph- V Station	RS-23	249225	25010	500	Govt. (State)	Viaduct construction	G+0 Bldg	1	121
23	Before NH -8 Crossing	RS-24	25015	25055	293	Govt. (State)	Viaduct construction	Nil	0	0
24	After crossing NH-8 (RHS Track)	RS-25	25160	25215	474	Govt. (State)	Viaduct construction	Nil	0	0
25	After crossing NH-8 (RHS Track)	RS-26	25215	25250	284	Govt. (State)	Viaduct construction	Nil	0	0
26	Before cyber city station	RS-27	24990	25020	221	Private	Viaduct construction	G+0 Bldg	1	121
27	Before cyber city station	RS-28	25035	25060	137	Govt. (State)	Viaduct construction	Nil	0	0
28	Before cyber city station	RS-29	25070	25162	888	Govt. (State)	Viaduct construction	Nil	0	0

S. No.	Location	Plot No.	Chainage (m)		Area (Sqm)	Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area (Sqm)
			From	To						
29	After cyber city station	RS-30	25300	25430	872	Govt. (State)	Viaduct construction	Nil	0	0
30	After cyber city station	RS-31	25440	25725	2119	Govt. (State)	Viaduct construction	Nil	0	0
31	After Shankar chowk	RS-32	25790	25820	144	Govt. (State)	Viaduct construction	Nil	0	0
32	DLF Cyber City after NH-8 Crossing (LHS Track)	RS-33	25915	25980	431	Govt. (State)	Viaduct construction	Nil	0	0
33	After Basai Village station	RS-34	11795	11875	756	Private	Viaduct construction	3 Nos (G+1)	3	172
34	After Basai Village station	RS-35	11975	12125	645	Private	Viaduct construction	Nil	0	0
35	After Basai Village station	RS-36	12130	12240	583	Private	Viaduct construction	Nil	0	0
36	Dhobi Ghat Before Railway Track	RS-37	12250	12320	200	Private	Viaduct construction	Nil	0	0
37	After railway Track to Sector 101 station	RS-38	12360	12675	826	Govt. (State)	Viaduct construction	Nil	0	0
38	Near Sector-101 Depot Entry-2	Depot Entry	12370	12730	4529	Private	Depot entry	Nil	0	0
Total					17660				25	1705
Summary										
	Private Land				8361				20	1449
	State Govt. Land				9299				5	256
	Central Govt. Land				0				0	0
1	All dimensions shown in the drawing are tentative & may change during Detailed Design stage.									
2	Minimum Land Area has been considered for Station Entry /Exit Structures to minimize the land & property acquisition.									
Notes:-	Actual land boundaries should be verified from Revenue records at the time of preparation of land schedule before acquisition.									

TABLE 5.52: LAND TEMPORARILY REQUIRED FOR CONSTRUCTION DEPOT

S. NO.	PLOT NO.	LOCATION	DETAILS	LAND OWNERSHIP	AREA (SQM)
1	CD1-1	Near Bus Stand, Kadipur Village	Open Land	State Govt.	25000
2	CD1-2	Near Huda City Centre	Open Land	State Govt.	20000

TABLE 5.53: TREE LIST WITH GIRTH MORE THAN 30 CM

S. No.	Tree	Girth Range (in cm)	No. of Trees
1	AAM	18 - 65	12
2	AMLA	55 - 70	2
3	AMRUD	17 - 110	17
4	ANAR	61	1
5	ARAD	40	1
6	ARJUN	18 - 130	4
7	ASHOK	20 - 160	53
8	NEEM	70	1
9	BABOOL	18 - 160	76
10	BUD	38 - 98	8
11	BAEL	26 - 112	18
12	BER	22 - 240	43
13	BALAN KHIRA	46 - 235	16
14	BANYAN	46 - 400	8
15	BARGAD	25 - 586	39
16	BEL	27 - 108	3
17	BEL PATTHAR	45	1
18	CADAMBA	105 - 110	2
19	CANAL	20 - 95	85
20	CANALI	56 - 61	2
21	CANDER	25 - 150	135
22	CANDLE	18 - 155	84
23	CHALAL	25 - 150	351
24	CHILBIL	20	1
25	CHITVAN	20 - 210	221
26	PALM	110 - 124	4
27	GULAR	45 - 300	10
28	GULMOHAR	62 - 122	8
29	JAMUN	25 - 165	17
30	JUNGLI	25 - 230	602
31	KADAMB	25 - 385	23
32	KESAR	30 - 210	273

S. No.	Tree	Girth Range (in cm)	No. of Trees
33	KHAJOOR	80 - 150	5
34	KHEJADI	150 - 180	4
35	LYPTUS	50	1
36	MANGO	18 - 124	17
37	NEEM	110 - 310	615
38	LEMON	22 - 25	3
39	OKAT	30 - 325	4994
40	PAKAR	15 - 385	226
41	PEEPAL	21 - 785	218
42	ROVAR	45 - 166	6
43	SAFEDA	45 - 65	3
44	SAGWAN	28 - 161	65
45	SHEESHAM	65 - 40	2
46	SHAGUN	61	1
47	SHAHTOOT	25 - 230	42
48	SHIJAN	35 - 160	18
49	SIMAL	16 - 233	144
50	SUKHA	110	1

ANNEXURE 1

File No.EIC I-106001/1/2018-O/o SE-Infra I



GURUGRAM METROPOLITAN DEVELOPMENT AUTHORITY
File No. E-106001/01/2019-Infra-1

MINUTES OF MEETING

Date: 14.03.2019 at 03:00 PM.
Subject: Metro connectivity between HUDA City Centre-Subhash Chowk-Krishna Chowk-Sector-22-Cyber City, Gurugram.
Venue: Committee Room, GMDA office, Plot no. 44, Sector-32, Gurugram.
In the Chair: Sh. V. Umashankar, Chief Executive Officer (CEO), GMDA and Shri D.Suresh, Chief Administrator (CA)-cum-Managing Director, Haryana Mass Rapid Transit System Ltd. (HMRTC).

The list of participants is enclosed at Annexure I.

1) Advisor (Planning), HMRTC apprised that the Draft DPR of the Metro Project between HUDA City Centre-Subhash Chowk-Krishna Chowk-Sector-22-Cyber City, Gurugram was submitted by M/s RITES Ltd. The draft DPR was discussed in the 32nd Board Meeting of HMRTC held on 15.02.2019, wherein the same was approved. The Board of HMRTC resolved that the matter may be submitted on file for approval of Hon'ble CM, Haryana. The draft report has been forwarded to the concerned departments for their comments.

2) Detailed discussions were held regarding implementation issues arising from the approved alignment and station locations. The first point of discussion was the location of station at HUDA City Centre. M/s RITES Ltd. suggested the following three options: -

- Option - 1: On sector dividing road of Sector-41 & 44/45 near Sector 45.
- Option - 2: At HUDA City Centre parking site.
- Option - 3: On sector dividing road of Sector-29 and Sector-41.

- (a) Option 1 was discussed first, wherein it was observed that the Yellow line of Delhi Metro shall have to be extended upto Sector-45. The station in that case would be double level with the existing DMRC Metro station at Level 1 and the proposed new station at Level 2. This is because the gauges of the two Metro lines are different. DMRC line is operating on broad gauge and the proposed Metro line from HUDA City Centre to Cyber City shall be standard gauge line. This option was not considered feasible due to lack of space available at this location and dependency on DMRC for extension of Yellow line upto Sector-45.

File No.EIC I-106001/1/2018-O/o SE-Infra I

- (b) As far as location of Metro station on the parking site of HUDA City Centre Metro Station is concerned, it was observed that it will lead to further congestion at HUDA City Centre Station due to heavy pedestrian traffic and parking. Also there is proposal to construct a flyover on the road connecting HUDA City Center Metro Station and it would become very difficult to manage the traffic at this location.
- (c) Regarding the third option of locating the proposed station on the sector dividing road of Sector-29 and Sector-41, Gurugram, M/s RITES Ltd. informed that space is available at site and the proposed Metro station can be connected with the HUDA City Centre Metro station at concourse level. This will minimize the movement of pedestrian traffic at ground/road level bound to travel on yellow line.
- 3) After detailed discussions, Option-3 for location of proposed metro station of HUDA City Centre-Cyber City Metro line was considered as the best suited given the constraints and management of traffic. It was also decided that the height of the proposed station near HCC may be raised considering the proposal of the flyover along the road. The structural design of the flyover being constructed by GMDA (Infrastructure-I Division) would be done incorporating the central pier of proposed station above the flyover. This would divide the carriageway into two parts with the pier pillars of the Metro station coming in between the two.
- 4) Advisor (Planning), HMRTC informed that there is proposal to connect Gurugram–Faridabad Metro corridor which is to be terminated at Sector-45, Gurugram. Thus, necessary passenger interchange facility needs to be created for the terminal metro station at or near Sector-45, Gurugram for the Gurugram–Faridabad Metro.
- 5) CEO GMDA suggested that to avoid the congestion at proposed Sector-45, Gurugram metro station, the Gurugram – Faridabad Metro corridor may be planned to terminate at Sikanderpur metro station instead of Sector-45. Sikanderpur metro station can, thereby be the passenger interchange point. This would avoid congestion at HUDA City Centre besides enabling connectivity of the Gurugram-Faridabad Metro link with both the DMRC Metro link to Delhi and the Rapid Metro link to Cyber City. HMRTC shall accordingly take up the matter with DMRC.

File No.EIC I-106001/1/2018-O/o SE-Infra I

6) It was decided that the proposed location of Sector-46 station be shifted near HSVP District Shopping Centre in sector-47, Gurugram, after Bakhtawar Chowk instead of that proposed before Bakhtawar Chowk as Sector 47 is emerging as a commercial hub with the recent auctions of HSVP.

7) It was observed that at Subhash Chowk, MRTS planned by HSIIDC shall turn on Sohna road and move towards Vatika Chowk whereas the proposed metro from HUDA City Centre to Cyber City will move straight towards Hero Honda Chowk. Thus adequate turning radius would be required for the MRTS. It was decided that the alignment of HUDA City Centre-Hero Honda Chowk-Udyog Vihar Metro shall be shifted on left side of the flyover at Subhash Chowk instead of the right side, so that the MRTS can be planned on the right side of flyover with adequate turning radius. Representatives of M/s RITES Ltd. informed that the height of the station for the HUDA City Centre-Hero Honda Chowk-Udyog Vihar Metro shall be kept at the same level as that of the flyover at Subhash Chowk as adequate space to the left is available for the purpose.

8) It was observed that the location of Gurgaon Technology Park Limited (GTPL) metro station is quite a distance away from Hero Honda Chowk. This Chowk is a major road inter section and large number of passengers getting down at Hero Honda Chowk by other means of transport may find it difficult to walk up to the GTPL Station. Thus it was decided to shift the GTPL station further towards and as close to the Hero Honda Chowk as possible.

9) Considering the densely populated area along Sheetla Mata Road, it was suggested that a new station be added between Ashok Vihar and Sector-3 station.

10) It was observed that Krishna Chowk station indicated by M/s RITES Ltd. is a misnomer as Krishna Chowk is located on Old Delhi Road. It was decided that the proposed Krishna Chowk station be renamed as Bajghera Road station.

11) As the proposed Metro corridor is crossing elevated RRTS at Udyog Vihar, representatives of M/s RITES suggested that the Udyog Vihar RRTS station should be located further south-west of the junction of Major Sushil Aima Marg and Old Delhi-Gurgaon Road, so that the height of the Metro corridor can be reduced. Accordingly, NCRTC was requested to coordinate with M/s RITES for the purpose.

File No.EIC I-106001/1/2018-O/o SE-Infra I

12) Representatives of NCRTC were also requested plan for the integration of Sector-22 Metro station of the HUDA City Centre-Hero Honda Chowk-Udyog Vihar Metro link and Udyog Vihar RRTS station.

13) Representatives of M/s RITES requested GMDA to provide details of the road widening proposal of Jwala Mill Road, so that the metro alignment and the land requirement on this road can be finalized. CE Infrastructure I Division was accordingly directed to do so.

14) Integration of proposed HUDA City Centre-Hero Honda Chowk-Udyog Vihar Metro with existing Rapid Metro system was discussed in detail. Representatives of M/s RITES were requested to study the possibility of track integration of both the metro systems as it will add following benefits:

- The integration will help in reducing the number of interchanges a passenger has to take to reach the Sikanderpur DMRC Metro Station.
- Operations can be planned from Sector-56 itself and Depot facilities of the existing system can be utilized.

If integration with Rapid Metro is not feasible, then the HUDA City Centre-Hero Honda Chowk-Udyog Vihar Metro has to be taken underground to connect with the Sikanderpur DMRC Metro Station so that a single interchange is available for convenience of commuters.

15) Representatives of RITES were asked to study the number of DMRC stations built near the road junctions in Delhi and further divide them into elevated or underground so that a considered decision on whether to locate the Metro stations at road junctions could be taken. This arose from a concern expressed by CE, Infrastructure I Division, GMDA that locating the metro station at the junction forecloses the possibilities of any road improvement project being suggested at a later stage. Besides road junctions are traffic congestion locations and providing the metro station at the road junction may have an impact on the traffic management on the road. M/s RITES stated that locating the metro station at the junction is for the convenience of commuters as all four arms of the junction are covered.

File No.EIC I-106001/1/2018-O/o SE-Infra I

- 16) General Manager (Transportation), Shri K.C Sharma was asked to confirm the ownership details of proposed land for depot (Area = 12.7 Hectares) in Sector-101, Gurugram.
- 17) NHAI has a proposal for widening the road between Hero Honda Chowk and Umang Bhardwaj Chowk. Representatives of M/s RITES were requested to co-ordinate with NHAI for making provisions in their cross-section accommodating piers of metro viaduct and stations.
- 18) Representatives of M/s RITES informed that land acquisition within 60 m RoW has not been considered for the proposed Metro corridor. However, at stations where additional land is required beyond RoW, acquisition has been considered for the project. Representatives of the M/s RITES were requested to give the details of land to be acquired at various locations to HMRTC immediately.

ANNEXURE 2**GURUGRAM METROPOLITAN DEVELOPMENT AUTHORITY****MINUTES OF THE FOURTH MEETING****Date:** 27th May, 2019**Time:** 3.00 P.M**Venue:** Main Committee Room, 4th Floor, Haryana Civil Secretariat, Sector - 1, Chandigarh

The fourth meeting of the Gurugram Metropolitan Development Authority (GMDA) was held under the chairpersonship of Hon'ble Chief Minister on 27th May, 2019 at 3:00 PM in Main Committee Room, 4th Floor, Haryana Civil Secretariat, Sector - 1, Chandigarh. List of Members attending is at **Annexure-I**.

2. The Chief Executive Officer welcomed the Chairperson and the Members to the fourth meeting of the Authority. With the permission of the Chair, the Chief Executive Officer (CEO) initiated the proceedings of the meeting.

AGENDA ITEM 4.1**CONFIRMATION OF MINUTES OF THE THIRD MEETING**

3. The CEO informed that as required under sub-rule (3) of Rule 11 of the Gurugram Metropolitan Development Authority Rules, 2018, the minutes of the third meeting of the Authority held on 6th March, 2019 were circulated to all Members. No comments or objections have been received in terms of sub-rule (4) of Rule 11 of GMDA Rules, 2018. The Authority noted the same and confirmed the minutes.

AGENDA ITEM 4.2**ACTION TAKEN REPORT ON THE DECISIONS OF AUTHORITY**

4.1 The CEO submitted the action taken report on the decisions in the meeting of the Authority held on 6th March, 2019.

4.2 On the construction of multi-level parking, the CEO informed that HSVP has informed that instead of the proposed commercial land of HSVP, some other land of Municipal Corporation, Gurugram (MCG) may be identified. It was informed that MCG has

AGENDA ITEM NO. 4.3**DPR FOR METRO CONNECTIVITY IN GURUGRAM**

5.1 A presentation was made by M/s RITES on behalf of Haryana Mass Rapid Transit Corporation Ltd. (HMRTC) on the draft detailed project report (DPR) for Metro Rail connectivity from Huda City Center to Cyber City/ Rapid Metro Gurugram. It was informed that the total length of the corridor is 28.31 km with 25 stations, 6 interchange stations and a depot spread over 12.70 hectare. The total cost of the project inclusive of all taxes and duties was estimated at Rs. 5126 crores. As per proposed time lines for implementation of project, the commencement of operations will be by June, 2025.

5.2 The proposed alignment was scrutinised. It was mentioned that the alignment involves limited land acquisition and except for the turn near sector 9 where three constructed plots may need to be acquired, there was no major land acquisition involved. Shri A.K Singh, PSCTP stated that the three affected plots would be rehabilitated and provided alternate plots to accommodate the Metro alignment.

5.3 After detailed deliberations, it was felt that the Metro connectivity at Cyber City with Rapid Metro route may be through track integration for seamless integration between the new Metro route and the existing Rapid Metro route. It was mentioned by M/s RITES that there are two technical issues: first that the Rapid Metro stations are designed on the basis of 3-car system whereas the proposed Metro would be designed for a 6-car system. Therefore, the existing stations of Rapid Metro would not be able to accommodate the trains proposed to be run on the new Metro. Second, the electrification for DMRC metro lines is overhead whereas that for the Rapid Metro is through a third track. The other alternative of taking the proposed Metro underground from Udyog Vihar side to Sikanderpur would increase cost by approximately Rs 2000 crores besides the issue of two tracks running parallel for a certain length.

5.4 After detailed discussions, it was felt that station integration at the node points is extremely essential to facilitate ease of interchange. Therefore, track integration may be the best way ahead from the view-point of user so that Sikanderpur Metro Station becomes the nodal Station linking the DMRC and Rapid Metro routes with the proposed Metro route for the benefit of easy interchange at Sikanderpur Metro station. It was suggested that while the third-track electrification issue may not represent a technical challenge but would increase costs marginally, the station at Sikanderpur may have to be re-designed for accommodating

6-cars. M/s RITES was accordingly asked to re-work the technical feasibility for station expansion at Sikanderpur.

5.5 The Chairperson directed that the stations should be located, to the extent possible, at the proximity of junctions.

5.6 Shri Rajiv Singh, Member, proposed that the Metro route may be extended to Sector 21 in Dwarka through a spur near Palam Vihar. He suggested an alignment along the proposed Dwarka Expressway. Shri A.K Singh, PSTCP, mentioned that a Metro connectivity from Dwarka to Badsa along the Dwarka Expressway was being examined for techno-economic feasibility which would conflict with the route suggested by Shri Rajiv Singh. On examination of the possible access points, the Chairperson suggested that the road from Rezangla chowk to Bijwasan and Dwarka may be considered as an alternative. HMRTC was requested to explore the possibility of extending a spur connectivity from Rezangla chowk up to Sector 21 Dwarka separately. Shri Rajiv Singh, Member, offered assistance in extending the route. He also offered to assist in the re-design of the Sikanderpur Metro Station

5.7 M/s RITES suggested that the alignment of the proposed Metro from HUDA City Centre to Manesar & Bawal may need reconsideration in view of the alignment decided for the Gurugram City Metro and the decision on track integration with the Rapid Metro line. The CEO informed that with the coming of the Rapid Rail Transit System (RRTS) from Sarai Kale Khan to Shahjahanpur-Neemrana-Behror, Metro proposed by HSIIDC should be re-planned as a City Metro upto Panchgaon as RRTS would provide service to commuters beyond Manesar in Dharuhera, Rewari and Bawal. It was also mentioned that the HSIIDC Metro is unlikely to find justification from the ridership estimation. Accordingly, it was decided that HMRTC should take up the proposed Metro. Further, instead of HUDA City Centre, the new alignment for the HSIIDC Metro could be from Sohna Adda-Rajiv Chowk-Subhash Chowk onwards.

5.8 Shri T.V.S.N. Prasad, ACS (Finance) mentioned that para 5.6 of the Agenda Note states that Finance Department had commented that there is no increase in the rates of immovable property and there is no need to impose additional charge on the stamp duty at this time. He mentioned that no such comment has been given by the Finance Department. It was clarified by Managing Director, HMRTC, that the comments in para 5.6 have been given by the Revenue Department and not the Finance Department and the para be read accordingly. This was noted.

5.9 Shri T.V.S.N. Prasad, ACS (Finance), stated that revenues from Transit Oriented Development (TOD) charges should be raised for funding the cost of the project. This was accepted by Shri A.K Singh, PSTCP.

5.10 The Chairperson desired that the time lines may be reduced so as to complete the project latest by March 2024 and preferably by December 2023.

5.11 After deliberations, it was decided to approve the Gurugram Metro connectivity project with the following additions:-

- (a) Metro connectivity at Cyber City with Rapid Metro route may be through track integration for seamless integration between the new Metro route and the existing Rapid Metro route as track integration may be the best way ahead so that Sikanderpur Metro Station becomes the nodal Station linking the DMRC and Rapid Metro routes with the proposed Metro route for the benefit of easy interchange at Sikanderpur Metro station;
- (b) the station at Sikanderpur may be re-designed for accommodating 6-cars based on technical assessments;
- (c) a spur connectivity from Rezangla chowk up to Sector 21 Dwarka may be considered separately and technically assessed for land availability;
- (d) Metro proposed by HSIIDC should be re-planned as a City Metro upto Panchgaon to be taken up by HMRTC and instead of HUDA City Centre, the new alignment for the HSIIDC Metro could be from Sohna Adda-Rajiv Chowk-Subhash Chowk onwards for which techno-economic feasibility may be undertaken by HMRTC;
- (e) time lines may be reduced so as to complete the project latest by March 2024 and preferably by December 2023.

AGENDA ITEM NO. 4.4

A COMPREHENSIVE DRAINAGE PLAN FOR GURUGRAM

6.1 A presentation was made on the comprehensive drainage plan for Gurugram. The comprehensive plan proposes to arrest the run-off from the areas beyond the Gurugram Manesar Urban Complex Development Plan area by a multi-pronged approach creating check

Chapter – 6

STATION PLANNING

6. STATION PLANNING

6.1. BACKGROUND

The proposed metro rail system has been planned to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, interchange requirements with other modes of transport, station spacing, alignment, utilities, road and pedestrian requirements, etc. The locations of stations along the metro corridor from HUDA City Centre to Cyber City and Spur to Dwarka Expressway have been finalized after site visits and detailed discussions with HMRTC and GMDA. The stations attributes are presented in **TABLE 6.1** and **FIGURE 6.1**.

TABLE 6.1: STATIONS AND INTER-STATION DISTANCE

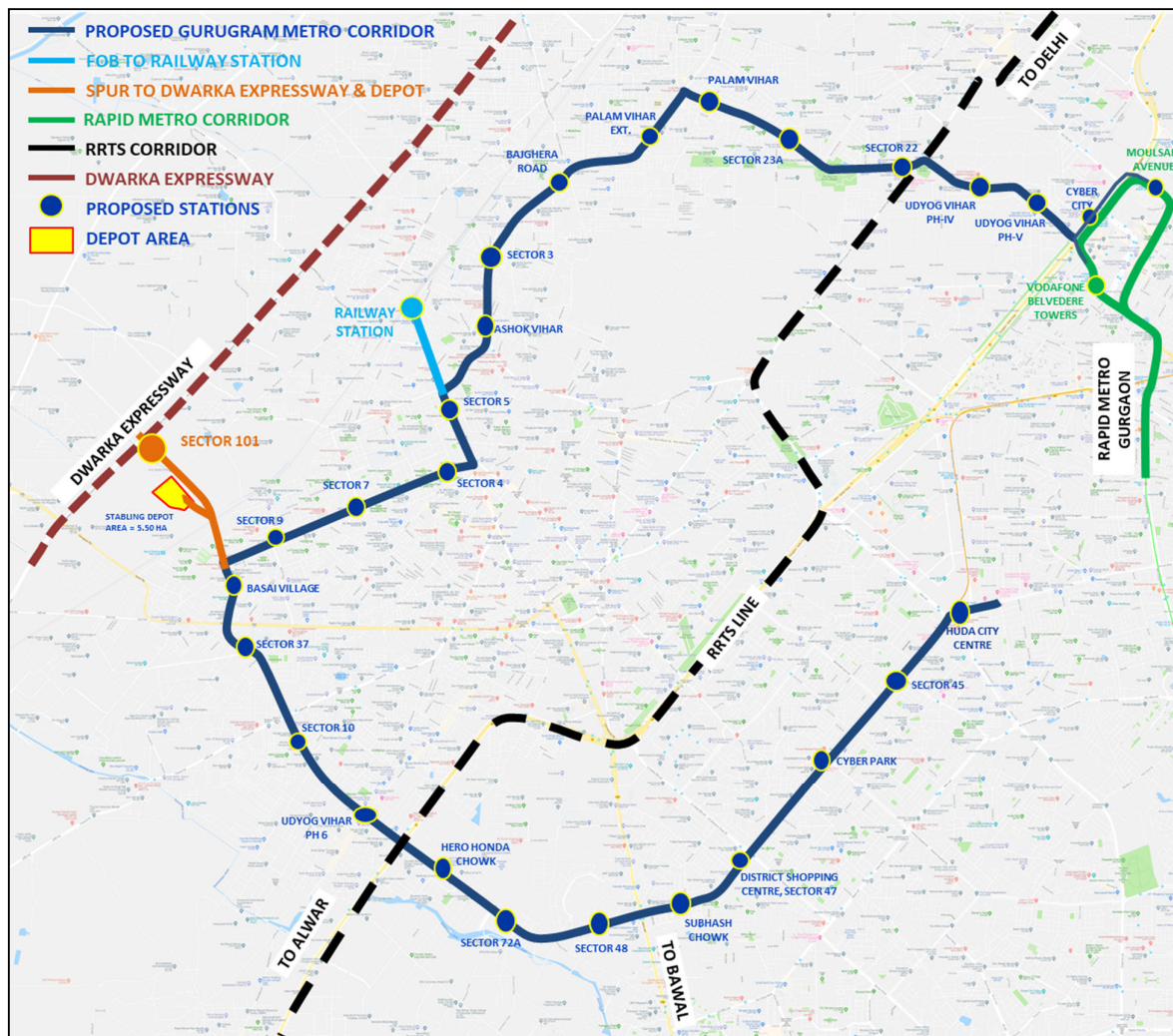
S. No.	Station Name	Chainage (km)	Inter Station Distance	Remarks
HUDA City Centre to Cyber City				
1	HUDA City Centre	0	0	Interchange with existing metro line
2	Sector 45	1000	1000	
3	Cyber Park	2200	1200	
4	District Shopping Centre, Sector 47	3665	1465	
5	Subhash Chowk	4480	815	Interchange with DMICDC Metro
6	Sector 48	5500	1020	
7	Sector 72A	6370	870	
8	Hero Honda Chowk	7400	1030	
9	Udyog Vihar Phase 6	8659	1259	
10	Sector 10	9535	876	Integration with proposed Bus Stand
11	Sector 37	10815	1280	
12	Basai Village	11645	830	
13	Sector 9	12438	793	
14	Sector 7	13215	777	
15	Sector 4	14480	1265	
16	Sector 5	15465	985	Integration with Railway Station
17	Ashok Vihar	16510	1045	
18	Sector 3	17510	1000	
19	Bajghera Road	18435	925	
20	Palam Vihar Extension	19591	1156	
21	Palam Vihar	20400	809	
22	Sector 23A	21491	1091	
23	Sector 22	22773	1282	Interchange with RRTS
24	Udyog Vihar Phase-IV	23653	880	
25	Udyog Vihar Phase-V	24476	823	

S. No.	Station Name	Chainage (km)	Inter Station Distance	Remarks
26	Cyber City	25235	759	Interchange with Gurugram Rapid Metro
Spur to Dwarka Expressway				
27	Sector 101	13426	1784 (From Basai Village Station)	Spur: Basai Village to Dwarka Expressway

6.2. STATION AREA CHARACTERISTICS

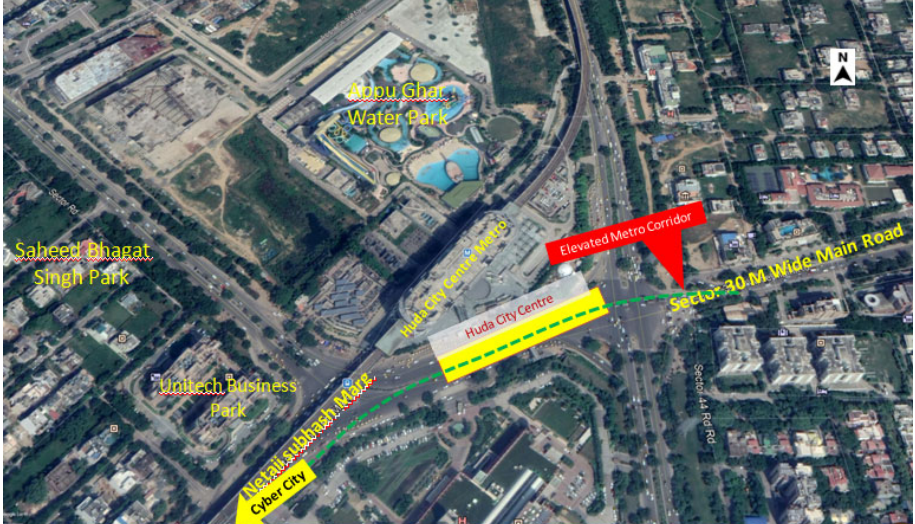
The catchment areas for all stations, issues and concerns, potential improvements along the metro corridor are summarized below.

FIGURE 6.1: PRIORITY MRTS CORRIDORS ALONG WITH STATION LOCATIONS



i. HUDA CITY CENTRE

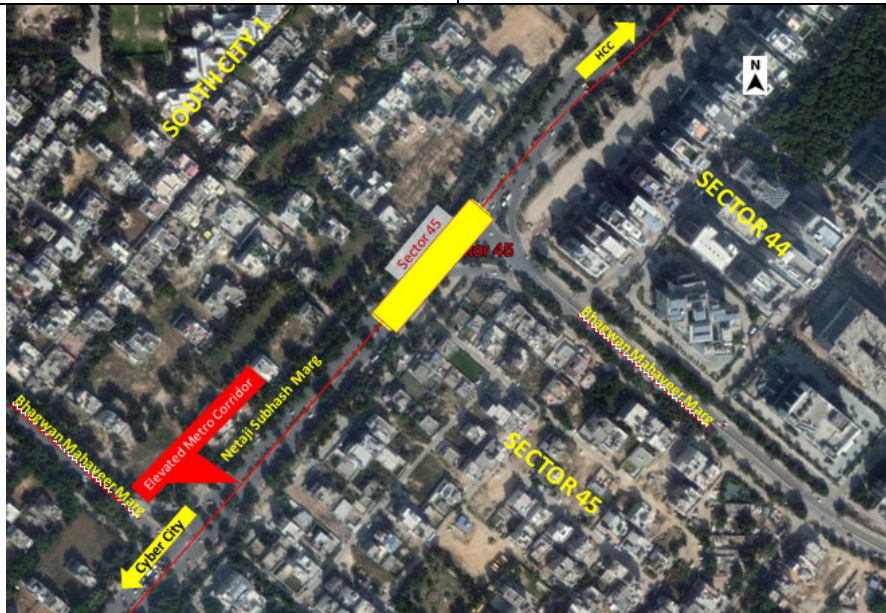
Huda City Centre is the terminal station of Gurugram Metro corridor. The station is proposed along main road towards main entry of existing metro station near Fortis Hospital. The station will have passenger interchange with the existing metro station operated by DMRC. The proposed station is abutted by mixed land use. The immediate catchment of station include the residential and commercial areas of South City, Sushant Lok, Sector 29 and Sector 30. Max Hospital and Fortis Memorial Hospital are located in the immediate vicinity.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width and creates congestion - Footpaths inaccessible due to encroachment - Violation of traffic rules (wrong side driving) - Absence of NMT Facilities (cycle tracks) and continuous footpaths	- Regulatory Measures for curbing On-Street Parking and Street Vendors/Hawkers - Dedicated pedestrian and NMT facilities like FOB and cycle tracks. - Enforcement and education for adherence to traffic rules.
	
	
1. Lack of Continuous footpaths	2. Encroachment of footpaths by Street Vendors
	
3. Violation of traffic rules (wrong side driving) creates conflicts	4. Absence of NMT Facility (Cycle Tracks)

ii. SECTOR 45

Sector 45 is an elevated station proposed along Netaji Subhash Marg (Arya Samaj Marg) located near Apollo International Ltd. The catchment area is primarily characterized by commercial and residential landuse. Bhagwan Mahaveer Marg provides connectivity to Sector 44, Sector 45 and Kanhai Village. Shrimati Santosh Yadav Road connects the western residential areas of South City 1. Major commercial units in the vicinity include Infinite Computer Solutions, AMB Group, Medecube Healthcare and JBM Group.

Issues & Concerns	Potential for Improvements
- Encroachment of footpaths by street vending activities. - On-street parking reduces effective carriageway width - Bicycle lane occupied by vehicular traffic	- Regulatory Measures for curbing On-Street Parking of Vehicles - Provision of continuous footpaths for encouraging pedestrian activity - Enforcement and education for adherence to traffic rules and use of NMT.



1. Encroachment of footpaths by vendors obstruct pedestrian movement



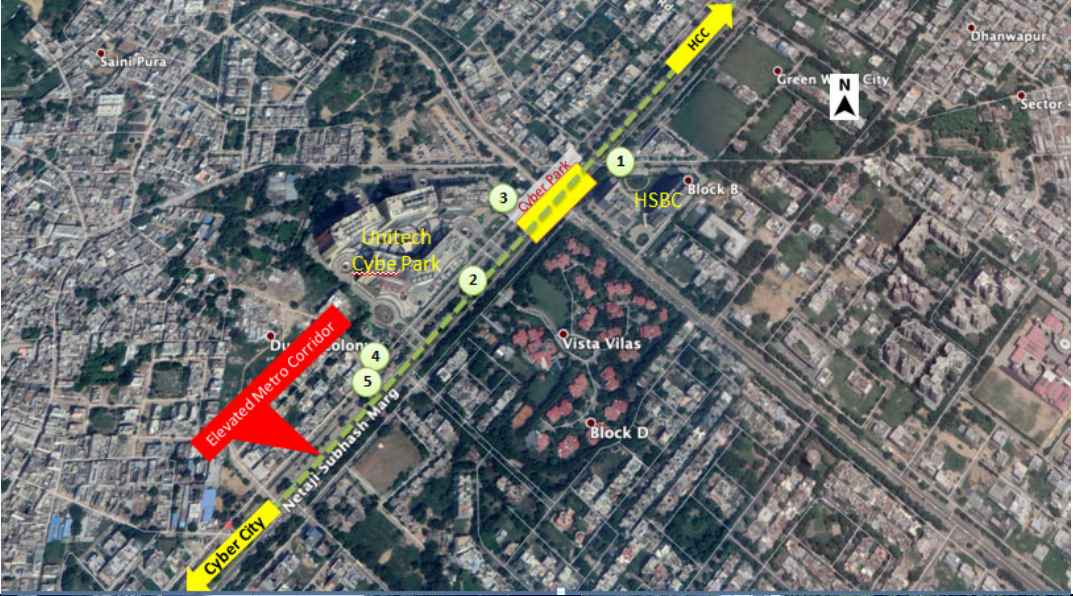
2. Lack of continuous footpaths force pedestrians to use carriageway

	
3. On-Street Parking reduce effective carriageway width	4. Absence of Road Markings
	
5. On-Street Parking of Heavy Vehicles obstruct movement of NMT traffic	6. Bicycle lane occupied by vehicular traffic

iii. CYBER PARK

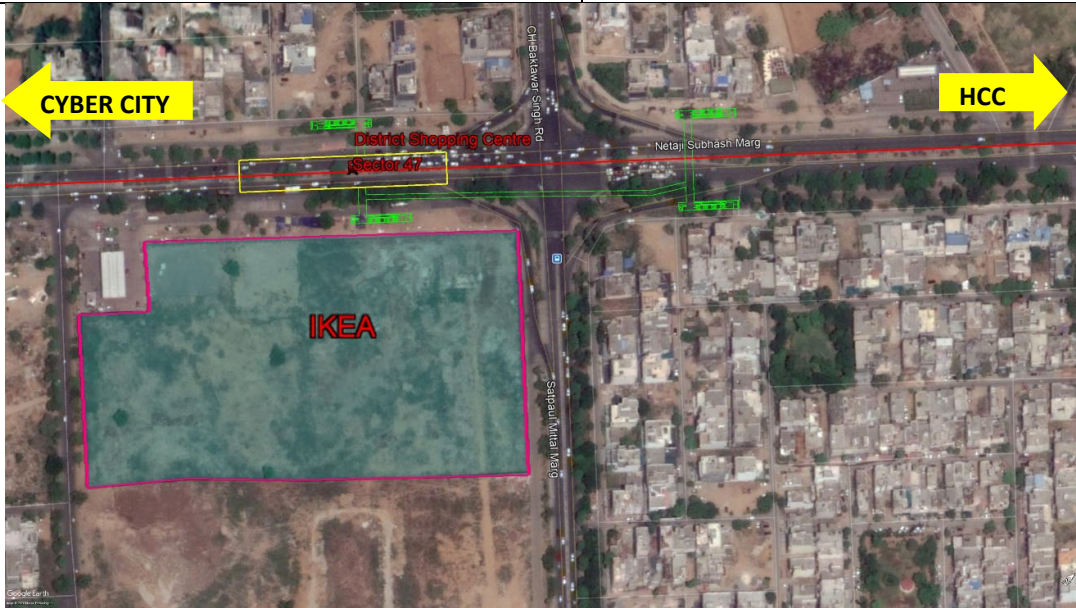
Cyber Park is an elevated station proposed along Arya Samaj Marg near Unitech Cyber Park. The station area has predominance of commercial and residential land use. The immediate catchment includes Unitech Cyber Park, Vista Villas and Residency Greens. The station also connects the educational centers like Sun City School Ryan Global School and ManavRachana School. Artemis Hospital (about 2 Km) is connected via Netaji Subhash Marg.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Lack of pedestrian crossings and FOB - Obstruction in traffic movement due to roadside construction activities - Encroachment of footpaths by vendors.	- Regulatory Measures for curbing On-Street Parking of Vehicles - Dedicated pedestrian and NMT facilities like pedestrian crossings FOB and cycle tracks. - Enforcement and education for adherence to traffic rules.

	
	
1. Poor Road Surface affects traffic speed	2. Lack of maintenance of footpaths
	
3. Lack of Crossing and FOB pose safety issues Pedestrian	4. On-Street Parking reduce the effective carriageway width
	
5. Encroachment of footpaths by street vendors obstructs pedestrian movement	6. Roadside construction activities affects traffic movement

iv. DISTRICT SHOPPING CENTRE, SECTOR 47

District Shopping Centre, Sector 47 is an elevated station proposed along Netaji Subhash Marg near Bakhtawar Chowk. The station is majorly abutted by residential landuse with few commercial pockets. The station provides connectivity to residential areas of Sector 34, Sector 46 - Jal Vihar Colony, Huda Colony, Sector 47 and Jharsa Village. The station is proposed adjacent to the upcoming Shopping centre by IKEA. Ch. Bakhtawar Singh Road connects the proposed station to northern and southern parts of city.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width and obstructing Cycle Lane - Discontinues footpath encourage peoples to use carriageway lead to accidental Hazards - Encroachment due to temporary vendors. - Haphazard Movement of various modes on the road may lead to accidental Hazards	- Regulatory Measures for curbing On-Street Parking of Vehicles - Enforcement and education for adherence to traffic rules. - Dedicated pedestrian and NMT facilities like FOB and cycle tracks.
	
	
1. Encroached Footpaths force pedestrians to use carriageway	2. Lack of continuous footpaths reduces its usage by pedestrians

	
3. On-street Parking reduce effective carriageway width	4. Unorganized movement of animals obstruct the traffic movement
	
5. Unmanaged Footpaths discourage pedestrians to use it	6. Wrong side driving causes conflicting movements

v. SUBHASH CHOWK

Subhash Chowk is an elevated station along Netaji Subhash Marg proposed between Subhash Chowk and Baktawar Chowk. The station is abutted by mixed landuse. Major roads connecting the station to other parts of city are Sohna Road and Satpaul Mittal Road. This Station provides connectivity to the residential and commercial areas of Sector 38, Sector 47 and Islampur Village.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width and obstructing Cycle Lane - Discontinues footpath encourage peoples to use carriageway lead to accidental Hazards	- Regulatory Measures for curbing On-Street Parking of Vehicles - Enforcement and education for adherence to traffic rules. - Dedicated pedestrian and NMT facilities like FOB and cycle tracks.



	
1. Station location showing vehicular movement	2. Lack of proper footpath & parking affects pedestrian movement
	
3. Road side parking near station location	4. Poor Road Surface affects traffic speed

vi. SECTOR 48

Sector 48 is an elevated station proposed along Netaji Subhash Marg located 500m from Subhash Chowk and Omaxe Celebration Mall. Presently the station is abutted by open mixed landuse. The immediate catchment area includes commercial units of UnitechInfospace - Genpact, Cognizant, Evalueserve Private Limited and NTT Data Global Delivery Service Ltd. The station also connects the residential centres - Unitech Resorts like Rail Vihar and Pragati Hills Society.

Issues & Concerns	Potential for Improvements
- On-street parking and Encroachment reduces effective carriageway width. - Lack of traffic signal lead to congestion in the peak hours - Poor condition of road surface hampers the average speed of traffic - Lack of NMT and Pedestrians facility	- Regulatory Measures for curbing On-Street Parking - Provision of Traffic Signals at major intersections - Enforcement and education for adherence to traffic rules. - Dedicated pedestrian and NMT facilities like FOB and Cycle tracks.

	
	
1. Unsignalled U-Turn creates bottleneck	2. On-Street Parking reduces carriageway width
	
3. Poor mangement of pedestrian footpaths	4. Degraded Road Surface Quality
	
5. Lack of NMT Facilities expose cycle users to vehicular traffic	6. Safety issues for NMT Users

vii. **SECTOR 72A**

Sector 72A is an elevated station proposed near Sector 72 & 72A on Netaji Subhash Marg. The source of passengers are Sector 72, Sector 72A, Uniworld Resorts includes commercial units of UnitechInfospace - Genpact, Cognizant, Evalueserve Private Limited and NTT Data Global Delivery Service Ltd.

Issues & Concerns	Potential for Improvements
- On-street parking and Encroachment reduces effective carriageway width. - High Tension wire near Station location - Poor condition of road surface hampers the average speed of traffic - Lack of NMT and Pedestrians facility	- Regulatory Measures for curbing On-Street Parking - Proper relocation of the High Tension wire - Enforcement and education for adherence to traffic rules. - Dedicated pedestrian and NMT facilities like FOB and Cycle tracks.



Proposed location of the station



Station location showing wide median



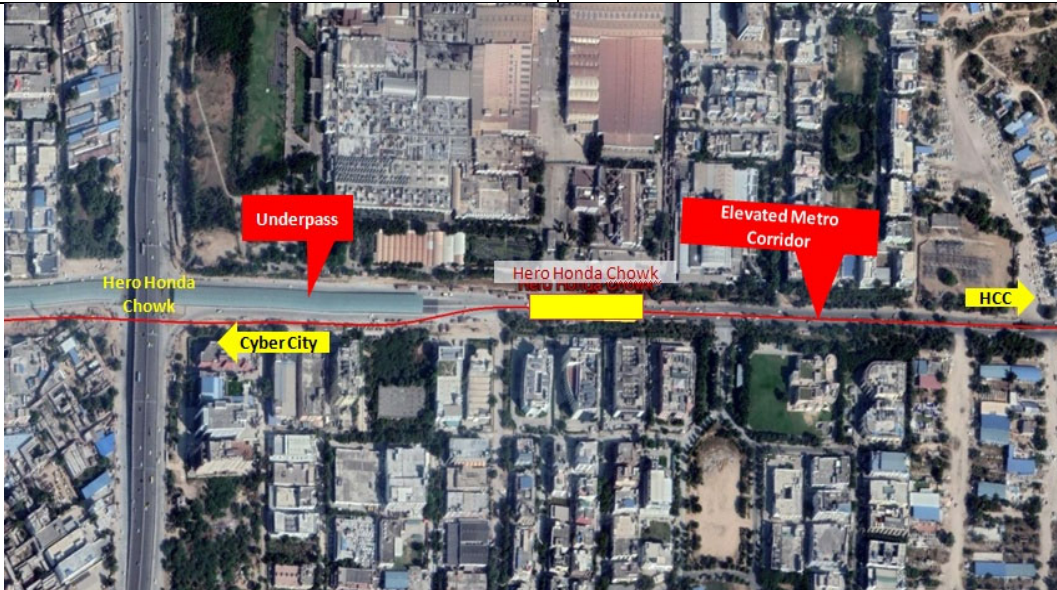
Poor mangement of pedestrian footpaths



Vehicular movement and high tension wire near station location

viii. HERO HONDA CHOWK

Hero Honda Chowk Station is an elevated station along Hero Honda Road proposed near Municipal Corporation Gurugram. The station is located 800m from Delhi-Gurugram Expressway (NH-48) and about 300m to north-west of Honda Chowk. Major activity centers in vicinity include Municipal Corporation and Info Technology Park. This station also provides dispersal connectivity to residential areas of Sector 72, Sector 34.

Issues & Concerns	Potential for Improvements
- On-Street Parking (Buses of IT Infotech Park) creates congestion on road. Reduce effective carriageway - Lack of pedestrian facility force them to use the carriageway and exposing to vehicular traffic - Lack of traffic signals result in haphazard movement of vehicles. Affects smooth flow of traffic.	- Pick up/ drop facilities for Bus and IPT. - Dedicated pedestrian and NMT facilities like footpath, FOB and cycle tracks. - Restriction on on-street parking - Provision of signalized Intersections - Enforcement and education for adherence to traffic rules.
	
	
1. On Street Parking of vehicles reduce effective carriageway width	2. Vehicular movement near station location



3. Lack of traffic signal result in conflicting vehicular movements



4. Lack of pedestrian footpaths and crossings

ix. UDYOG VIHAR PH-6

Udyog Vihar PH-6 Station is proposed to be an elevated station along Hero Honda Road at about 200m from Ambedkar Chowk. Delhi-Gurugram Expressway (NH-48) runs 700m to the south-east of proposed station location. Major catchment of the station is Udyog Vihar Industrial Area. The station also provides connectivity to residential & commercial areas of Sector 37, sector 10 A, Pace City, and Tara Patti.

Issues & Concerns	Potential for Improvements
- Encroachment and On-street parking reduces the effective carriageway width - Road side construction activities and parking affects the traffic flow - Lack of Pedestrian crossings raise safety issues for pedestrians - Usage of footpaths by vehicular traffic expose pedestrians to unwanted risk	- Dedicated pedestrian and NMT facilities like footpath, crossings, FOB and cycle tracks. - Strict parking regulatory measures to curb on-street parking - Effective utilization of RoW to segregate vehicular and pedestrian traffic - Enforcement and education for adherence to traffic rules



	
1. Encroachment and on-street parking reduce effective carriageway width	2. Lack of Pedestrian crossings results in conflict with vehicular traffic
	
3. Lack of continuous footpaths limits its usage	4. Interference of Two Wheelers on footpaths present safety issues for pedestrians
	
5. Poor Road Surface hampers the smooth flow of traffic	6. Construction activities along road affects the traffic flow

x. SECTOR-10

Sector 10 station is an elevated station proposed along Hero Honda Road 125m away from the Pataudi road intersection. The station is located at around 500m away from new bus terminal planned at Sector 10. The station provides connectivity to residential, commercial and industrial areas of Sector 37A, Sector 10, Sector 10A, Housing Board Colony, Kadipur Village and Kadipur Industrial area. The immediate residential catchments are Shivalic Apartment, Himgiri Ashram, Hariyan Apartment, Sanskriti Apartment, Deepmala Apartment and Saraswati Enclave.

Issues & Concerns	Potential for Improvements
• Unorganised Movement of vehicles - lack of lack discipline • Lack of Pedestrian facility lead to pedestrian spill on roads • Vehicular traffic runs on footpaths in peak hour • Lack of Pick/drop facilities for PT users • Unsignalized junctions leads to conflicting movement	• Provision of Pickup/dropoff facilities for Bus and IPT. • Dedicated pedestrian and NMT facilities like footpath, FOB and cycle tracks. • Construction of road median and road widening measures. • Restriction on street parking
	
 1. Absence of NMT facilities raise safety issues for bicycle/cycle rickshaw users	 2. Lack of median and violation of traffic rules

	
3. Footpaths occupied with onstreet parking and waste materials	4. Lack of pedestrian facilities expose pedestrians to vehicular traffic
	
5. Two wheelers in footpaths posing threat to pedestrian safety in peak hour	6. Lack of pick/drop facilities for public transport

xi. SECTOR 37

Sector 37 station is an elevated station proposed along Hero Honda road at intersection of Gali No. 6 (Sector 37C). The catchment area is abutted by mixed landuse. The proposed station provides connectivity to residents of Sector 37, Sector 37C and Kadipur Village. It also connects Kadipur Industrial Area having industrial units like Jyoti Rubber Industries and Pataka Market. Sector 10 Hospital and Police Station are within 300m range.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Footpaths inaccessible due to encroachment - Lack of NMT Facilities	- Regulatory Measures for curbing On-Street Parking and encroachment - Dedicated pedestrian and NMT facilities like cycle tracks.

	
	
1. On-street parking on footpath along with maintenance issues reduce its usage	2. On-Street Parking reduce effective Carriageway Width
	
3. Poor NMT Facility/ Encroachment of Street Vendors	4. Encroachment of roads by hawkers

xii. BASAI VILLAGE

Basai village is an elevated station proposed between Star Banquets hall and Vidya Medical Centre located about 350m to the north of Basai Chowk. The station catchment area is abutted by mixed landuse. The station serves the residential and commercial areas of Basai Village, Sector 9B and Bhawani Enclave. Basai Road provides the major connectivity to the eastern and western parts of city.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Obstruction to traffic due to roadside construction and unmanaged waste - Lack of pedestrian and NMT facilities	- Regulatory Measures for curbing On-Street Parking and construction activities - Provision of pedestrian footpaths and cycle tracks. - Regular Maintenance of roads
	
	
Location of proposed Basai Village Station	Location showing parking of vehicles and debris
	
Road near Station area and board showing industrial area	Access road near station showing poor maintenance of road & absence of footpath

xiii. **SECTOR 9**

Sector 9 is an elevated station proposed along Neki Ram Marg at the intersection of sector 9 access road. The station catchment area is primarily dominated by residential land use along with small commercial units. The station provides connectivity to areas of Sector 9 and Sector 9A.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Maintenance issues of footpaths affect their usage - Poor road surface conditions affects traffic flow speed	- Restriction on on-street parking - Dedicated pedestrian and NMT facilities like crossings and cycle tracks. - Regular maintenance of road surface and footpaths
	
	
1. Maintenance issues of footpaths	2. Degrading road surface affects traffic flow
	
3. On-Street Parking reduces effective carriageway width	4. Lack of NMT Facilities (Cycle Tracks)

xiv. SECTOR 7

Sector 7 is an elevated station proposed along Neki Ram Marg located near ESIC Hospital at about 300m from Sector 9 Chowk. The station influence area is dominated by residential colonies. The catchments of station include the areas of Sector 7, Sector 9, Sector 9A, Ambedker Nagar and Surya Vihar.

Issues & Concerns	Potential for Improvements
- On-street parking & encroachment of footpaths by unauthorised vendors result in pedestrian spill on carriageway - Lack of NMT Facilities (Cycle Tracks)	- Regulatory measures for curbing On-street Parking and Encroachments - Provision of continuous footpaths and cycle tracks.
	
	
1. Lack of pedestrian and NMT Facilities	2. Lack of continuous Footpaths limits its usage
	
3. On-street Parking and construction obstruct pedestrian footpaths	4. Encroachment of footpaths by street vendors

xv. SECTOR 4

Sector 4 station is an elevated metro station proposed along Neki Ram Marg (Main Road) located about 300m to the west of Vishwakarma Chowk. The station catchment area has predominance of Residential Landuse. The station provides connectivity to the population of Sector 4, Sector 7, Shivpuri and Acharyapuri.

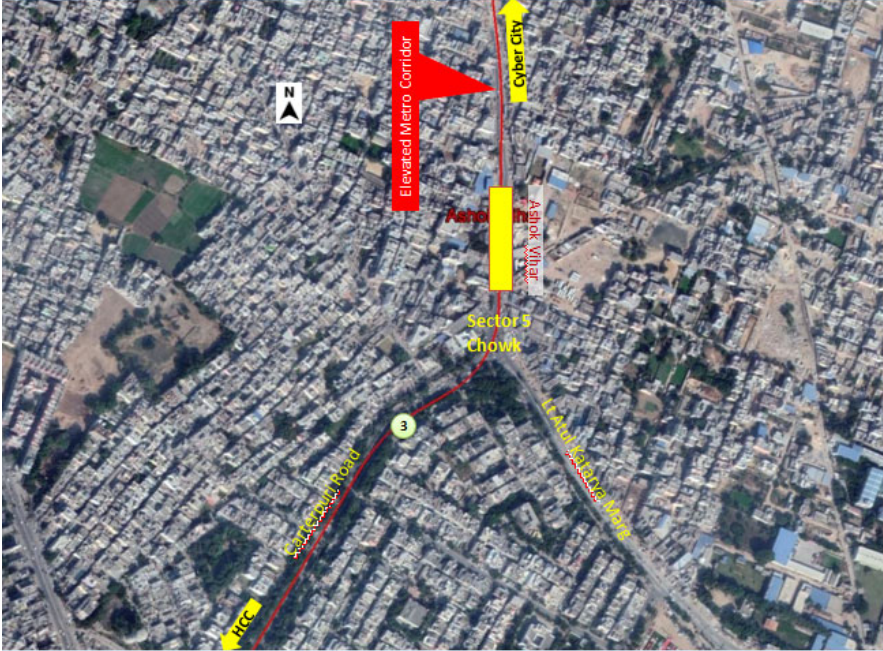
Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Lack of pedestrian crossing and obstructed footpaths result in pedestrian spill on carriageway - Lack of NMT Facilities - Violation of traffic rules	- Regulatory Measures for curbing On-Street Parking of Vehicles - Dedicated pedestrian and NMT facilities like crossings and cycle tracks. - Enforcement and education for adherence to traffic rules.
	
	
1. Lack of continuous footpaths	2. Lack of dedicated facilities for NMT
	
3. On-Street Parking reduce effective carriageway width	4. Mismanagement of Construction waste create obstructions

	
Location of proposed Sector 5 station	Showing parking of vehicles & vendors near proposed station location
	
Proposed station location showing Road Median & Lack of footpath	Another side of proposed station location

xvii. ASHOK VIHAR

Ashok Vihar Station is an elevated station proposed between Ashok Vihar Block E & C on Carterpuri Road. The station area has predominance of residential landuse with pockets of educational and medical centres. The catchment area of station includes the residential and commercial areas of Phase 1, Gurugram Rural, Sheetla Colony Ph-2 and Ashok Vihar.

Issues & Concerns	Potential for Improvements
- Lack of continuous footpath lead to pedestrian spill on carriageway - On-street parking and encroachment reduce effective carriageway width - Maintenance issues of Public Transport (Bus) Stops and Footpaths	- Regulatory Measures for curbing On-Street Parking and encroachment - Dedicated pedestrian and NMT facilities

	
	
On-Street Parking reduce carriageway width	Poor maintenance of road and absence of footpath
	
Heavy vehicular movement near proposed station location	Location showing encroachments

xviii. **SECTOR 3**

Sector 3 is an elevated station proposed along Carterpur Road near Palam Corporate Plaza. The station area is primarily surrounded by commercial establishments like ISTA Fitness, IndusInd Bank. The immediate catchments of station include offices of major banks like Yes Bank, IndusInd Bank and ICICI Bank. The residential areas of Sector 3, Ashok Vihar Phase 3 Extension, Park View Residency and RatanVihar will also benefit from the proposed station.

Issues & Concerns	Potential for Improvements
- Lack of waste management create nuisances on roads - On-street parking reduces effective carriageway width - Maintenance issues of Public Transport (Bus) Stops and Footpaths - Lack of pedestrian and NMT facility	- Regulatory Measures for curbing On-Street Parking and unauthorized vendors - Provision of dedicated facilities for pedestrians and non motorized transport - Enforcement and education for adherence to traffic rules.



1. Lack of waste management create nuisances on roads



2. Encroachment of footpaths by street vendors

	
3. Maintenance issues of Public Transport (Bus) Stops and Footpaths	4. Lack of Pedestrian and NMT Facility
	
5. Lack of traffic signages and signals result in conflicting movements	6. On- Street Vehicle Parking reduce effective Carriageway

xix. BAJGHERA ROAD

Bajghera Road station is proposed along Carterpuri Road (Rezang La Road) located near Krishna Chowk Temple. The catchment area of station has predominance of residential and commercial areas. Northern and Southern parts of station influence area can be accessed by Najafgarh-Gurugram road. The station provides connectivity to the areas of PalamVihar C1, Ashok Vihar Extn. 3, Sector 12 and AllaWardi.

Issues & Concerns	Potential for Improvements
- On-street parking and encroachment reduces effective carriageway width - Lack of continuous footpaths encourage people to use carriageway - Obstruction of traffic due to roadside construction activities	- Regulatory Measures for curbing On-Street Parking and encroachment - Dedicated pedestrian and NMT facilities like and cycle tracks. - Enforcement and education for adherence to traffic rules.

	
	
1. On Street Parking and lack of pedestrian footpaths	2. Lack of continuous footpaths force pedestrians to use carriageway
	
3. Wrong side driving creates conflicting traffic movements	4. Encroachment of roads and footpaths expose pedestrians to vehicular traffic
	
5. Lack of waste management create nuisances on roads	6. Lack of NMT (Bicycle) lane raise the safety issues for cycle users

xx. PALAM VIHAR EXTENSION

Palam Vihar Extension station is an elevated station along Rezang La Marg proposed near PalamVihar Block A Bus Stop and Palam Triangle building. The station provides connectivity to the residential and commercial areas of Sector 2, Sector 23 and Palam Vihar Extension. Carterpuri Govt. Sr. Secondary School is major educational center in the catchment.

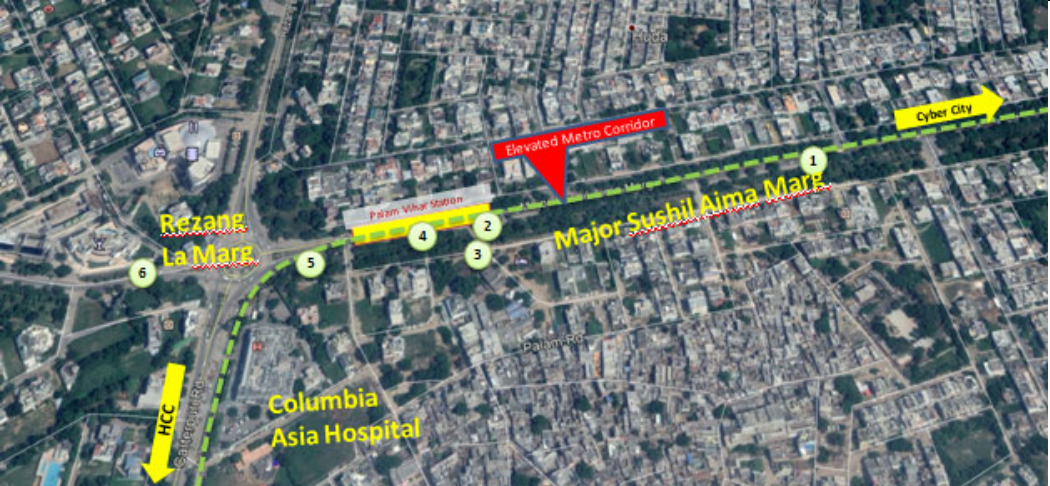
Issues & Concerns	Potential for Improvements
• Encroachment of footpaths by unauthorised vendors. • On-street parking reduces effective carriageway width • Lack of Pedestrian facility lead to pedestrian spill on roads	• Parking regulations to curb on-street parking • Enforcement and education for adherence to traffic rules. • Dedicated pedestrian and NMT facilities
	
 1. Encroachment of footpath results in pedestrian spill on carriageway	 2. On-Street Parking and Hawkers activity reduce effective carriageway

	
3. Lack of continuous footpaths and NMT facilities	4. On-Street Parking hampers the traffic flow
	
5. Obstructions along footpath discourage its usage	

xxi. PALAM VIHAR

PalamVihar station is an elevated station along Major Sushil Aima Marg proposed at a distance of 150m to the east of Rezang La Chowk. The station provides connectivity to residential and commercial areas of PalamVihar, Sector 23 and Carterpuri Village. The catchment area also includes Columbia Asia Hospital and Defense Service Officer's Institute.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Lack of proper disposal facility for waste and residual construction material. - Encroachment of footpaths by unauthorised vendors.	- Enforcement and education for adherence to traffic rules. - Restriction On-Street parking of Vehicles - Construction of road median - Dedicated pedestrian and NMT facilities like FOB and cycle tracks.

	
	
1. On-Street Parking reduce effective carriageway	2. Untidy footpaths discourage its usage
	
3. Lack of maintenance of access roads	4. Encroachment of footpath by Vendors
	
5. Hawkers activity along footpaths obstruct pedestrian flow	6. Improper disposal of waste on roads hinders vehicular and pedestrian traffic

xxii. SECTOR-23A

Sector 23A is an elevated station proposed along Major Sushil Aima Marg near HP Petrol Pump – Auto Care Centre. The station is abutted by mixed landuse. The catchments of station include the residential and commercial areas of Sector 23, Sector 23A and Carterpuri. The Station also provides the immediate connectivity to the North Cap University.

Issues & Concerns	Potential for Improvements
- On-street parking reduces effective carriageway width - Obstruction of traffic due to roadside construction activities - Footpaths inaccessible due to encroachment	- Regulatory Measures for curbing On-Street Parking of Vehicles - Enforcement and education for adherence to traffic rules. - Dedicated pedestrian and NMT facilities like FOB and cycle tracks.
	
	
1. On-Street Parking reduces effective Carriageway Width	
	
2. Obstruction in Traffic due to Roadside Automobile Shops	3. Encroached Footpaths result in pedestrian spill on Carriageway

	
4. Roadside construction obstructs traffic flow	5. Untidy conditions of footpaths discourage its usage

xxiii. SECTOR-22

Sector 22 is an elevated station proposed on Major Sushil Aima Marg about 100 m from Old Delhi Gurugram road. The station provides connectivity to the residential and commercial areas of Sector 22, DLF Phase 4 and Electronic City. The station is located at around 200m from the proposed UdyogVihar station of DelhiAlwar Regional Rapid Transit System (RRTS) corridor.

Issues & Concerns	Potential for Improvements
- Obstructed pedestrian flow along footpaths result in pedestrian spill on carriageway thus exposing them to vehicular traffic - Effective carriageway reduced due to encroachments and on-street parking.	- Dedicated pedestrian and NMT facilities like footpath, FOB and cycle tracks. - Restriction on On-Street Parking - Construction of Road Median
	

	
1. Footpath inaccessible due to construction activities	2. Lack of pedestrian facilities on access roads
	
3. On Street Parking reduces effective carriageway	4. On-street Parking force pedestrians to use main carriageway
	
5. Vendor activities obstruct pedestrian flow	6. Encroached footpaths obstruct pedestrian flow

xxiv. UDYOG VIHAR PHASE IV

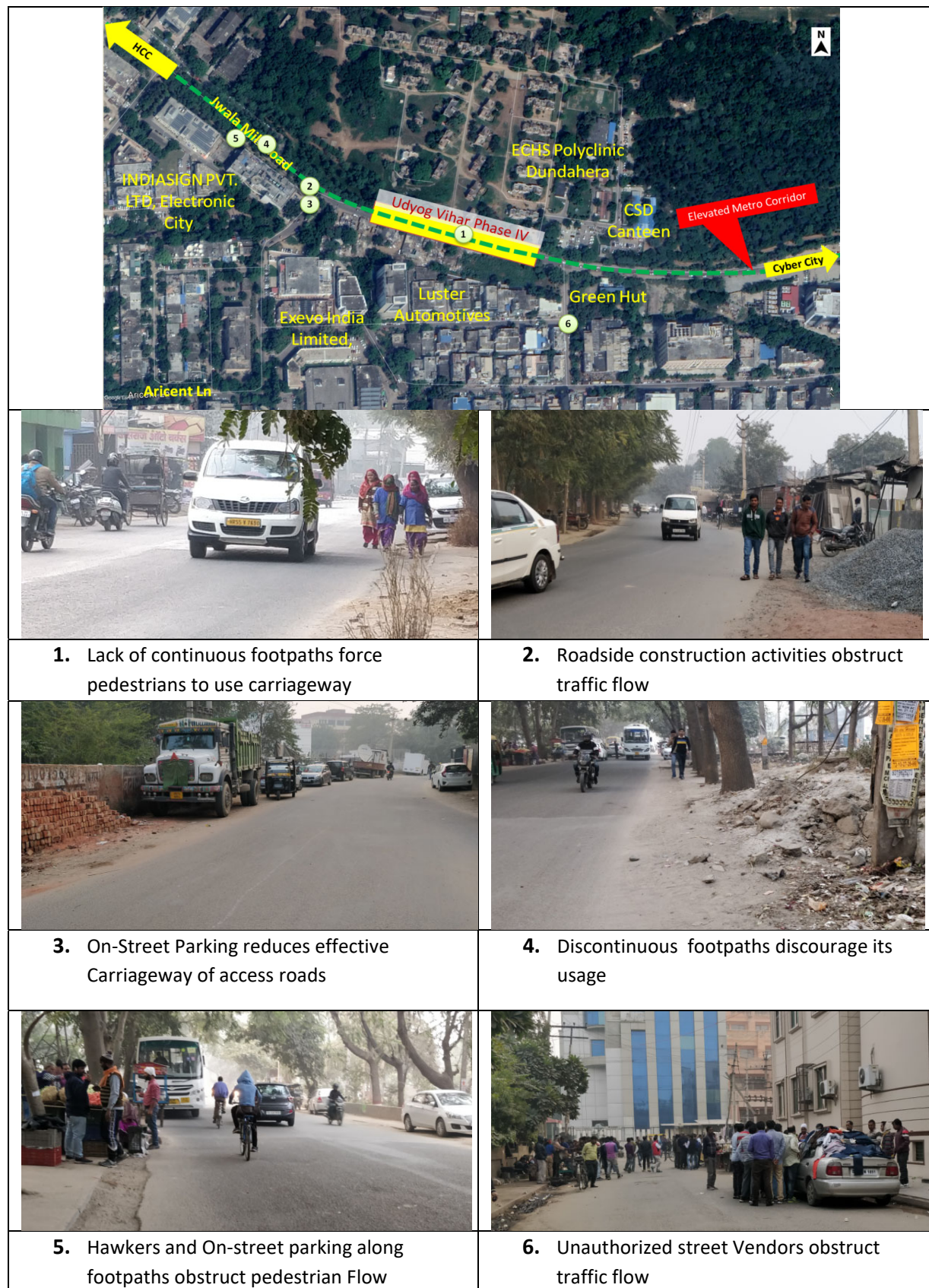
UdyogVihar Phase IV is an elevated station proposed along Jwala Mill Road. The station influence area is characterized by residential as well as industrial landuse. The station provides connectivity to the IDPL Township, UdyogVihar Phase IV and UdyogVihar Phase V. The Old Delhi Gurugram Road is the major connecting road in the station vicinity.

Issues & Concerns

- Encroachment / Parking on footpath results in pedestrian spill on carriageway
- On-street parking reduces the effective carriageway width

Potential for Improvements

- Regulatory Measures for curbing On-Street Parking of Vehicles
- Enforcement and education for adherence to traffic rules.
- Dedicated pedestrian and NMT facilities like FOB and cycle tracks.



xxv. UDYOG VIHAR PHASE V

UdyogVihar Phase V is an elevated station proposed along Jwala Mill Road near Delhi Law Academy. The station is majorly abutted by residential and commercial landuse. The station provides connectivity to the residential areas of UdyogVihar Phase III, UdyogVihar Phase IV, UdyogVihar Phase V and Sector 19. Delhi-Jaipur Expressway is the major connecting road to the station.

Issues & Concerns	Potential for Improvements
- Unsignalized intersection lead to conflicting movements - Encroachment / Parking on footpath encourage peoples to use carriageway - On-street parking reduces effective carriageway width - Lack of pedestrian and NMT Facilities	- Regulatory Measures for curbing On-Street Parking of Vehicles - Enforcement and education for adherence to traffic rules. - Dedicated pedestrian and NMT facilities like FOB and cycle tracks.



1. Lack of traffic signal results in conflicting vehicular movements



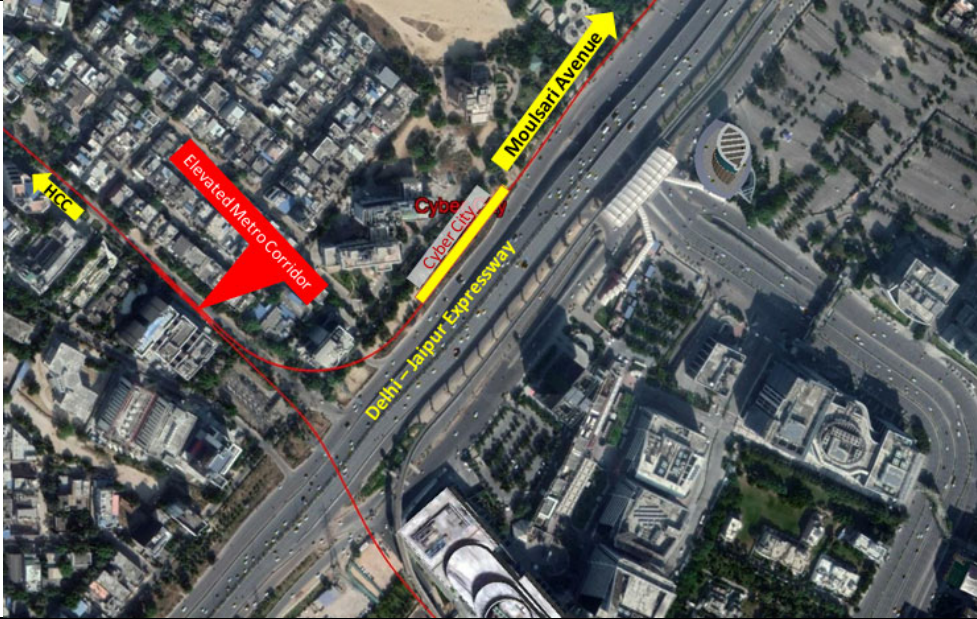
2. Lack of Continuous footpaths results in pedestrian spill on carriageway

	
3. Footpath inaccessible due to encroachment and on street parking	4. Lack of Pedestrian and NMT Facilities
	
5. On-Street Parking reduces effective Carriageway Width	6. Encroached Footpaths result in pedestrian spill on Carriageway

xxvi. CYBER CITY

Cyber City is last station of Gurugram Metro corridor. It is proposed on parking ground near Shyam Chowk besides Delhi-Jaipur Highway. The station has one side platform with concourse at same level. The rail level for this station is taken as 9m. The station is majorly abutted by commercial landuse. The station provides connectivity to the Cyber City, DLF City Park. It also connects the residential areas of DLF Phase 2, Shahpur and Sector 25. The station is also connected by Gurugram Rapid Metro through Micromax/Moulsari Avenue Rapid Metro Station.

Issues & Concerns	Potential for Improvements
• Encroachment/Parking on footpath encourage peoples to use carriageway • On-street parking reduces effective carriageway width • Lack of pedestrian crossings and NMT Facilities • Improper disposal of waste and Potholes hinders vehicular traffic	• Regulatory Measures for curbing On-Street Parking of Vehicles • Enforcement and education for adherence to traffic rules. • Dedicated pedestrian and NMT facilities like FOB and cycle tracks.

	
	
1. Location of Proposed Cyber City Station	2. Unavailability of footpath force pedestrians to use carriageway
	
3. On-Street Parking and Congestion reduces the effective carriageway width	4. Parking on Footpath/Encroachment decreases the use of footpaths
	
5. Lack of pedestrian crossings expose them to vehicular traffic	6. Degraded Road Surface (Potholes) affects average speed of traffic

xxvii. SECTOR 101

Sector 101 is an elevated station on Spur from Basai Village to Dwarka Expressway. The source of passengers of this station are Sector 99, 101, 102, 103, Dhanwanpur Village etc.

Issues & Concerns	Potential for Improvements
- Water logged area - Lack of pedestrian crossings and NMT Facilities	- Taking precautionary measure during and after construction - Dedicated pedestrian and NMT facilities

**6.3. STATION PLANNING****6.3.1 Planning Parameters**

i The Station planning will respond to and be determined by the following factors:

- Operational requirements
- Station Boarding/Alighting and the resulting entry/exit location requirements
- Utilities such as firefighting systems, ventilation, water requirements
- Structural Requirements
- Flexibility in design to allow stations to respond to site specific requirements
- Future expansion

The essential quality in a good station layout is the provision of adequate space for efficient movement of passengers between ground level entrances on to the trains and vice versa in the most direct, simple and logical way.

- ii The horizon year of the Study is taken as 2041, when a maximum PHPDT of about **34309**. Accordingly, maximum capacity required at any station for emergency evacuation has been adopted.
- iii The platform length is planned with the capacity of 6 cars / train.
- iv The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the next level is considered as 5.5 minutes (as per NBC 2016) considering that the stations are open and the risk is much less.
- v The Station Design is in compliance to the “Guidelines and space Standards for Barrier Free Built Environment for Disabled and Elderly persons” published by the Ministry of Urban Affairs and Employment India in 1998.

6.3.2 Planning Norms & Standards

a. Entry/Exit

The position of entrances is determined by the juxtaposition of building location of roadway footpath width, space availability and flow directions of passenger traffic. The width of entrances takes into account the predicted passenger flow and available space. All entrances extending to street level are proposed to be protected against flooding. This protection is done by the provision of a minimum of 3 steps up to a landing (+450 mm minimum).

b. Walkways/Ramps

Walkways/ramps are planned based on established principles of pedestrian flow and arranged to minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers. Cross flow and changes in direction are minimized or eliminated.

c. Concourse Planning Standards

- The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the AFCs.
- Concourse consists of “Non Public Areas” and “Public Areas”. The “Non Public Areas” comprise of the Back of House (BOH) areas. The BOH areas consists of PST, System Rooms, Operations, Staff Facilities, Tunnel Ventilation System, Station ventilation System, Water Supply and Drainage System and Miscellaneous requirements. A list of BOH areas is given in **Table 6.2**. The description of such areas is also detailed in the subsequent paragraphs.

- The “Public Area” is further subdivided into “Paid” and “Unpaid Areas”. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the “paid area”, which includes access to the platforms.
- Passenger handling facilities comprise of stairs/escalators, lifts, ticketing counters/automatic ticket vending machines and ticket gates required to process the peak traffic from street to platform and vice-versa. These facilities are provided in the concourse and they also act as a medium to transfer between Paid and Unpaid areas (these facilities also enable evacuation of the station under emergency conditions, within a set safe time limit).
- Uniform number of these facilities has been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station based on the peak hour passenger load.

TABLE 6.2: STATION FACILITIES ACCOMMODATION

PST (POWER SUPPLY & TRACTION)	STAFF FACILITIES
Auxiliary substation Track disconnection switch DG set, Fuel tank	Staff toilets/ locker (male) Staff toilets/ locker (female) First aid Staff mess room Train crew room
SYSTEM ROOMS	
SIGNALING	
Signaling Equipment Room (SER) UPS room (signaling)	
TELECOMMUNICATION	
TER Mobile phone equipment room UPS room (telecom)	
OPERATIONS	STATION VENTILATION SYSTEM
Station control room (SCR) Station manager Ticket office/ticketing Ticket office supervisor Audit and cash storage TVM/ BOMS Security/ police room Excess fare office (EFO)	Chiller plant Cooling tower Staircase Pressurization(in enclosed staircase)
MISCELLANEOUS	WATER SUPPLY & DRAINAGE SYSTEM
Emergency equipment room Cleaners room-1 Cleaners room-2 Refuse store Permanent Way Store	Sewage pump room Seepage pump room-1 Seepage pump room-2 Smoke extraction fan room

d. Operational Rooms- for Public Use

i. Ticketing Gates

- The requirement of the number of gates is based on the peak hour passenger traffic at the station.
- Ticketing gates' requirement has been calculated taking the gate capacity as 32 persons per minute per gate for 2041. At least two ticketing gates will be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided at all stations where gates can be installed as and when required.
- The total number of gates also includes one more gate in case of breakdown or maintenance. Special gates are designed for Disabled persons access, Customers with luggage, Customers with strollers.

ii. Ticket Counters and Ticket Vending Machines (TVMs)

- It is proposed to deploy manual ticket issuing counters in the beginning of the operation of the line. At a later stage, automatic TVMs would be used, for which space provision will be made at the concourse. Capacity of manual ticket vending counters is assumed as 5 passengers per minute per window and it is assumed that only 20% of the commuters would purchase tickets at the stations while performing the journey. The rest are expected to buy prepaid tickets, prepaid card, smart card etc. About 10% of the Smart card users will use the Ticket window for renewal/recharging etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.
- The number of TVMs required is governed by the peak hour passenger traffic, the fare policy and the ticketing. Depending on the composition of monthly pass/smart card users and single ticket users, the number of TVMs could change. As a general thumb rule, it is proposed to provide 7 to 10 TVMs for stations with high traffic and 2 to 5 TVMs for other stations.

iii. Ticket Office

The number of Ticket Offices is determined by the passenger traffic and the operation policy. A minimum of 2 ticket office per station in the stations with high traffic, and 1 ticket office per station in the stations with low traffic have been planned.

iv. First Aid Room

First aid room is not a specific operation room but is proposed to be located in every station in accordance with the technical provisions of the project. This room could also be used as a detention room if it is needed.

v. Passenger Amenities

Toilets for disabled are not specific operation rooms are proposed to be provided at all stations in accordance with the technical provisions of the project.

e. Operation Rooms - for Staff Use

i. Safe deposit

In each station, a safe deposit room located next to the main ticket office shall be provided. This room has to be near the Ticket Office and TVM back-store, with restricted and monitored access, and shall be directly connected with it in the operation area, in order to avoid money transfer to be visible to the public. It should also be close to the Station Master's Control Room for management reasons.

ii. Male and Female Locker and Rest Rooms

These rooms are proposed close to the staff operation areas in the non- public operation area. The area of these rooms is dependent on the number of employees in each station.

iii. Male and Female Staff Toilet

It is recommended to fit the stations with specific toilets for the employees. Separate male and female toilets are proposed for each station.

f. Operation Rooms in Terminal Stations or Intermediate Terminal Station

i. Train Driver Rooms

In case of start and shut down operation directly in terminals with stabled trains during the night, train driver rooms are required. These rooms are preferably located at the platform level and include:

- Train drivers dispatch office,
- Training room / emergency room,
- Operation storage room,
- Male and female locker rooms separated,
- Restrooms

The train drivers dispatch office is a specific room allowing conductors to sign on/sign off and to be informed of new instructions and special orders.

ii. Lost and Found Room

Management of Lost and Found items will be centralized in a specific station for the entire network. The lost and found room is proposed to be located into the public area at a Terminal Stations (Huda City Centre and Cyber City). The lost and found location will require a public zone and a restricted room dedicated to lost objects.

g. Passenger Handling Facilities

The regulations and standards shall form the basis for the design of escalator elevator system and Stairs are American National Standard Institute (ANSI), American Society of testing Materials (ASTM), International Electro technical Commissions (IEC), Indian

Standard (IS), European Norm (EN), National Electrical manufacturers Association (NEMA), National Fire Protection Association (NFPA), Underwriter's Laboratories, Inc. (UL)

- **Design Criteria - Escalator**

The escalators will be heavy duty "public" service escalators capable of operating safely, smoothly and continuously in either direction, for a period of not less than 20 hours per day, seven days per week, (except special holiday which may be operated 24 hours a day) within the environmental conditions prevailing within the well way and at the location where the escalators are installed. The maximum allowable passenger load of each step should not be less than load equivalent of three 65 kg person per step.

The escalators will be equipped with energy saving system. Speed of escalators will be in the range of 0.6-0.75 m/s for normal operation. The energy saving system will reduce speed of escalators to standby speed mode of 0.20 m/s during low traffic hour.

The number of flat steps at the upper landing should be in proportion to the vertical rise of the escalator. For 6.1 m to 18.3 m rise, minimum four flat steps should be provided and for a rise up to 6.1 m manufacturers' standards should be used (2-3 flat steps).

The design of the escalators will be such that they can be used as fixed staircases under a condition of power failure, activation of stop button or activation by safety/protection devices. When the escalators are stationed, no slipping, jerking, sliding and vibration should occur. Escalators will be equipped with protective barriers, where necessary.

- **Design Criteria- Elevator Requirements**

Lifts will be of the goods/passenger public service type and rated at minimum 180 starts per hour. Lifts will be of proven technology and designed to have low energy consumption, low operational costs and will provide environment friendly passenger service. Lifts will be rope traction type capable of operating safely and smoothly without jerking under all loading conditions, for a period of not less than 20 hours per day (except special holiday which may be operated 24 hours a day), seven days per week within the environmental conditions prevailing within the hoist-way and at the location where the elevators are installed.

The size of Lift is 2500 mm x 3000 mm wide, the door width will be minimum 1,100 mm clear and 2,200 mm high.

The speed of lift will be capable of reaching the uppermost discharge point in not more than one minute. The time will be calculated from the time the doors are fully closed at the lowest discharge point to the time that they begin to open at the uppermost discharge point. The minimum speed will be not less than 1.0 m/s irrespective of the travel distance. Lifts will be equipped with facilities for physically challenged people, in

accordance with the relevant standards.

The Interfacing Requirements shall be monitored by the SCADA and abnormal conditions will be alarmed - Incoming power lines healthy, Direction status, Running, Fault and Emergency Status

- **Design Criteria- Stairs Requirements**

- A central handrail is provided where stair width is 4.5m or more.
- Risers per flight: 3 minimum, 12 maximum
- All Steps in a flight of Stairs have the same dimensions
- Tread width of steps will be 300mm
- Riser will be 150mm
- Length of intermediate landing: lesser of 2m or width of stairs
- Handrail: 0.9m high, 50mm diameter, 45mm clearance to wall.
- Step noses will be rounded and color contrasted
- Minimum Stair width for public use: 2400mm
- Minimum Stair width for emergency evacuation: 1100mm

h. Platform Design Standards

- The length of the Platform will be 130 meter for 6 car system.
- The nominal platform width measured from the platform edge to any continuous (longer than 2000mm) fixed structure shall be a minimum of 3000 mm. The minimum distance from the platform edge to any isolated obstruction e.g. columns, shall be 2500mm (an isolated obstruction shall not be longer than 2000 mm). This clearance shall be maintained for safety reasons, irrespective of passenger flow. The platform width greater than the minimum may be required at stations with large passenger flow.
- The platform edge shall have a safety margin of 600 mm wide with a non slip surface and a yellow warning strip of 100 mm wide of contrasting texture. The platform ends shall be provided with a 1200 mm wide security gate and be installed with a Pressure Mat Alarm system.
- Platform widths shall be determined to cater to the following scenarios:
 - Normal service: The platform width shall be determined by multiplying the peak minute flow by 0.5 sqm/person and headway, then dividing by the platform length.
 - Delayed/Emergency service: The platform width shall be determined by the peak minute flow, allowing for two missed headways. The crush load is assumed as sectional load between two stations.

- Markings on the platform to assist and control the flow of passengers for boarding and alighting the trains shall be provided. Space occupied by stairs, escalators, structure, seating, platform supervisor's accommodation etc. is not to be included as part of the platform area.

i. Emergency Evacuation Standards

- The Requirement is to evaluate people from a station platform to another location, initially the next level below or above and then on to street level without hindrance.
- The principles to be followed are :-
 - The maximum distance to an exit route on the platform shall not be more than 100m.
 - The time required walking from the farthest point on a platform to the escalator or stair landing must be considered.
 - A Check shall be made to ensure that sufficient capacity exists at the level to which passengers are evacuated as being a place of ultimate safety so that people can move freely away from stairs and escalators as they arrive.
 - The emergency is assumed to be occurring in one direction of travel only at any given point of time.
- For ensuring adequacy of platform area, stair widths and requirement of additional emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising waiting passengers at the platform (including two missed headways) and section load (or full train load if the section load exceeds a full train load) expected to be evacuated at the station in case of an emergency.

j. Commercial Programs

- A high level of passenger traffic using the stations presents a great potential for high commercial value for advertising. The conditions of success to attract announcers and advertising in transit systems include
 - A high level of passenger traffic:
 - Importance of light and the treatment of light to see the posters
 - Advertising sales agency to manage the advertising space.
- The different possibilities of advertising spaces include
 - On the platforms (20% of the spaces on the platform could be used for advertising).
 - On the walls beside the escalators
 - On the walls of the first level of the stations
 - Inside the Rolling Stock (specific dedicated areas)

The provision of advertisements at stations is presented in **Figure 6.2**.

- On the Rolling Stock: train wearing advertisement campaign (train is used as an advertising medium for one campaign). Advertisement on Rolling Stock is presented in **Figure 6.3**.
 - New technologies can be used especially on the platforms: LCS screens (about 8m²) with projection. It implies cables have to be set up in the stations and on the platforms. The screens include sensors to calculate the number of passengers who pass and see the poster. The screen can also communicate with mobile phones.
- iii. General Principles about the advertising space:
- Advertising spaces must be seen by the customers on the platforms and on the platforms.

FIGURE 6.2: ADVERTISEMENTS AT STATIONS& PLATFORM

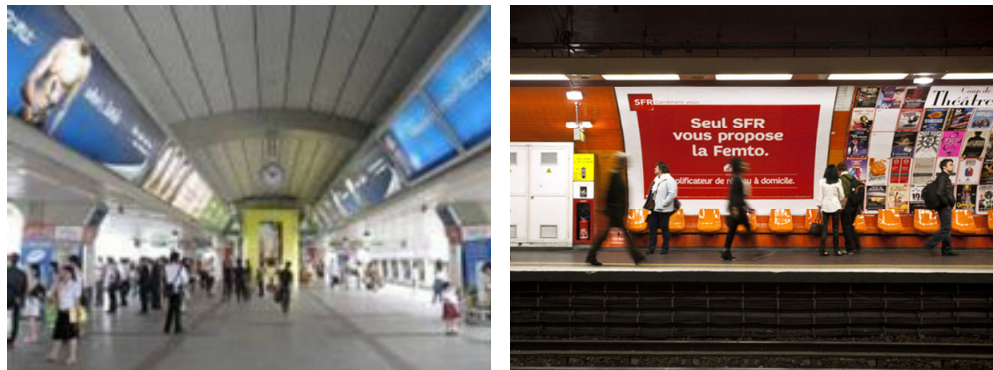


FIGURE 6.3: ADVERTISEMENTS ON ROLLING STOCK



- iv. Like Advertising, retail shops in the stations could provide additional financial income. The expected level of passenger traffic in the stations provides great potential for a high commercial value for the retail shops. An agency will preferably be appointed for management of these retail shops at all stations on the proposed Corridor.
- v. The different area possibilities for location of retail shops;
- Inside the stations (paid as well as unpaid areas)

- vi. Inside the stations (before the tool zone)
 - Space for automatic vending machines could be dedicated (for example: for cash, photos)
 - In the covered zone: space for a shopping mall could be created depending on the market potential.
- vii. Outside the stations (in front of the cars parks or the bus stops)
 - Small corners or kiosks; licenses could be created and negotiated for such shops.
 - Commercial areas and designs will be guided by the market characteristics and local habits.

6.3.3 Typical Planning of Metro Stations

The conceptual station designs are the adaptations of the typical stations finalized keeping projected traffic, site conditions and land & cost optimization in consideration.

Since land is at a premium throughout the corridor, the process of reconciling the land that is actually required for the station development has had a major influence upon the design process and important elements of the stations such as entry/exits, concourse, platforms, ancillary buildings etc have been designed and marked for each station to overcome land acquisition problems. But, wherever the vacant land parcels have not been found available, land acquisition has been proposed for placing the necessary utilities/facilities.

The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation. The space planning requirement for each of the stations with respect to the number of AFC gates, ticket windows, stair width, and number of escalators, platform width etc. in normal and emergency conditions are based on peak hour passenger traffic. These calculations not only accommodate the normal and delayed operation but also satisfy NBC 2016 Metro station guide lines.

The stations have been provided with an internal environment suitable for a world class metro railway system by incorporating the experience of international best practices to the design. The stations have been designed in such a way that they are easily operated, maintained and can be upgraded in future

A number of standardized station typologies, which can respond to the context at specific locations have been developed. The length of the station is 130m for 6 car rake composition.

The width of a typical elevated station has been derived on the basis of Track Centre, Passenger's Boarding-Alighting, Size of Staircase, Escalator and Lift and minimum platform width required as per code etc. A minimum of 2.4m wide staircase with an escalator (clear width 1m) and a Lift have been provided at either side of the station. A minimum of 3m wide platform have been proposed on either side to ease circulation.

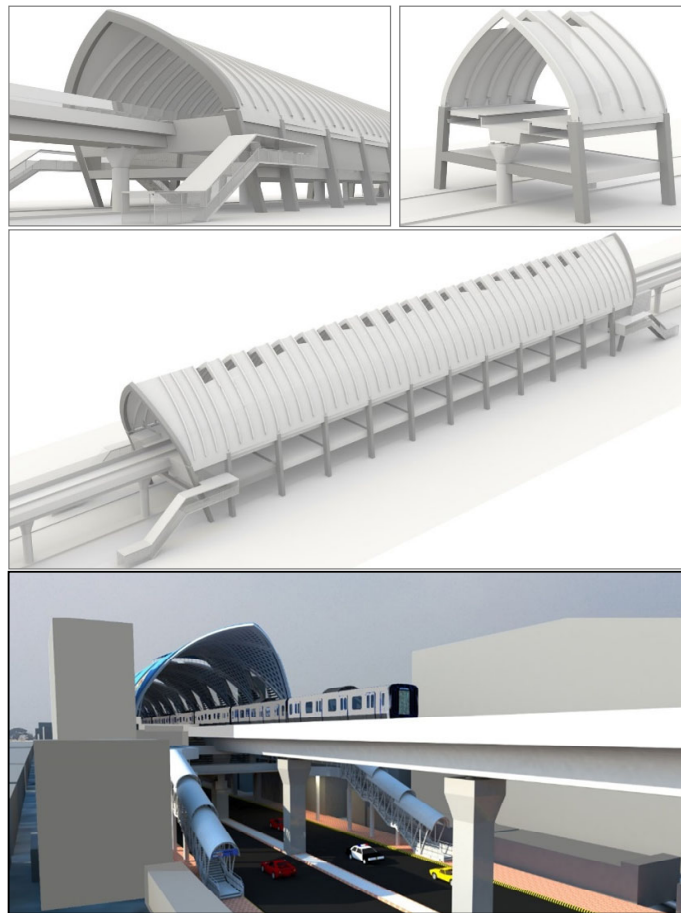
Traffic requirements being low for most of the stations, single unpaid concourse with minimum 2 entry/exits from ground to concourse have been proposed. In stations, where entry/exit requirements are more than 2 nos., 2 more entry/exits could be added on either

side of the road linking depending upon the catchments.

With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer as compared to an At-grade station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and are light looking have been envisaged. A slim and ultra-modern concrete form is proposed, as they would look both compatible and modern high-rise environment as well as the lesser-built, low-rise developments along some parts of the corridor.

Platform roofs that can invariably make a structure look heavy; have been proposed to be of steel frame with aluminium cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. In order to allow unhindered traffic movement below the stations, portals across the road have been proposed in the concourse part, over which the station structure would rest. The rest of the station structure is supported on a single column, which lies unobtrusively on the central verge. Isometric views of such a structure have been shown in **FIGURE 6.4**.

FIGURE 6.4: ISOMETRIC VIEWS OF ELEVATED STATION



Based on the above mentioned criteria and traffic calculations, the typology of stations has been determined. Emphasis has been laid on keeping minimum typologies that would broadly cover design of all 27 stations. Any minor variations from the one type have been included as a subtype and a separate typology has not been created for the same, **Table 6.3.**

TABLE 6.3: STATION TYPOLOGIES

Sr. No.	Proposed Type	Station Concourse Dimensions	Remarks
1	Type A	130m x 20m(Typical)	Station platforms for all the three typologies are 130 m in length. Only the width of the station varies as per the requirements
2	Type B	130mx 28m(Cyber City)	
3	Type C	130mx 22m(Huda City Centre)	

Type A: 130m X 20mTypical Elevated Station(Cantilever)

In this typology the station has width of 20m and length 130m with 85m concourse in the middle of the station. The passenger area on concourse level is concentrated in the middle of the station, with staircases, escalators & elevators leading from either side of the road.

Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, EFO, UPS & Battery S&T Room, Signaling Equipment Room, Communication Equipment Room, Security Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5m has been provided under the concourse. The height may vary in case of grade separated facility is proposed. Concourse floor level is about 7.5m above the road (w.r.t 5.5m vertical clearance). Consequently, platforms are at a level of about 12.5m from the road. To reduce physical and visual impact of the elevated station, stations have been made narrow towards the ends.

The room schedule for Type A, and typical elevated section are presented in **Table 6.4** and **Figure 6.5.**

TABLE 6.4: ROOM SCHEDULE FOR STATION TYPE A

Room No.	Room Name	Size of Room(m)		Area Provided (sq.m)
A-0.1	Station Control Room (SCR)Area	10.00	4.00	40.00
A-02.1	Excess Fare Office (EFO)	2.50	2.50	5.00
A-03.1	Ticket Office	2.63	9.18	24.14
C-01	Signaling Equipment Room	8.84	6.12	54.10
C-03	Communication Equipment Room	8.84	7.79	68.86

Room No.	Room Name	Size of Room(m)		Area Provided (sq.m)
P-01,02	Auxiliary Sub Station	10	19.60	196.00
P-03	UPS Battery S & T Room	8.84	5.28	46.67
P-04	TSS Room	VARIES	VARIES	90.24
O-02	Unpaid Area	VARIES	VARIES	269
O-03.1	Paid Area	VARIES	VARIES	521
O-04	Security Room	4.06	2.79	11.32
O-8.1F	Toilet Female	7.16	3.06	21.90
O-8.2F	Toilet Female	7.16	3.06	21.90
O-8.1M	Toilet Male	7.16	3.07	21.98
O-8.2M	Toilet Male	7.16	3.07	21.98
O-09.1	Toilet (H)	3.29	2.25	7.40
O-09.2	Toilet (H)	3.29	2.25	7.40
O-12 & O-14	Cleaners Room & Refuse Store	7.84	4.34	34.02
O-13	Staff Room	7.42	2.69	21.44
O-06.1	Lift	2.50	3.00	7.50
O-06.2	Lift	2.50	3.00	7.50
O-06.3	Lift	2.80	3.00	8.40
O-06.4	Lift	2.80	3.00	8.40

Type B –130m X 28m Cyber City Station (Portal)

The size of **Type B** elevated station has been kept as **130m x 28m**. The station is planned for one sided platform with concourse at same level. Two staircases, two escalators and two lifts from Ground to Concourse has been proposed for this station. The overall width of the station is restricted to 28 m.

Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, EFO, UPS & Battery S&T Room, Signaling Equipment Room, Communication Equipment Room, Security Room, Staff Toilets etc. The public zone is further divided into paid and unpaid areas.

Since the station is at the side of the road, vertical clearance of 7m has been provided under the concourse. Rail level is taken as 9m from the exiting road, consequently, concourse/platform is at a level of about 9.89m from the road.

The room schedule for Type B is presented in **Table 6.5**. The typical plans for Type B is presented in **Figure 6.6**.

TABLE 6.5: ROOM SCHEDULE FOR STATION TYPE B

Room No.	Room Name	Size of Room(m)		Area Provided (sq.m)
A-0.1	Station Control Room (SCR)Area	10.00	4.00	40.00
A-02.1	Excess Fare Office (EFO)	2.50	2.50	5.00
A-03.1	Ticket Office	2.63	9.18	24.14
C-01	Signaling Equipment Room	8.84	6.12	54.10
C-03	Communication Equipment Room	8.84	4.55	40.22
P-01,02	Auxiliary Sub Station	10	16.36	163.60
P-03	UPS Battery S & T Room	8.84	5.28	46.67
P-04	TSS Room	7.84	6.56	51.43
O-02	Unpaid Area	VARIES	VARIES	1524
O-03.1	Paid Area	VARIES	VARIES	625
O-04	Security Room	4.06	2.79	11.32
O-8.1F	Toilet Female	7.16	3.06	21.90
O-8.1M	Toilet Male	7.16	3.07	21.98
O-09.1	Toilet (H)	3.29	2.25	7.40
O-12 & O-14	Cleaners Room & Refuse Store	7.84	4.34	34.02
O-13	Staff Room	7.42	2.69	21.44
O-06.1	Lift	2.50	3.00	7.50
O-06.2	Lift	2.80	3.00	8.40

Type C: 130m X 22m HUDA City Centre Station (Cantilever)

In this typology the station has width of 22m and length 130m with 85m concourse in the middle of the station. The passenger area on concourse level is concentrated in the middle of the station, with staircases, escalators & elevators leading from either side of the road.

Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, EFO, UPS & Battery S&T Room, Signaling Equipment Room, Communication Equipment Room, Security Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas.

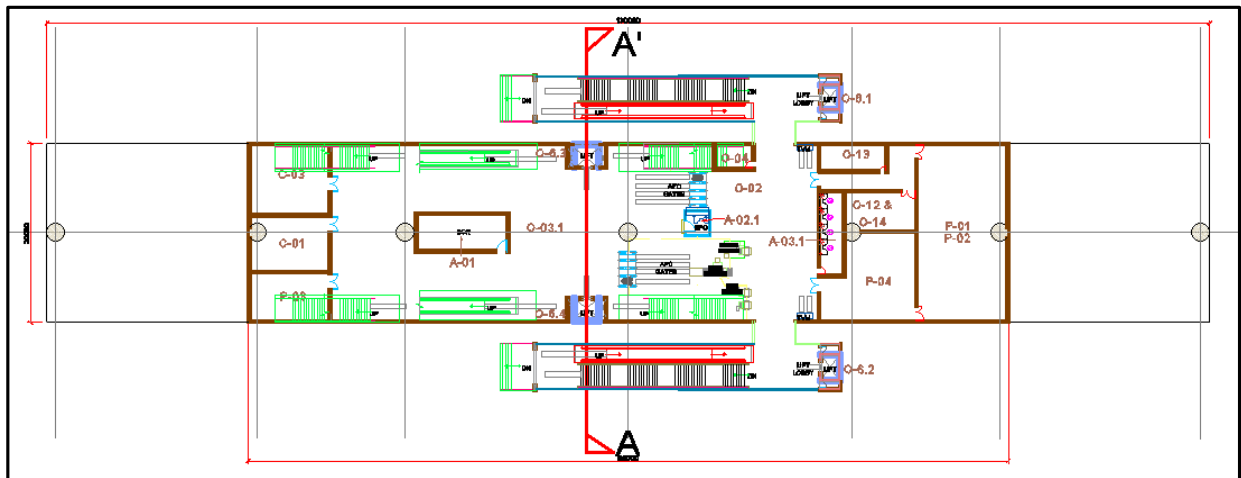
Due to proposed low height fly-over at the station location, Concourse floor level has planned at 10.5m above the road. Consequently, platforms are at a level of about 15.5m from the road. To reduce physical and visual impact of the elevated station, stations have been made narrow towards the ends.

The room schedule for Type C is presented in **Table 6.6**. The typical plans for Type C is presented in **Figure 6.7**.

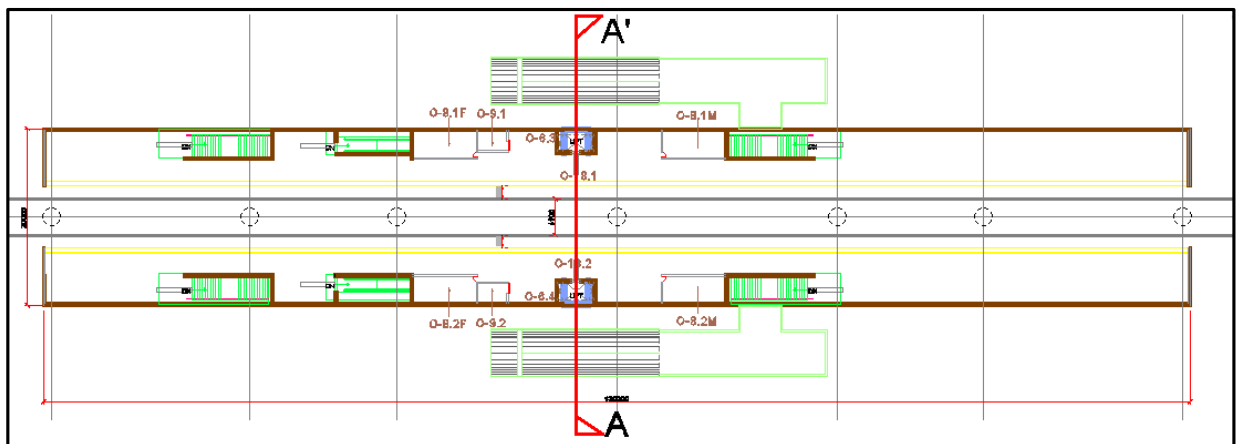
TABLE 6.6: ROOM SCHEDULE FOR STATION TYPE C

Room No.	Room Name	Size of Room(m)		Area Provided (sq.m)
A-0.1	Station Control Room (SCR)Area	10.00	4.00	40.00
A-02.1	Excess Fare Office (EFO)	2.50	2.50	5.00
A-03.1	Ticket Office	2.63	9.18	24.14
C-01	Signaling Equipment Room	8.84	6.12	54.10
C-03	Communication Equipment Room	8.84	8.79	77.70
P-01,02	Auxiliary Sub Station	10	21.60	216.00
P-03	UPS Battery S & T Room	8.84	6.29	55.60
P-04	TSS Room	VARIES	VARIES	101.54
O-02	Unpaid Area	VARIES	VARIES	386
O-03.1	Paid Area	VARIES	VARIES	595
O-04	Security Room	4.06	2.79	11.32
O-8.1F	Toilet Female	7.16	3.06	21.90
O-8.2F	Toilet Female	7.16	3.06	21.90
O-8.1M	Toilet Male	7.16	3.07	21.98
O-8.2M	Toilet Male	7.16	3.07	21.98
O-09.1	Toilet (H)	3.29	2.25	7.40
O-09.2	Toilet (H)	3.29	2.25	7.40
O-12 & O-14	Cleaners Room & Refuse Store	7.84	4.34	34.02
O-13	Staff Room	7.42	3.86	28.64
O-06.1	Lift	2.50	3.00	7.50
O-06.2	Lift	2.50	3.00	7.50
O-06.3	Lift	2.80	3.00	8.40
O-06.4	Lift	2.80	3.00	8.40

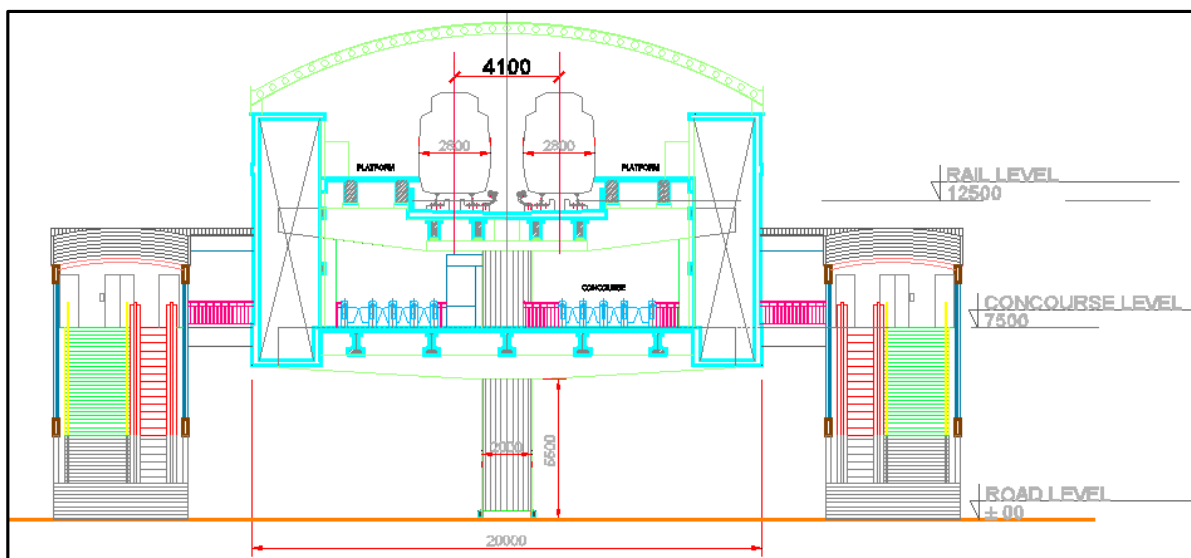
FIGURE 6.5: TYPE A: 130M X 20M



CONCOURSE LEVEL PLAN

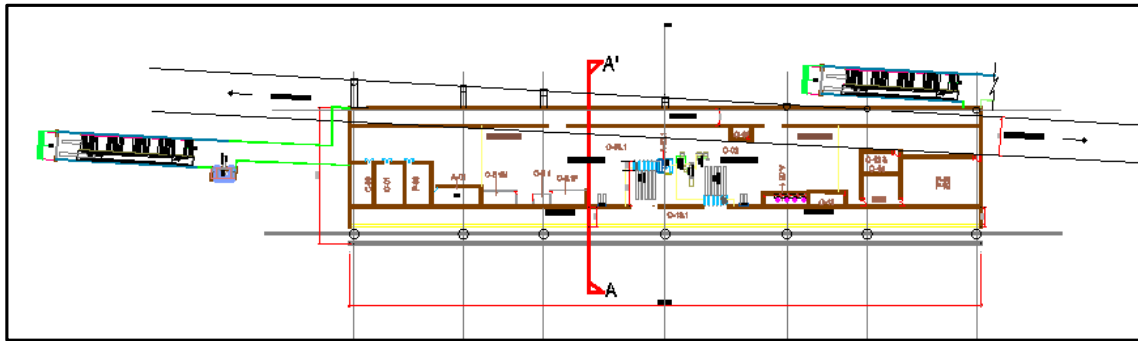


PLATFORM LEVEL PLAN

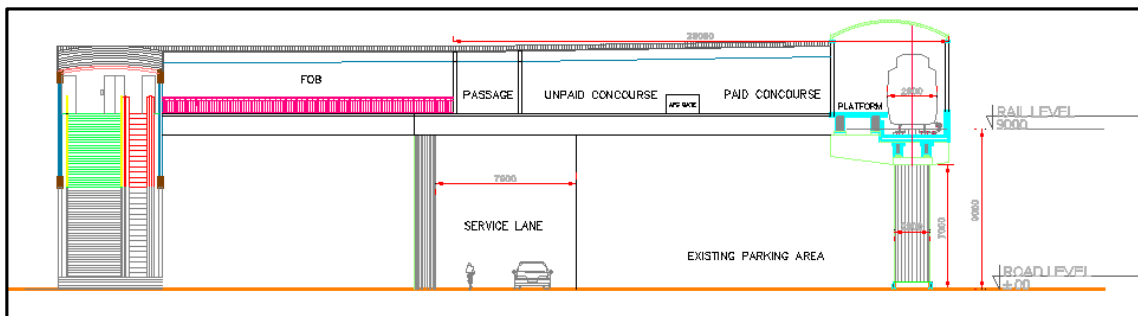


CROSS SECTION AA'

FIGURE 6.6: TYPE B: 130M X 28M

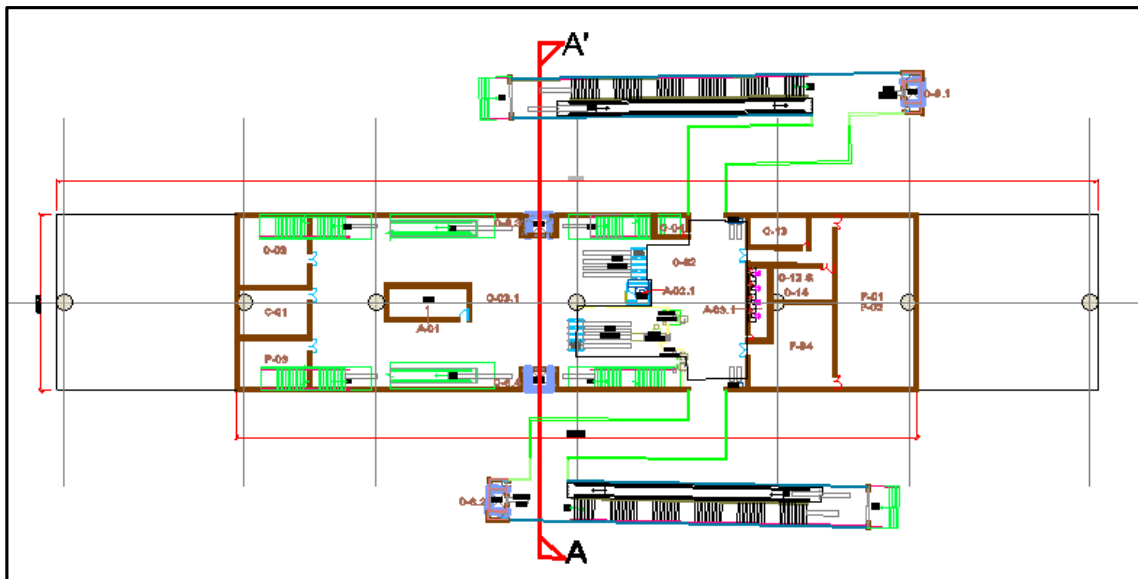


CONCOURSE & PLATFORM LEVEL PLAN



CROSS SECTION AA'

FIGURE 6.7: TYPE C: 130M X 22M



CONCOURSE LEVEL PLAN

6.3.4 Typologies and Stations

TABLE 6.7: DETAILS OF STATION TYPES

Sr. No.	Stations	Type	Concourse Dimensions (Sq.m)
1	HUDA City Centre	C	130*22
2	Sector 45	A	130*20
3	Cyber Park	A	130*20
4	District Shopping Centre, Sector 47	A	130*20
5	Subhash Chowk	A	130*20
6	Sector 48	A	130*20
7	Sector 72A	A	130*20
8	Hero Honda Chowk	A	130*20
9	Udyog Vihar Phase 6	A	130*20
10	Sector 10	A	130*20
11	Sector 37	A	130*20
12	Basai Village	A	130*20
13	Sector 9	A	130*20
14	Sector 7	A	130*20
15	Sector 4	A	130*20
16	Sector 5	A	130*20
17	Ashok Vihar	A	130*20
18	Sector 3	A	130*20
19	Bajghera Road	A	130*20
20	Palam Vihar Extension	A	130*20
21	Palam Vihar	A	130*20
22	Sector 23A	A	130*20
23	Sector 22	A	130*20
24	Udyog Vihar Phase IV	A	130*20
25	Udyog Vihar Phase V	A	130*20
26	Cyber City	B	130*28
27	Sector 101	A	130*20

6.4. ACCESSIBILITY FOR DIFFERENTLY ABLED

Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons-1998 and revised in 2013 by Ministry of Home and Urban Affairs and other international best practices have been considered.

User-friendly mass transport system can ensure accessibility to persons with differently abled, people travelling with small children or carrying luggage and the elderly persons. The following measures will be considered while planning of metro stations for such persons:

- A metro route map in Braille/raised numbers shall be maintained at the enquiry/ticketing window. In each car, there shall be an announcement and provision of a visual display of the names of stations en route.
- Tactile Guiding Paver (Line-Type) and Tactile Warning Paver (Dot-Type) shall be installed from station entry upto the platform boarding/alighting place for visual impaired persons wherever is needed.
- At least one of the ticket gates shall allow a wheelchair user through and have a continuous line of guiding paver for people with visual impairments.
- Public dealing counters (Information or help desks) shall be close to the terminal entrance, and highly visible. They shall be clearly identified and accessible to both those who use wheelchairs and those who stand.
- Staircase, lift and ramp shall be planned for persons with learning differently abled, intellectual differently abled, and elderly persons. Location shall be clearly visible from the pedestrian route. Lifts shall have both visual and audible floor level indicators.
- In emergency situations, audible alarms with 'voice instructions' Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).

FIGURE 6.8 shows various differently abled features as proposed in a metro station.

FIGURE 6.8: VARIOUS DIFFERENTLY ABLED FEATURES IN/AROUND METRO STATIONS



	
Signage for accessible washroom	Way finding signage

6.5. PARKING ON STATIONS

Dedicated parking provision for metro are key factors in determining success of a metro system. Parking provisions along pedestrian facilities like footpath and feeder systems would encourage more commuters to use the transit system who could safely park their vehicles at the nearest station, walk to the station or rely on feeder connectivity. The tentative station wise parking facility area is presented in **TABLE 6.8**.

TABLE 6.8: DETAILS OF PARKING AREAS

S. No.	Station	Identified Land Parcel Area (m ²)
1	Subhash Chowk	4780
2	Sector 37	3865
3	Sector 5	3970
4	Palam Vihar	4500
TOTAL AREA		17115

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity other than walking to the metro station. For catchment area of about 0.5-1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-Wheeler and auto-rickshaws. Areas beyond the 2-km catchment will require regular feeder bus services to reach the metro station. Adequate arrangements have been provided for receiving and dispatch of PT/ IPT at all metro stations.

Chapter – 7

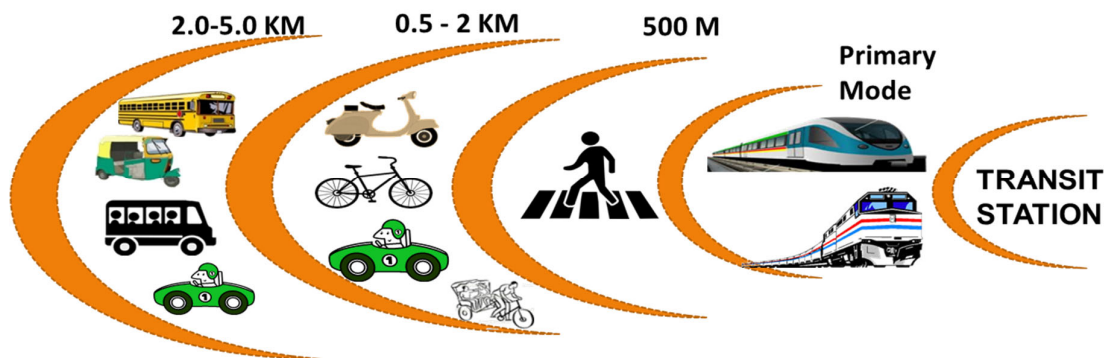
INTERMODAL INTEGRATION

7. INTER-MODAL INTEGRATION

7.1 INTRODUCTION

The proposed system will be accessed by passengers coming from different areas by different modes including public transport (PT), intermediate public transport (IPT), private modes and non motorized transport (NMT). The preferable mode choice to be opted for access/dispersal to/from the nearest station to the surrounding neighbourhood is based on the distance of catchment from the station area, as depicted in **Figure 7.1**.

Figure 7.1: ACCESS/DISPERSAL MODES FROM TRANSIT MODE



Access and dispersal to/from the proposed stations by various modes need to be addressed by intermodal integration at each station for overall horizon year demand for facilitating the users and progressive ridership on the transit system.

Intermodal integration depends on many factors such as nature of station terminal (terminal or en route), its catchment, availability of access/dispersal modes, and interchange with other mass transport, distance from station, trip length and destination. It includes planning for roads, footpaths/pedestrian facilities, bus stops, IPT stands, parking for different modes, pick and drop areas etc.

7.2 PRINCIPLES OF INTEGRATION

Location of stations for the proposed Metro system has been finalized after extensive stakeholder consultations. Planning principles taken into account for intermodal integration are as follows:

- Seamless connectivity to and from catchment area of the station
- Integration with all possible modes including other mass transport systems
- Priority to pedestrians followed by public transport
- Parking facilities for all modes including non motorized transport (NMT) at important stations
- Minimal land acquisition

7.3 RECOMMENDATIONS FOR PROPOSED STATIONS

The following Intermodal Integration and Dispersal recommendations have been suggested at metro stations for efficient passenger movement.

i. **Seamless connectivity**

- For seamless connectivity, direct interchange in the form of FOB/ Skywalk or Subway is recommended wherever possible, either from paid to paid concourse or paid to unpaid concourse
- Effective passenger interchange with feeder modes
- The circulating area adjoining the station building shall be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.
- The station entry/exit shall be planned keeping in view the major growth centers/activity areas. The entry/exits for all the 27 stations are planned to integrate with the existing/ proposed bus stops/bus bays, pick-drop bays, parking lots, business Hubs etc.
- Demarcated pick and drop zones and bays for feeder modes like buses, IPT shall be proposed near the station.
- Off street parking shall be planned wherein adequate land is available for encouraging park and ride at identified important stations. The existing on street parking can be moved to these parking lots for availability of total carriageway for vehicular movement.

ii. **Augmentation of road geometry & footpaths:**

- Full RoW shall be utilized to cater to the future traffic volume. The existing road shoulder areas and service lanes shall be augmented/ strengthened in the design
- A continuous, encroachment free and well maintained footpaths-the design of the footpaths shall be such that it can even be used by physically challenged people

iii. **Uninterrupted traffic flow/smooth traffic conditions:**

Vendors/hawkers and parking shall be relocated for unobstructed movement of pedestrians and vehicles along the main road, approximately in the 500 m catchment of the station

iv. **Pedestrian & disabled friendly design:**

- Junctions and intersections shall be planned with proper pedestrian crossings having table top crossings or ramps with gentle slope ranging from 1:5-1:7 for wheelchair users



Table top crossing for pedestrians



Ramp from footpath to carriageway for easy movement

- Proper road markings, Traffic Signages, Zebra crossings and pedestrian signals shall be proposed to provide safe and uninterrupted pedestrian movement

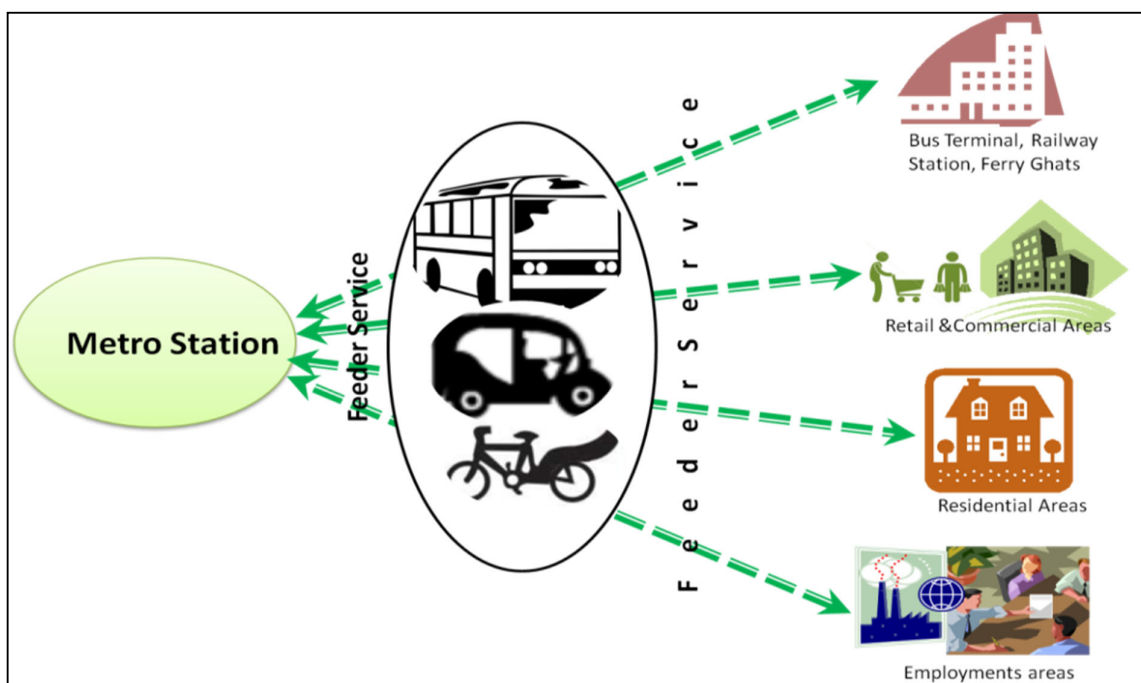
Based on the above proposals, intermodal integration and dispersal plans of three selected stations are illustrated in Annexure 7.1 (Sector 47), Annexure 7.2 (Sector 5) and Annexure 7.3 (Sector 22).

7.4 FEEDER SERVICES PLANNING AT STATIONS

The planning of seamless transport integration facilities at the influence zones of various metro stations is of utmost importance. Feeder services to the proposed metro network are essential for convenient and quick transfer of passengers. As all commuters will not be living within walking distance of the proposed network, proper planning for feeder services will be necessary.

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity to the metro station. For catchment area of about 0.5-1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-wheeler and cycle/auto-rickshaws. Areas beyond the 2-km catchment will require feeder buses to reach metro station.

The feeder service facilities are proposed at metro stations to connect the trip generation/attraction areas in the influencing zones. **FIGURE 7.2** shows the concept of provision of feeder services to a metro system. The facilities of footpaths, feeder buses and bicycles (bike sharing) have been planned for peak hour passenger demand.

FIGURE 7.2: CONCEPT OF FEEDER SERVICES AT METRO STATIONS

7.4.1 Feeder Bus System

The feeder buses shall be of high quality, ultra-modern and customer oriented that can deliver fast, comfortable and cost-effective urban mobility. Easy-to-board (low floor), attractive and environmentally friendly mini buses with air conditioning having capacity of 35 (for minibuses) are proposed for feeder system.

The facilities of feeder buses have been estimated for peak hours of various horizon years. Station wise fleet requirement for proposed feeder routes in different horizon years are presented in **TABLE 7.1**. The total number of fleets required in the year 2026 is 49. The station wise feeder route plan is presented in **FIGURE 7.3**.

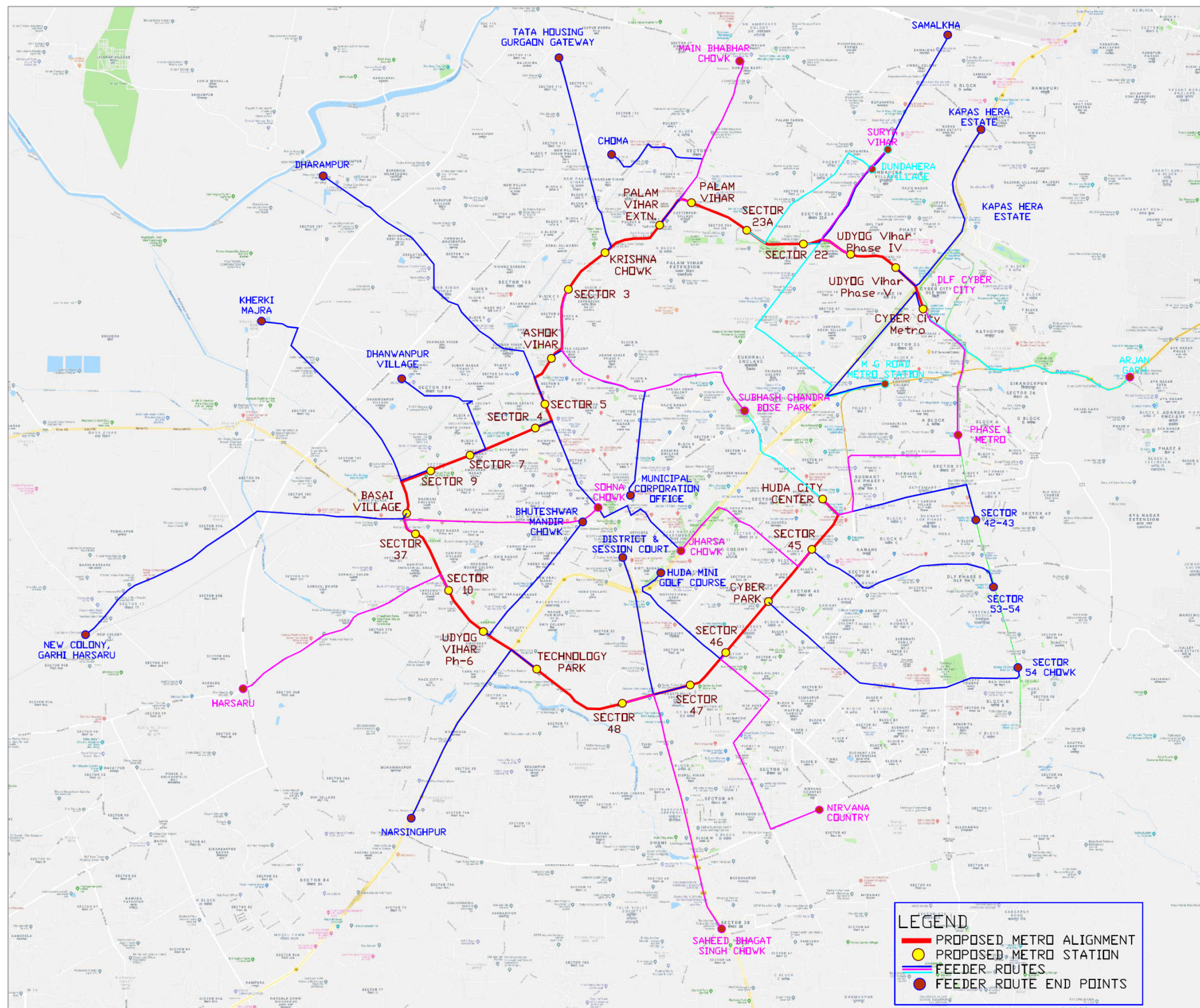
TABLE 7.1: FLEET REQUIREMENT FOR METRO CORRIDOR

S. N.	Metro Station	Route No.	Route Bus Route Name	Length (in Km)	Buses in Peak Hour		
					2026	2031	2041
1	Huda City Centre	R1	HCC to Sector 42- 43 Metro via sector road and DLF Garden Villas Sushant Lok Phase 1	3.1	1	2	2
		R2	HCC to Phase I Metro via DLF Galleria Road	3.83	3	3	5
		R3	HCC to Subhash Chandra Bose Park via Sector Road	2.41	2	3	3
2	Sector 45	R1	Sector 45 Metro Station to Sector 53-54 Metro Station via Bhagwan Mahaveer Marg, St. Tomas Marg	3.94	1	1	1

S. N.	Metro Station	Route No.	Route Bus Route Name	Length (in Km)	Buses in Peak Hour		
					2026	2031	2041
		R2	Sector 45 to Jharsa Chowk via Smt. Santosh Yadav Marg and Delhi Jaipur Expressway	3.26	1	1	1
3	Cyber Park	R1	Cyber Park to Sector 54 Chowk Metro Station Via Netaji Subhash Marg, Indira Colony 1, Sushant Lok and Kendriya Vihar Sector 56	6.98	3	3	4
4	District Shopping Centre, Sector 47	R1	Sector 46 to Huda Mini Golf Course via Ch. Bakhtawar Singh Marg and Kirti Nagar	2.7	1	1	1
		R2	Sector 46 to Nirvana Country Via Satpaul Mittal Marg, Vikash Marg and Golf Course Extn. Road	4.9	1	2	2
5	Subhash Chowk	R1	Sector 47 to District and Session Court via Subhash Chowk and Sohna Road	3.2	2	3	2
6	Sector 48	R1	Sector 48 to Shaheed Bhagat Singh Chowk Via Sohna Marg	5.1	5	7	9
		R2	Sector 48 to Sohna Chowk via Rajiv Chowk and Kirti Nagar	4.1	4	6	8
7	Hero Honda Chowk	R1	Technology Park to Narsinghpur via Delhi-Jaipur Expressway	4.29	2	2	3
8	Udyog Vihar Ph.6	R1	Udyog Vihar Phase 6 to Bhuteshwar Mandir Chowk via Khandsa Road and Ambedkar Chowk	2.92	1	2	3
9	Sector 10	R1	Sector 10 to Harsaru via Pataudi Road	4.35	4	6	8
10	Sector 37	R1	Sector 37 to Sohna Chowk via Gurgaon Basai Road	3.98	3	4	5
11	Basai Village	R1	Basai village to New Colony Garhi Harsaru Jn. Railway Station via Garhi Road	6.76	2	2	2
12	Sector 9	R1	Sector 9 to Kherki Majra via Sector 101 and Sector 102	5.1	2	1	2
13	Sector 7	R1	Sector 7 to Dhanwanpur Village via Surya Vihar main road and Dhanwanpur Road	2.7	1	1	1
14	Sector 4	R1	Sector 4 to Jharsa Chowk via Old Railway Road, Gurudwara Road and Jharsa Road	4.29	1	1	1
15	Sector 5	R1	Sector 5 to Dharampur via Daulatabad Main Road and Dharampur Main Road	5.76	2	2	2

S. N.	Metro Station	Route No.	Route Bus Route Name	Length (in Km)	Buses in Peak Hour		
					2026	2031	2041
16	Ashok Vihar	R1	Ashok Vihar to Municipal Corporation office via Lt Atul Kataria Marg and Bus Stand Road	3.85	2	2	3
17	Sector 3	R1	Sector 3 to Subhash Chandra Bose Park via LT Kataria Marg	5.34	1	1	1
18	Bajghera Road	R1	Krishna Chowk to Tata Housing Gurgaon Gateway, Sector 112 via Najafgarh-Bajghera Road	3.72	1	1	2
19	Palam Vihar Ext.	R1	Palam Vihar Ext. to Choma via Choma Road	3.37	1	1	1
20	Palam Vihar	R1	Palam Vihar to Main Bhabhar Chowk via Carterpuri Road	3	1	1	1
21	Sector 23A	R1	Sector 23A to Dundahera Village via Sector Road	3.23	1	1	1
22	Sector 22	R1	Sector 22 to Samalkha via old Delhi Gurgaon Road	4.5	2	2	3
		R2	Sector 22 to DLF Cyber City via Shankar Chowk road and old Delhi Gurgaon Road	3.7	1	2	2
		R3	Sector 22 to MG Road Metro via Sector 17/18 Dividing Road, Mehrauli Gurgaon Service Road and Old Delhi	4.73	2	2	3
23	Udyog Vihar Phase IV	R1	Udyog Vihar Phase IV to Surya Vihar via Old Delhi Gurgaon Road, Jwala Mill Road, Sector 22 and Dundahera	2.51	1	1	1
24	Udyog Vihar Phase V	R1	Udyog Vihar Phase V to Kapas Hera Estate via Delhi-Jaipur Expressway and Sector 22	3.73	1	2	1
25	Cyber City	R1	Cyber City to MG Road Metro Station via Delhi-Jaipur Expressway and Mehrauli Gurgaon Road	3.26	1	1	1
		R2	Cyber City to Phase I Metro via DLF Golf Course Road, DLF Phase II and Chak Sadhu	2.84	1	1	1
		R3	Cyber City to Arjan Garh via Mehrauli Gurgaon Road, Sikanderpur Ghosi and Sector 26	4.65	1	1	1
	Total Buses Required for Corridor -				59	72	87

FIGURE 7.3: FEEDER BUS ROUTE PLAN



7.4.2 Public Bicycle Sharing Service

The bicycle sharing service will be provided for the passengers for 1 km to 2 km of the metro stations influence area. A bicycle sharing system is the service in which bicycles are made available for free and shared use to metro passengers on a short-term basis. The main purpose is to allow passengers to depart or arrive at metro stations. The requirement of bicycles along the metro corridors is estimated and is presented in **TABLE 7.2.**

TABLE 7.2: BICYCLE SHARING SCHEME FOR METRO CORRIDOR

S. N.	Metro Station	Bicycles in Peak Hour		
		2026	2031	2041
1	Huda City Centre	77	107	132
2	Sector 45	17	20	24
3	Cyber Park	14	19	22
4	District Shopping Centre, Sector 47	18	27	30
5	Subhash Chowk	13	22	25
6	Sector 48	84	119	141
7	Hero Honda Chowk	14	18	21
8	Udyog Vihar Ph.6	12	25	33
9	Sector 10	34	51	65
10	Sector 37	40	73	82
11	Basai Village	8	11	15
12	Sector 9	20	21	24
13	Sector 7	13	16	20
14	Sector 4	9	11	13
15	Sector 5	18	19	21
16	Ashok Vihar	28	38	50
17	Sector 3	13	15	16
18	Bajghera Road	17	22	30
19	Palam Vihar Ext.	11	16	20
20	Palam Vihar	9	14	18
21	Sector 23A	11	12	19
22	Sector 22	78	103	129
23	Udyog Vihar Phase IV	24	27	32
24	Udyog Vihar Phase V	17	21	25
25	Cyber City	33	35	43
Total Sharing Bicycles required		632	862	1050

7.5 RECOMMENDATIONS FOR INSTITUTIONAL, PHYSICAL, FARE, OPERATIONAL AND TECHNOLOGY INTEGRATION

Some of the essential features of an integrated multi-modal urban transport system are the physical integration of public transport services, fares, ticketing, infrastructure provision, management, pricing, and integration of transport authorities.

7.6.1 Physical Integration

Physical integration refers to the provision of jointly used transport facilities & equipment to provide seamless mobility. Integration of physical space, network planning and physical infrastructure have been planned to facilitate easy transfer of commuters between metro, city bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

Augmentation of carriageway and footpath in station vicinity to cater to traffic volumes has been proposed through strengthening of road shoulder areas and relocation of vendors/hawkers, on-street parking and all encroachments.

7.6.2 Operational Integration

This involves application of management techniques to optimize the allocation of transit resources and coordinate services. The techniques/principles of network integration include:

- Coordinated Routing and Scheduling- in which high-capacity, such as metro system is considered as trunk system and buses act as feeder to the metro. Accordingly, the integrated route network may be planned by generating feeder bus routes for selected metro station.
- Rationalization of redundant services - wasteful duplication of transit service by competing systems may be eliminated and resources redeployed to reduce headways on existing routes and extend services into new areas.
- Network coordination and access- in which access facilities may be provided for non-motorized transport (pedestrians and cyclists) and private transport to support and enhance the public transport operations, to achieve overall network integration.

The service integration takes into account all modes implying the services will be complementary to each other within the station area.

7.6.3 Fare Integration

The basic principle behind fare integration is that one ticket provides access to all modes of transport even when managed by different operators. Choice of fare structure is a very important part of public transport planning. It directly influences operators' revenue. At its simplest, integration of fares, allows a person to make a journey that involves transfers (within or between different transport modes) with a single ticket that is valid for the

complete journey, modes being buses, trains, subways, taxis, parking, etc. The major benefits of fare integration are as follows:

- It encourages people to use public transport by simplifying the transfer between transport modes and by increasing the efficiency of the services
- Provides a common ticket across the modes
- Improves the experience of seamless mobility

Smartcard ticketing systems enable commuters to carry one durable card for use on all transit modes. A single multipurpose ticket makes using multiple transport modes much simpler and less time consuming. In turn, this facilitates the multimodal travel behaviour that is encouraged by operators and transport planners. In this regard, smartcard ticketing is proposed facilitating a genuinely seamless multimodal transport system in the Gurugram.

7.6.4 Information Integration

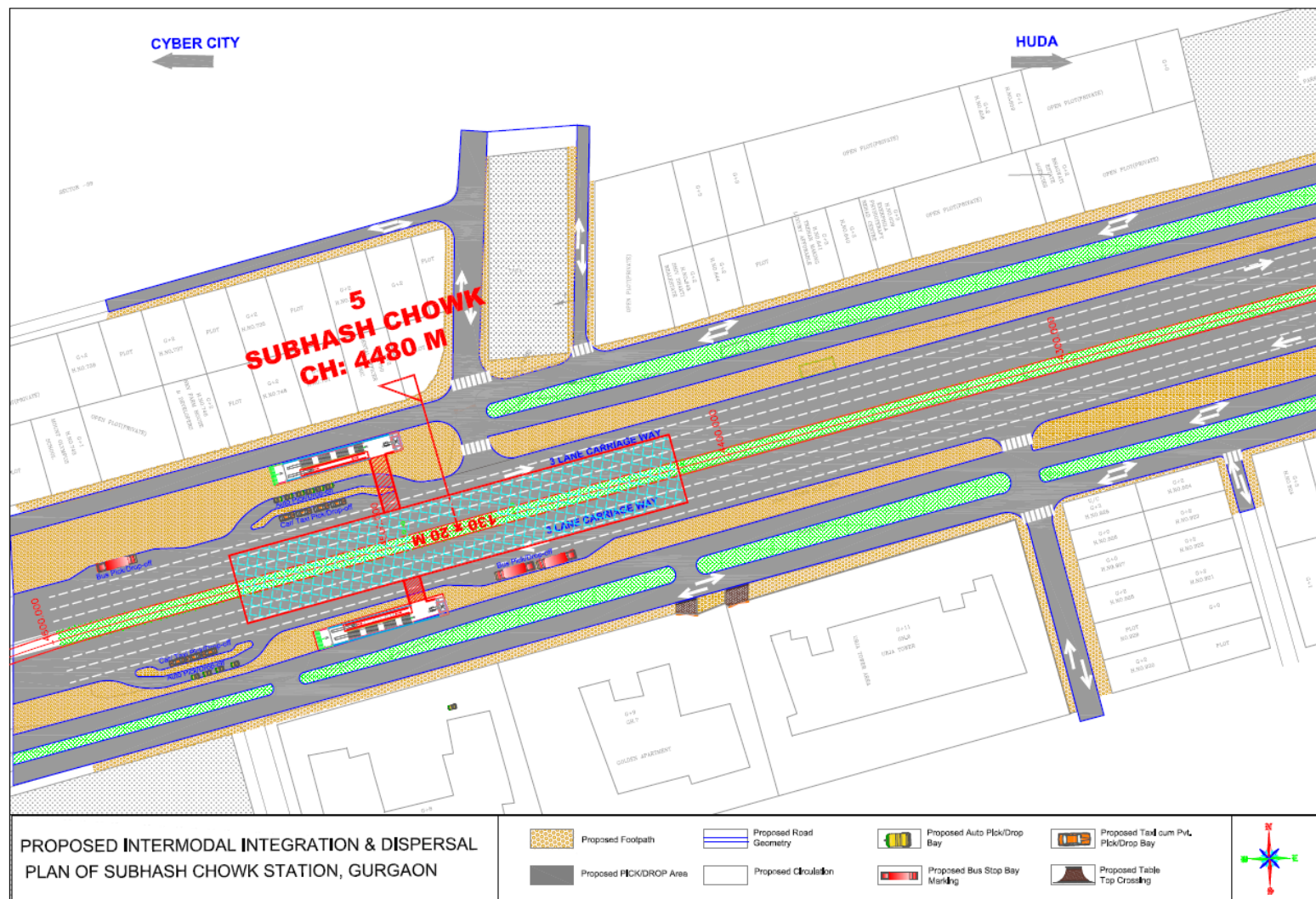
Creating the possibility to get information about the entire journey and not having to enquire at different sources. To take an informed decision during travel, real-time access to information is of strategic importance.

Information integration deals with the Information on routes, schedules, fares, and transfer points for all transit modes and services throughout the urban area, which is provided by a centralized source. Information services include route maps, timetables, fare schedules, and promotion materials, uniform street signs and vehicle identification, display at stops, transfer points and major stations, and telephone inquiry answering service. Providing integrated information during journey before and in between is important, to make them attractive. Information integration for all transit modes in the city is proposed for the metro network.

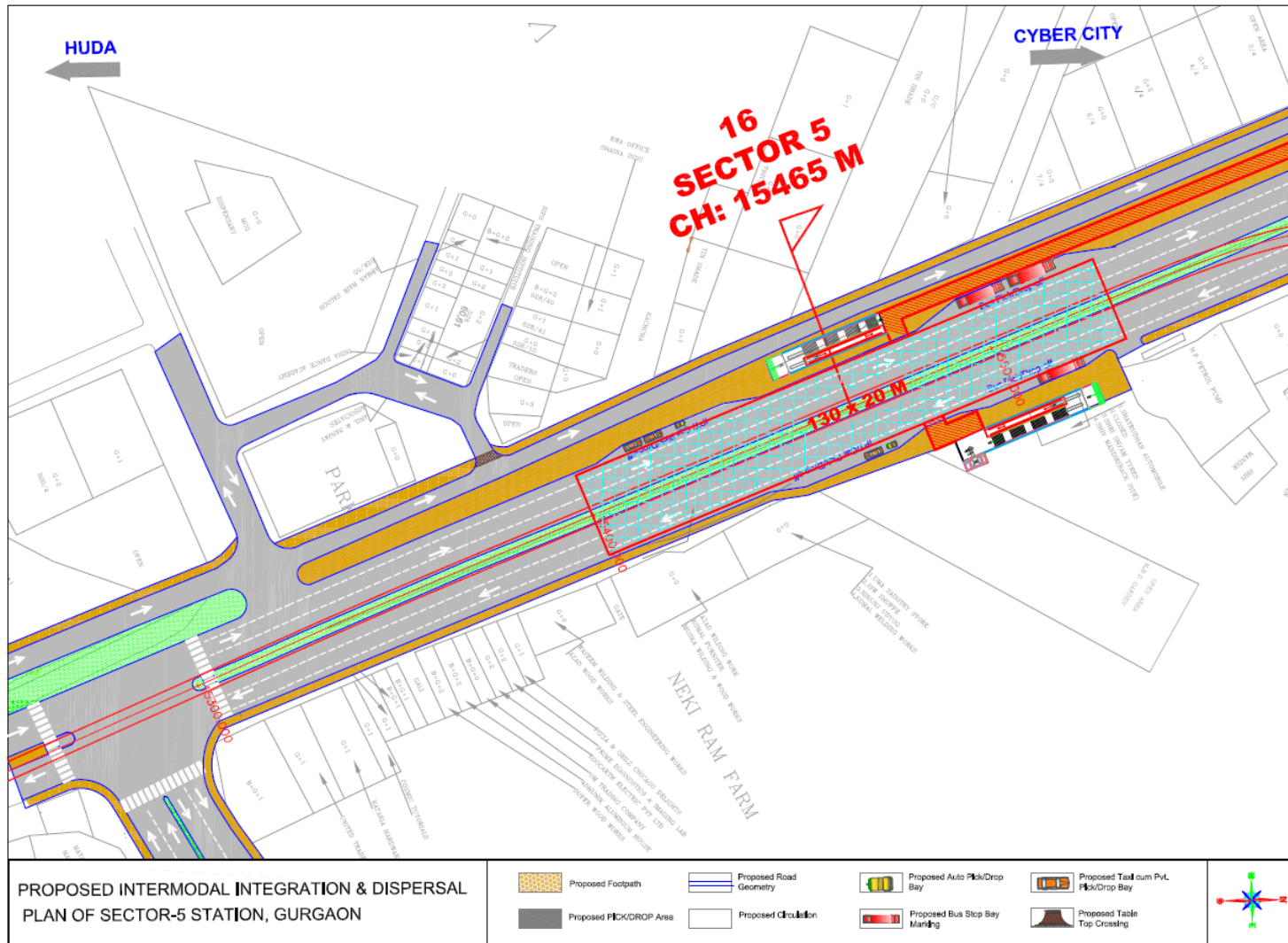
7.6.5 Institutional Integration

City growth strategies are usually guided by documents like land use plans, development plans and master plans etc. and the urban transport models are determined by parameters like existing road network, public transport and its related infrastructure, personal vehicles, licensing mechanism and authorities, land ownership, fare structure of public transport, Intelligent Transport System (ITS) mechanism, traffic enforcement agencies and traffic law enforcing mechanisms, goods and freight movement and their operators, road safety and accident management system etc. All these agencies which prepare these policy documents and oversee governing these functions generally work independently and usually there is no synergy between them. There exists no umbrella agency that monitors and integrates these multiple bodies in order to ensure smoother functioning of all aspects related to urban transport in any city.

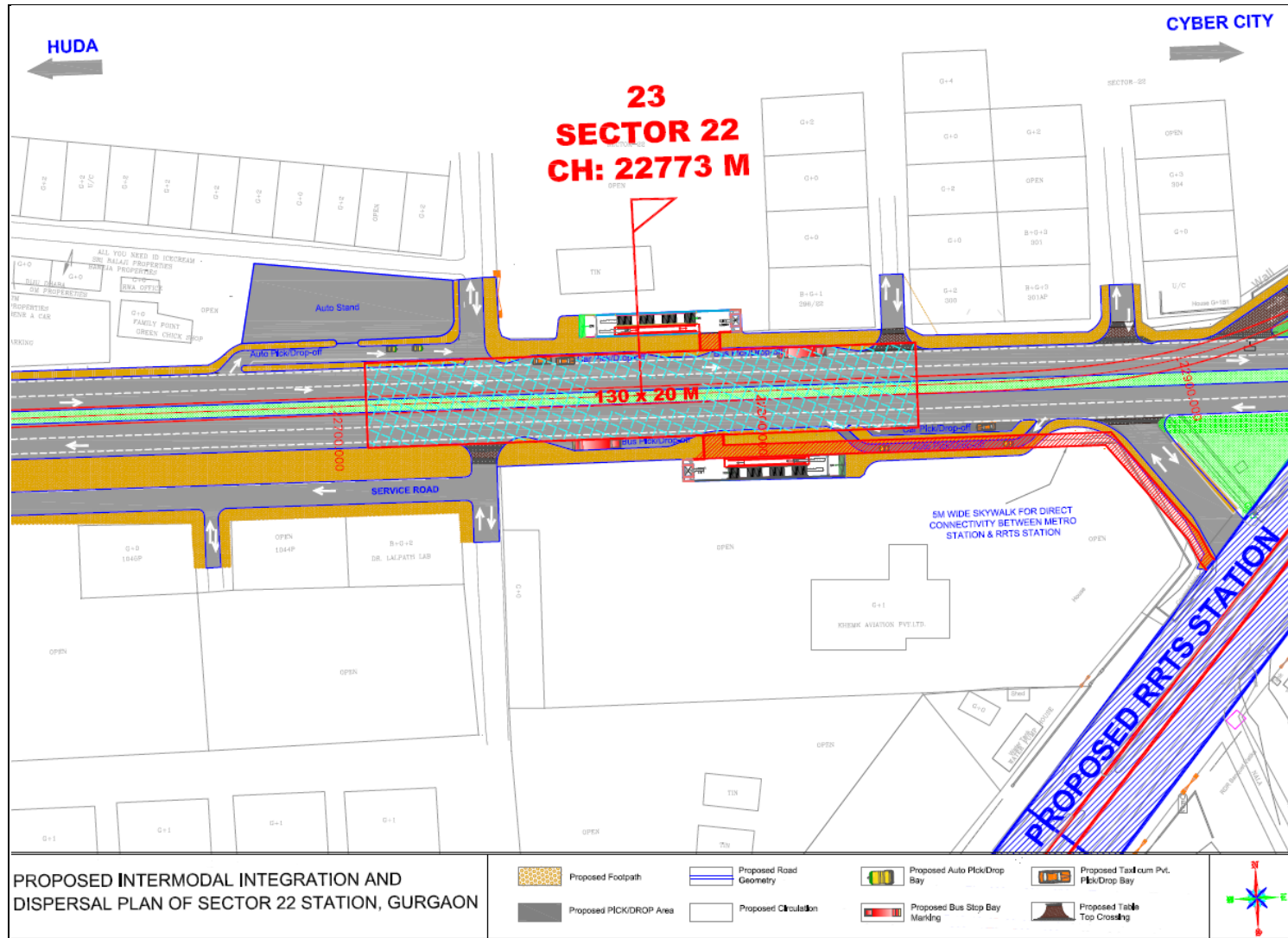
ANNEXURE 7. 1: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF SECTOR-47 METRO STATION



ANNEXURE 7. 2: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF SECTOR-5 METRO STATION



ANNEXURE 7. 3: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF SECTOR-22 METRO STATION



Chapter – 8

TRAIN OPERATIONS PLAN

8. TRAIN OPERATION PLAN

8.1 TRAIN OPERATION PHILOSOPHY

8.1.1 Train operation plan for proposed Corridor of Gurugram Metro (Huda City Centre to Cyber City and Spur to Dwarka Expressway) has been envisaged based on the ridership assessment/ data. The design peak hour peak direction traffic (PHPDT) is 34309 for the Corridor.

Gurugram metro is planned to be integrated with the Rapid Metro. Therefore, system similar to Rapid Metro is proposed. The system should have high reliability and adequate capacity to carry required number of passengers to meet peak hour peak direction trips (PHPDT) demand. The underlying operation philosophy is to provide Mass Rapid Transit Services at economical cost with fixed Infrastructure and Rolling Stock planning.

The frequency of Train services shall be optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.

- A minimum train service frequency shall be provided during lean period so as to keep the option of this service attractive during lean period as well.
- The frequency of services shall be regulated to meet the growing traffic demand in horizon years.
- Basic unit selected is two motor car and one trailer car.

The train operation plan for Huda City Centre to Cyber City and Spur to Dwarka Expressway will be based on the following salient features:

- Running of services for 17 hours of a day (6:00 hrs to 23:00 hrs) with a station dwell time of 20-30 seconds.
- Scheduled speed of 34 kmph.
- Make up time of 5% with 8% coasting.
- Adequate services to ensure comfortable journey for commuters even during peak periods.

8.1.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the purpose of planning of services for the proposed corridors for years 2026, 2031 and 2051 are indicated below in **Table 8.1**.

TABLE 8.1: YEAR WISE PEAK HOUR PEAK DIRECTION TRAFFIC (PHPDT)

Corridor details	Maximum PHPDT		
	2026	2031	2041
HUDA City Centre – Cyber City and Spur to Dwarka Expressway	19359	27263	34309

The section wise traffic for the corridor for different horizon years is shown in **Annexure 8.1**. It is observed in most urban rail transit systems that ridership materialization in the initial years of operation is less than projected and takes time to reach the expected levels. Therefore, the train operation plan is formulated considering ridership at 70% for the commencement year 2026 i.e. 13551 PHPDT. This will enable to optimize the rolling stock requirement in initial years of operation. The PHPDT for the Year 2031 and 2041 will remain same.

8.1.3 Train Formation

The features of the rolling stock for Gurugram metro corridor will be similar to that of Rapid Metro. The composition, capacity and headway required for the operation in the proposed corridor is given below:

i. Composition

The car composition to be adopted for Gurugram MRTS is given below-

DMC : Driving Motor Coach

TC : Non Driving Trailer Coach

MC : Non Driving Motor Coach

3-Car Rake Composition: **DMC-TC-DMC**

6-Car Rake Composition: **DMC-TC-MC-MC-TC-DMC**

Every coach shall be fully interchangeable with any other coach of same type.

ii. Capacity

For the purpose of calculating rake requirement of rolling stock, passenger carrying capacity is considered as below in **Table 8.2**.

TABLE 8.2: CARRYING CAPACITY OF COACHES

Description	Driving Motor Car (DMC)			Trailer Car (TC) /Motor Car (MC)			3 Car Train			6 Car train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	30	30	30	30	30	30	90	90	90	180	180	180
Standing	141	212	282	162	243	324	444	667	888	930	1396	1860
Total	171	242	312	192	273	354	534	757	978	1110	1576	2040

Normal - 4 Per/sqm, **Crush**- 6 Per/Sqm, **Dense Crush** – 8 Per/Sqm of standee area

iii. Headway

To meet the above projected traffic demand, the possibility of running trains with 3 car rake composition at different headways has been examined. The traffic capacity and demand have been matched by suitable regulation of headways. Operation with 3 car trains will be sufficient to cater to the traffic demand of the corridor in year 2026 and 2031. However, with increase in traffic demand, combination of 3 and 6 car trains will run on the corridor to meet the demand. Thus, considering the traffic demand in year 2041, operation with combination 3 car and 6 car trains is proposed.

The operation of the trains is planned from Huda City Centre to Sector 56. The existing section of rapid metro rail will be utilized for the operations. An additional train operation from Huda City Centre to Sector 101 is planned to provide connectivity to the 1.85 km spur section from Basai Village to Sector 101. The trains with the peak period headway of 20 minutes are planned for the spur section.

Based on above, the headway and capacity provided for for the various horizon years is as below in **Table 8.3**.

TABLE 8.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED

	Items	2026	2031	2041	
Huda City Centre – Cyber City - Sector 56	Cars/ Train	3	3	3	6
	Headway (Sec.)	4.3	2.1	2.1	
	Trains/hr	14	28	21	7
	Capacity @6p/m ²	10598	21196	26929	
	Provided @8p/m ²	13692	27384	34818	
	PHPDT Demand	13551	27263	34309	
Huda City Centre to Dwarka Expressway (Sector 101)	Cars/ Train	3	3	3	
	Headway (Sec.)	20.0	20.0	20.0	
	Trains/hr	3	3	3	
	Capacity	2271	2271	2271	
	Provided	2934	2934	2934	

**70% PHPDT considered for initial year of operation*

Considering above, the headway and capacity provided for different sections of the corridor is given in Table 8.4:

TABLE 8.4: HEADWAY AND CAPACITY PROVIDED FOR DIFFERENT SECTIONS

Section	Parameters	2026	2031	2041
Huda City Centre to Basai Village	Headway	3.0	2.1	2.1
	Capacity @6 p/m ²	17411	23467	29200
	Capacity @8 p/m ²	22494	30318	37752
Basai Village to Sector 56	Headway	2.6	1.9	1.9
	Capacity @6 p/m ²	15140	21196	26929
	Capacity @8 p/m ²	19560	27384	34818
Basai Village to Sector 101 (Spur)	Headway	20.0	20.0	20.0
	Capacity @6 p/m ²	2271	2271	2271
	Capacity @8 p/m ²	2934	2934	2934

The above train operation and headway for different horizon years is proposed to meet the Peak hour peak direction traffic demand (PHPDT) with standees @ 6 passengers/ m² in most of the sections, except in some sections meeting with standees @ 8 passengers/ m². This

arrangement will optimise the rolling stock requirement.

8.1.4 Train Operation Plan

The corridor is proposed to be integrated with the existing Rapid Metro line to provide connectivity till Sector 56 Rapid Metro station. The integration is planned near Cyber city. The details on the integration plan are given in Chapter 5 – Civil Engineering Chapter.

The following train operations have been planned for Gurugram Metro :

- (i) Huda City Centre – Cyber City - Sector 56
- (ii) Huda City Centre to Dwarka Expressway (Sector 101)

The train operation has been planned such that for majority of the sections, the traffic demand is met by the passengers @6p/m2. For the spur section (i.e. Huda City Centre to Section 101), the operation is planned with the headway of 20 minutes during the peak hour to provide a suitably attractive service to the passengers.

The graphs showing the traffic demand and capacity provided in different sections of the corridor are given below:

FIGURE 8.1: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2026)

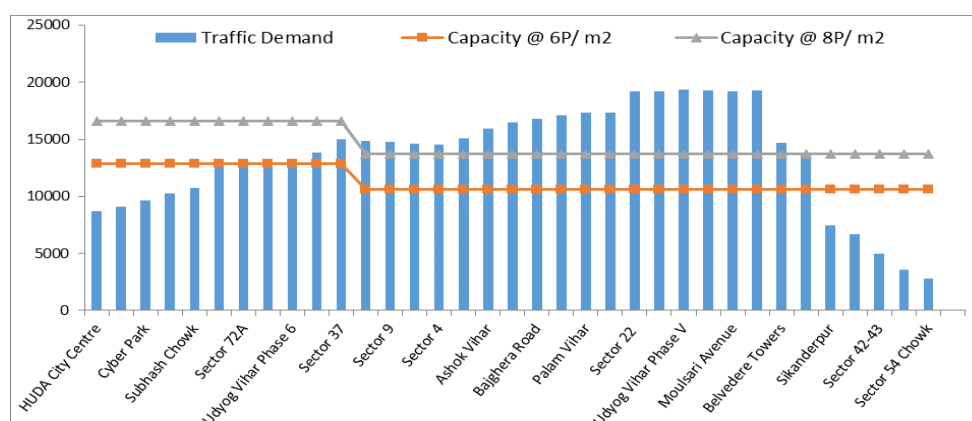


FIGURE 8.2: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2031)

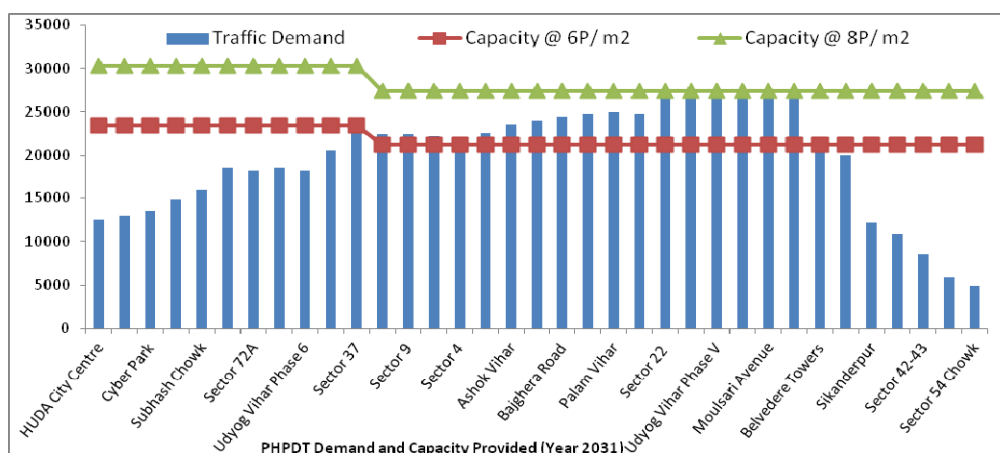
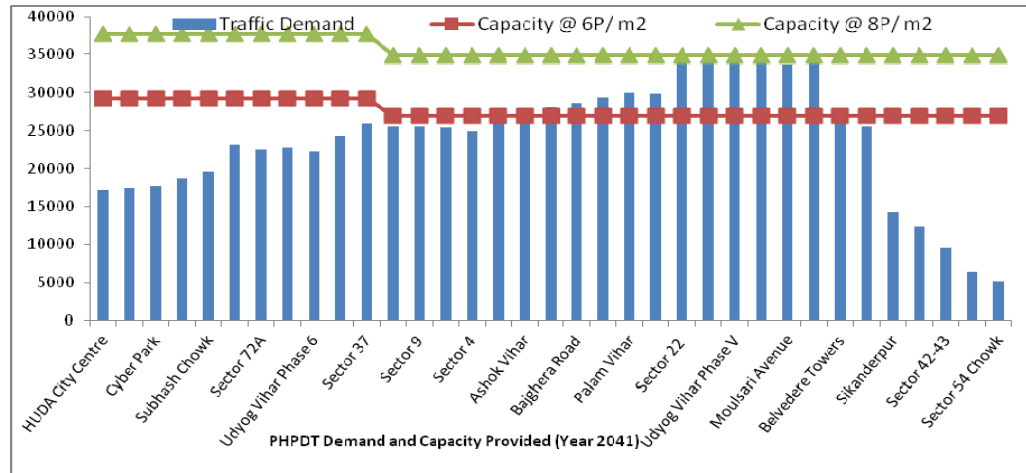


FIGURE 8.3: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2041)

8.2 SYSTEM FREQUENCY

The services for Gurugram Metro rail shall be operational for 17 hours of a day (6:00 hrs to 23:00 hrs). No services are proposed between 23:00 hrs. to 6:00 hrs. which are reserved for maintenance of infrastructure and rolling stock.

The frequency of train operation during the peak hours is presented in **Table 8.4**. It is expected that the traffic demand during other time of the day i.e. off peak hours will be less. Therefore, operation with lesser number of trains is planned during the off peak period. The hourly distribution of daily train operation between Huda City Centre and Cyber City for various horizon years is enclosed in **Annexure 8.2**.

8.3 ROLLING STOCK REQUIREMENT

8.3.1 Requirements of coaches for the corridor are calculated based on following assumptions:

- Coach requirement has been calculated based on headway during peak hours.
- Schedule speed is taken as **34 Kmph** for the round trip.
- Turn round time is taken as **4 min** at terminal stations.
- The calculated number of rakes in fraction is rounded off to next higher number.
- Traffic reserve is taken as 5% to cater to failure of train on line and to make up for operational time lost.
- Repair and maintenance has been estimated as 10% of total requirement (Bare+Traffic Reserve).

Based on above assumptions and train operation plan, the rake requirement for the time horizon 2026~2041 are indicated below in **Table 8.5**

TABLE 8.5: ROLLING STOCK REQUIREMENT

Train Operation	Time horizon Year	Headway in Min	Section length km		Rakes Req'd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake reqmt	Total coach reqmt
			Dir. 1	Dir. 2						
Huda City Centre – Cyber City - Sector 56	2026	4.3	35.29	33.60	30.23	31	2	3	36*	108*
	2031	2.1	35.29	33.60	60.47	61	3	6	70	210
	2041	2.1	35.29	33.60	75.58	76	4	8	88	264
Huda City Centre to Dwarka Expressway (Sector 101)	2026	20.0	13.43	13.43	2.77	3	0	0	3	9
	2031	20.0	13.43	13.43	2.77	3	0	0	3	9
	2041	20.0	13.43	13.43	2.77	3	0	0	3	9

*Existing Rapid Metro system has total of 12 rakes i.e. 36 Coaches. Accordingly, in the initial year of operation (2026), additional 81 coaches will be required.

8.3.2 Stabling of Rakes

The stabling facility for the rakes of the corridor is provided at Sector 101 depot. The depot layout plan has been discussed in detail in Chapter 14. Also, the existing depot of the rapid metro will be utilized for the stabling of rakes. In addition, stabling facility for 6 Nos of rakes will be provided at terminal stations i.e. Huda City Centre station and Sector 56 station. 4 Nos rakes will be stabled at Sector 101 station.

8.3.3 Vehicle Kilometer

Based on the above planning, the vehicle Kilometers for the proposed train operation for years 2026, 2031, 2041 and design year is given below in **Tables 8.6 and Table 8.7.**

TABLE 8.6: VEHICLE KILOMETER FOR HUDA CITY CENTRE TO SECTOR-56

Year	2026	2031	2041	
Section Length (Dir. 1)	35.29	35.29	35.29	
Section Length (Dir. 2)	33.60	33.60	33.60	
No of cars per Train	3	3	3	6
No of working Days in a year	365	365	365	365
Number of Trains per day each Way	151	306	232	81
Daily Train –KM	10657.0	21596.3	16373.6	5716.66
Annual Train - KM (10 ⁵)	38.90	78.83	59.76	20.87
Annual Vehicle - KM (10 ⁵)	233.39	472.96	358.58	125.19

TABLE 8.7: VEHICLE KILOMETER FOR HUDA CITY CENTRE TO SECTOR-101

Year	2026	2031	2041
Section Length	13.43	13.43	13.43
No of cars per Train	3	3	3
No of working Days in a year	365	365	365
Number of Trains per day each Way	35	35	35
Daily Train –KM	939.82	939.82	939.82
Annual Train - KM (10 ⁵)	3.43	3.43	3.43
Annual Vehicle - KM (10 ⁵)	20.58	20.58	20.58

Annexure-8.1

SECTION WISE TRAFFIC FOR GURUGRAM METRO CORRIDOR

Station Name		2025		2031		2041	
From	To	Dir 1	Dir 2	Dir 1	Dir 2	Dir 1	Dir 2
HUDA City Centre	Sector 45	8483	8678	11665	12520	16435	17161
Sector 45	Cyber Park	9091	9005	12398	12926	16994	17363
Cyber Park	Sector 46	9600	9349	13170	13496	17517	17612
Sector 46	Subhash Chowk	10263	10021	14309	14827	18490	18626
Subhash Chowk	Sector 48	10711	10489	14988	15942	19158	19503
Sector 48	Sector 72A	12896	12353	18541	16895	23130	20317
Sector 72A	Hero Honda Chwk	12651	12070	18255	16407	22538	19386
Hero Honda Chwk	Udyog Vihar Ph. 6	12932	11913	18566	15952	22811	18603
Udyog Vihar Ph. 6	Sector 10	12732	11896	18266	17053	22291	19822
Sector 10	Sector 37	13014	13804	18667	20570	22566	24261
Sector 37	Basai Village	13827	14977	21192	22653	24860	25834
Basai Village	Sector 9	14252	14856	21629	22493	25359	25465
Sector 9	Sector 7	14307	14794	21569	22397	25458	25483
Sector 7	Sector 4	14210	14637	21300	22224	25250	25325
Sector 4	Sector 5	14163	14544	21070	21933	25009	25010
Sector 5	Ashok Vihar	14529	15088	21552	22536	25684	25875
Ashok Vihar	Sector 3	14415	15968	21377	23542	25412	27292
Sector 3	Bajghera Road	14793	16449	21754	24025	26070	28039
Bajghera Road	Palam Vihar Ext.	15261	16812	22078	24427	26459	28535
Palam Vihar Ext.	Palam Vihar	15580	17109	22396	24735	27032	29340
Palam Vihar	Sector 23A	15924	17366	22731	24949	27622	30024
Sector 23A	Sector 22	15907	17351	22590	24797	27454	29829
Sector 22	Udyog Vihar Ph. IV	15987	19194	23036	27234	29454	34309
Udyog Vihar Ph. IV	Udyog Vihar Ph. V	15308	19243	22151	27182	28293	34146
Udyog Vihar Ph. V	Cyber City	15124	19359	21927	27263	27889	34050
Cyber City	Moulsari Avenue	12512	19259	19148	27113	24374	33790
Moulsari Avenue	Dlf Phase-3	12495	19209	19075	27038	24005	33660
Dlf Phase-3	Belvedere Towers	12544	19259	19149	27113	24134	33790
Belvedere Towers	Dlf Phase-2	12594	14689	19224	21636	24264	26846
Dlf Phase-2	Sikanderpur	10313	13685	16965	20055	21972	25506
Sikanderpur	Dlf Phase-1	5652	7459	10872	12225	12244	14285
Dlf Phase-1	Sector 42-43	4929	6652	9670	10886	10685	12409
Sector 42-43	Sector 53-54	3578	4967	7381	8560	8176	9572
Sector 53-54	Sector 54 Chowk	2783	3547	5882	5614	6478	6380
Sector 54 Chowk	Sector 55-56	2028	2780	4859	4602	5195	5088

Annexure-8.2(a)

HOURLY TRAIN OPERATION PLAN: HUDA CITY CENTRE TO SECTOR 56

Time of Day	Year 2026 (3 car)		Year 2031 (3 Car)		Year 2041		
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr	
						3 car	6 car
6 to 7	15.0	4	7.5	8	7.5	6	2
7 to 8	7.5	8	3.5	17	3.5	13	4
8 to 9	4.3	14	2.1	28	2.1	21	7
9 to 10	4.3	14	2.1	28	2.1	21	7
10 to 11	6.0	10	3.0	20	3.0	15	5
11 to 12	7.5	8	3.5	17	3.5	13	4
12 to 13	8.6	7	4.3	14	4.0	11	4
13 to 14	15.0	4	7.5	8	5.0	6	6
14 to 15	8.6	7	4.3	14	4.0	11	4
15 to 16	7.5	8	3.5	17	3.5	13	4
16 to 17	6.0	10	3.0	20	3.0	15	5
17 to 18	4.3	14	2.1	28	2.1	21	7
18 to 19	4.3	14	2.1	28	2.1	21	7
19 to 20	6.0	10	3.0	20	3.0	15	5
20 to 21	7.5	8	3.5	17	3.5	13	4
21 to 22	8.6	7	4.3	14	4.0	11	4
22 to 23	15.0	4	7.5	8	7.5	6	2
Total No. of trains per direction per day		151		306		232	81

Annexure-8.2(b)

HOURLY TRAIN OPERATION PLAN: HUDA CITY CENTRE TO SECTOR 101

Time of Day	Year 2025 (3 car)		Year 2031 (3 Car)		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
						3 car
6 to 7	60.0	1	60.0	1	60.0	1
7 to 8	30.0	2	30.0	2	30.0	2
8 to 9	20.0	3	20.0	3	20.0	3
9 to 10	20.0	3	20.0	3	20.0	3
10 to 11	30.0	2	30.0	2	30.0	2
11 to 12	30.0	2	30.0	2	30.0	2
12 to 13	30.0	2	30.0	2	30.0	2
13 to 14	60.0	1	60.0	1	60.0	1
14 to 15	30.0	2	30.0	2	30.0	2
15 to 16	30.0	2	30.0	2	30.0	2
16 to 17	30.0	2	30.0	2	30.0	2
17 to 18	20.0	3	20.0	3	20.0	3
18 to 19	20.0	3	20.0	3	20.0	3
19 to 20	30.0	2	30.0	2	30.0	2
20 to 21	30.0	2	30.0	2	30.0	2
21 to 22	30.0	2	30.0	2	30.0	2
22 to 23	60.0	1	60.0	1	60.0	1
Total No. of trains per direction per day		35		35		35

Contents

8. TRAIN OPERATION PLAN	8-1
8.1 TRAIN OPERATION PHILOSOPHY	8-1
8.2 SYSTEM FREQUENCY.....	8-5
8.3 Rolling Stock Requirement.....	8-5

LIST OF TABLES

Table 8.1: YEAR WISE PEAK HOUR PEAK DIRECTION TRAFFIC (PHPDT)	8-1
Table 8.2: CARRYING CAPACITY OF COACHES	8-2
Table 8.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED	8-3
Table 8.4: HEADWAY AND CAPACITY PROVIDED for different sections	8-3
TABLE 8.5: ROLLING stock requirement.....	8-6
TABLE 8.6: VEHICLE KILOMETER FOR HUDA CITY CENTRE TO SECTOR-56	8-6
TABLE 8.7: VEHICLE KILOMETER FOR HUDA CITY CENTRE TO SECTOR-101	8-6

LIST OF FIGURES

FIGURE 8.1: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2026).....	8-4
FIGURE 8.2: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2031).....	8-4
FIGURE 8.3: PHPDT DEMAND AND CAPACITY PROVIDED (YEAR 2041).....	8-5

LIST OF ANNEXURES

ANNEXURE 8.1: SECTION WISE TRAFFIC FOR GURUGRAM METRO CORRIDOR
ANNEXURE 8.2(A) : HOURLY TRAIN OPERATION PLAN: HUDA CITY CENTRE TO SECTOR 56 CORRIDOR
ANNEXURE 8.2(B) : HOURLY TRAIN OPERATION PLAN: HUDA CITY CENTRE TO SECTOR 101 CORRIDOR

Chapter – 9

SIGNALING AND TELECOMMUNICATION

9. SIGNALLING & TELECOMMUNICATION

9.1 SIGNALLING SYSTEM

9.1.1 Design Parameters

The signaling system shall provide the means of an efficient train control ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network. The system will have the following design parameters:

- Design Ridership : 34309 PHPDT
- Standard Gauge : 1435 mm
- Average Speed : 34 KMPH
- Corridor Length : 28.50 Km
- Total Stations : 27
- Train Configuration : 3&6 Car (Design Year)
- Required Headway : 2.1 minutes

9.1.2 Options for Signaling System

Depending on type of the Railway Network, Main Line or Metro Rail, Signaling & Train Control can be achieved by adopting any of the following Signaling System / Technologies available:

- (i) Automatic Signaling
- (ii) ETCS Level – 1
- (iii) ETCS Level – 2
- (iv) Distance to Go (DTG)
- (v) Communication Based Train Control (CBTC)

While system at S.No. (i) – (iii) have been developed / used for Main Line Railway networks, system at S.No. (iv) – (v) are for Metro Railway Networks. Therefore, to have a fair idea of the Signaling & Train Control system for metro railway, the relative merits & limitations of Distance to Go (DTG) and Communication based train control system (CBTC) are discussed as below:

9.1.2.1 Distance to Go (DTG) Signaling System:

Distance to Go (DTG) signaling system is mainly used for MRTS system and adopted by most of the recently commissioned MRTS system in India viz. DMRC (Delhi Metro)

Phase-I, Phase-II, Delhi Airport Metro Express Line, BMRCL Phase-I (Bengaluru Metro), JMRCL (Jaipur Metro) & Chennai Metro.

It has advanced features of Continuous Automatic Train Control (CATC) consisting of sub-system like Automatic Train Supervision (ATS), Automatic Train Protection (ATP) and Automatic Train Operation (ATO). These sub-system are briefly described below:

A. Automatic Train Supervision (ATS)

Automatic Train Supervision (ATS) is used to provide overall control of trains operation and remote control of the station. The main function of ATS is automatic management of train's movement by interfacing with ATP / CBI system for route setting, train supervision and regulation. The system supervises train movements continuously and optimizes train movements in case of abnormalities. ATS system also logs each train movement and displays it on traffic controller work stations and over view display panel at the OCC and also on workstations placed in the Station Control Room (SCR) for Station Controller.

B. Automatic Train Protection (ATP)

Automatic Train Protection (ATP) system (both on-board and way-side) in conjunction with Electronic interlocking , track profile and brake characteristics of rolling stock is provided to ensure safe as also optimal train services on the section. ATP system includes continuous transmission of various safety parameters (authorized speed, movement authority etc.) from track to train through coded audio frequency track circuit. This information received from way-side ATP system by on-board ATC system provides Cab signaling i.e display of maximum safe speed, current speed and target speed / distance. Facilities for automatic enforcement of temporary / permanent speed restrictions are also built in to enhance safety during maintenance work.

C. Automatic Train Operation (ATO)

Automatic Train Operation (ATO) operates the trains automatically from station to station within the safety envelope / parameters of ATP & also controls (opens / closes) the train doors. Train Operator (TO) is only required to Close the train doors and press a Start button when train is ready to depart. ATO in conjunction with ATP &ATS, can control / regulate running & dwell time at stations in accordance with headway / timetable regulation and also regulates the automatic reversal/turn back of trains at terminal stations.

D. Pros and Cons of DTG (Distance to Go) Signaling System:

The Distance to Go (DTG) Signaling system provides safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of 150 seconds with Continuous Automatic Train Control. DTG works on fixed block principle. It needs Audio Frequency Track Circuits (AFTC) for train detection and track to train communication. The reliability of the system depends on the reliability of AFTC.

With the advent of Communication Based Train Control (CBTC) at almost same costs, metro transport authorities / organizations are now favoring adoption of CBTC over DTG based Signaling System for all new projects. World over, for new MRTS projects, while adoption of DTG based system is on a decline, adoption of CBTC based system, because of their advanced features and low life cycle costs, are increasing steadily. In conclusion while DTG based System can be considered technology of the past, CBTC based system can be considered technology for the present & future.

Considering the high cost of Distance to Go (DTG) Signaling system and advent of new technology viz. Communication Based Train Control (CBTC), which supports advance features such as Unattended Train Operation, moving block etc. and is available at almost same cost, Distance to Go (DTG) Signaling system is NOT recommended for Gurugram MRTS.

9.1.2.2 Communication Based Train Control (CBTC) Signaling System:

Communication based Train Control (CBTC) Signaling System is mainly used for MRTS networks. It is the latest Signaling and Train Control Technology and is being adopted by modern metros around the world. It is also being adopted by all new MRTS Networks in India viz, **DMRC Phase-III, Kochi Phase-I, BMRCL Phase-II** etc.

Communication based Train Control (CBTC) Signaling System also has ATP, ATS,ATO/UTO functionality and works on the Moving or Virtual Block principle to reduce headways and increase transport capacity. CBTC relies on continuous two-way digital communication between each controlled train and a wayside control centre. On a moving block equipped railway, the line is usually divided into areas or regions, each area under the control of a computer and each with its own radio transmission system. Each train transmits its identity, location, direction and speed to the area computer which makes the necessary calculations for safe train separation (moving authority) and transmits this to the following train.

The radio link between each train and the area computer is continuous so the computer knows location of all the trains in its area all the time. It transmits to each train the location of the train in front and gives it a braking curve to enable it to stop before it reaches that train. In effect, it can be termed as a dynamic Distance-to-Go system. Axle counters shall be used as secondary train detection system as a fall back system.

As the CBTC based system has very few way side equipment and supports UTO, total life cycle cost of the system shall be substantially lower than other Signaling System due to low Maintenance & Operation (man power) costs.

A. Pros and Cons of CBTC Signaling System

The Communication based Train Control (CBTC) Signaling system provides adequate safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational

headway of **90 seconds** with continuous automatic train control. The CBTC Technology is proven now in many Metros around the World and is also suitable for UTO (Unattended Train Operation) / DTO (Driverless Train Operation).

After reviewing all available Signaling & Train Control Signaling Technologies, **Communication based Train Control (CBTC)** system, which is the latest technology available, is recommended for Gurugram MRTS. The existing section of Rapid Metro will be upgraded to CBTC signaling system.

9.1.3 Interlocking System: Computer Based Interlocking (CBI)

Station with Points and Crossings called “Main” or “CBI” stations, will have Interlocking equipment for achieving Computer Based Interlocking (CBI) for operation of points and crossings and setting of routes. Fixed Signals will be provided at Entry & Exit to Interlocking stations.

A. Train Depot: Signaling

All depot lines except the ones used for shunting in workshop shall be interlocked. A workstation each shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard.

B. Signaling at Stations with Points and Crossings

LED type signals for increased reliability and less maintenance efforts shall be provided for Line side signals to protect the points (switches).

9.1.4 Operation Control Centre (OCC)

The OCC shall monitor and control all train operations. During abnormal working, train operation shall fall-back to the fall-back control facilities at interlocked Stations which shall provide the minimum facilities for smooth operations.

OCC operations shall facilitate the safe, secure and reliable operation of planned passenger services and management of unplanned events. The OCC shall be the primary control centre having a backup control centre (BCC) to take over the operation if the OCC is to be evacuated due to unforeseen situation.

The key functions of the OCC shall be, but not limited to, as under:

- (i) Automatic Train Control (ATC);
- (ii) Equipment Control and Monitoring System
- (iii) Communication system management
- (iv) Operation management functions
- (v) Maintenance management functions

9.1.5 Maintenance Philosophy

For efficient operation and functioning of a metro signaling and telecom system, a robust maintenance organization and practices are necessary. Failure in signaling and telecom equipments have to be addressed in preventive and corrective manner. Otherwise, disruptions in Operations and passenger dissatisfaction may arise. The operations and maintenance practices have to be adequately planned with proper defect liability support, spares planning, trained manpower, annual maintenance contract of specific subsystem specifically wherever necessary etc. The spares and maintenance personnel also have to be suitably located all along the metro system to address the failures and remedy the same within a reasonable time.

9.1.6 Standards

TABLE 9.1.shows the standards that will be adopted.

TABLE 9.1: STANDARDS TO BE ADOPTED FOR SIGNALLING SYSTEM

Description	Standards
CBTC System	IEEE 1474.1-4
Interlocking	Computer Based Interlocking (CBI) adopted for station having switches and crossing shall be Hot Standby system with object controller conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for increased reliability and less maintenance efforts.
Train Protection System(ATP)	Automatic train protection system conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
ATS	Automatic Train Supervision System, movement of all trains to be logged on to a central computer and displayed on workstations in operation control centre (OCC) and at SCR. Remote control of stations from the OCC as well as local control from the interlocked stations. ATS/ATO will conform to SIL2 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Immunity to External Interference.	All data transmission on Optical Fiber Cables/Radio. All signaling cables will be separated from power cables. CENELEC standards EN50121-2&4 and EN50082-2 and EN 50081-2 as applicable for EMI/EMC.
Fail Safe Principles	SIL4 safety levels as per CENELEC standard for signal application.
Fall back system	Digital Axle Counter
Other Items	Suitable International Standards like CENELEC etc. shall be followed as per good industry practices.

Description	Standards
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of signaling equipment shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/manufacturer's premises.

9.2 TELECOMMUNICATION SYSTEM

9.2.1 Introduction

The telecommunication system acts as communication backbone for Signaling and other system and provides telecommunication services to meet operational and administrative requirements of metro network.

9.2.2 Telecommunication System used in other Metros

The telecommunications system used in different Metros are as given **TABLE 9.2**.

TABLE 9.2: TELECOMMUNICATION SYSTEM USED IN DIFFERENT METROS

DMRC	Line 1 Phase-I	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 4 155Mbps network Telephone System : EPABX Mobile Radio Communications: Digital Trunk Radio System (TETRA) Public Address (PA) System Centralized Clock System: Digital & Analog Clocks and Time Synchronization System Passenger Information Display System: LED based Network Management & Station Management System CCTV Cameras were provided later on for Security purposes
DMRC	Line 2 Line 3 Phase II	Same as above with Closed Circuit Television: fixed and PTZ Camera and PIDS LED and LCD based.
BMRC	Phase I	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network Telephone System : EPABX Mobile Radio Communications: Digital Trunk Radio (TETRA) Public Address System Centralized Clock System: Digital and Analog Clock System Passenger Information Display System: LED & LCD based.

		Network Management & Station Closed Circuit Television System : Fixed and PTZ Camera with monitors
Hyderabad Metro	Phase I	Digital Transmission System (DTS) - Optical Fiber Cable - IP based system with Layer 2 , Layer 3 and Access switches with OF interfaces Telephone System: EPABX Mobile Radio Communications: Digital Trunk Radio (TETRA) Public Address System Centralized Clock System: Digital and Analog Clock System Passenger Information Display System: LED & LCD based. Central Fault Reporting system (CFRS) Closed Circuit Television: fixed and PTZ Camera
JMRC	Phase I	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network Telephone System : EPABX Mobile Radio Communications: Digital Trunk Radio (TETRA) Public Address System Centralized Clock System: Digital and Analog Clock System Passenger Information Display System: LED & LCD based. Network Management System Closed Circuit Television: fixed and PTZ Camera
CMRL	Ph1	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 16 Telephone System: Hybrid PBX Mobile Radio Communications: Digital Trunk Radio System (TETRA) Public Address/Voice Alarm (PA/VA) System Centralized Clock System: Digital & Analog Clocks and Time Synchronization System Passenger Information Display System: LCD based Network Management & Station Management System CCTV SCADA

9.2.3 Proposed Telecommunication System and Transmission Media

The state of the art latest technology being used in different metros worldwide, is proposed to be used for the Gurugram MRTS.

9.2.3.1 Digital Transmission System (DTS)

A. Optical Fiber Cable – Main Telecommunication bearer

IP, GE (Giga Ethernet) based system is proposed for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall be arranged in two different cables for path diversity. Considering the channel requirement and keeping in view the future expansion requirements a minimum 144 Fiber, optical fiber cable is proposed to be laid in ring configuration with path diversity. Additional OFC can be considered to be provided if there is a demand for leasing Fiber from Telcos / Industries, providing a source of revenue generation.

The IP network shall consist of highly reliable and fault tolerant Layer-2, Layer-3 and Access switches configured with due redundancy both at Back bone and Access levels for the MAN/LAN. The switches shall have IP interface cards of 10 GBPS for backbone, 1 GBPS for interface with all telecommunication and non-telecommunication sub-system and 2 MBPS and higher levels for access level. All interfaces with other sub system shall be IP based with minimum 2 MBPS capacity.

B. Telephone Exchange

A cost effective solution of an IP PBX having at least 50 IP extensions will be provided at each station and 500 IP extensions PBX will be provided at the central, intermediate location on corridor and depot. The Exchanges will serve the subscribers at all the stations, OCC and depot. It shall also caters 02 emergency telephones on each platform for the use of passengers to contact SCR/OCC in case of emergency. Capacity of Exchanges can be suitably augmented, if required , depending on available subscribers. The exchanges will be interconnected at multiple IP interfaces (2 MBPS) through redundant optical fiber cable paths.

C. Mobile Radio Communication

Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. All the stations and the OCC will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets. These persons will be able to communicate with each other as well as with central control as shown in **FIGURE 9.1.**

The frequency band for operation of the system i.e 410-430 or 380-400 MHz may be taken as per availability. The system shall provide mobile radio communication between the motorman of the moving cars from any place and the Central Control. The motorman can also contact any station in the network through the central

control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance.

FIGURE 9.1: TRAIN CAB RADIO AND COMM. FACILITY FOR MAINTENANCE



To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. In addition to the TETRA Radio Coverage for the internal use of the Metro, the city is also having Mobile Coverage from Private Operators.

D. Public Address System

The public Address System shall be capable of digitized voice announcements and long range PA functionality suitable for evacuation situations in emergency. The public address is to for stations will generally operate in automatic mode providing information for the time and destination of the next schedule train, special upcoming event, safety and security announcement at pre-determined intervals and general information to enhance the travel experience for all users but more specially the visually impaired.

E. Centralized Clock System

The Clock System shall provide synchronized time for the whole Rail system. The time source shall be obtained from the Cesium Master Clock and Global Positioning System (GPS). The synchronized time information shall be displayed on slave clock units and provided to all other sub system including Rolling Stock & signaling via the Digital Transmission System and Track-Train Communication system as shown in **Figure 9.2**.

.

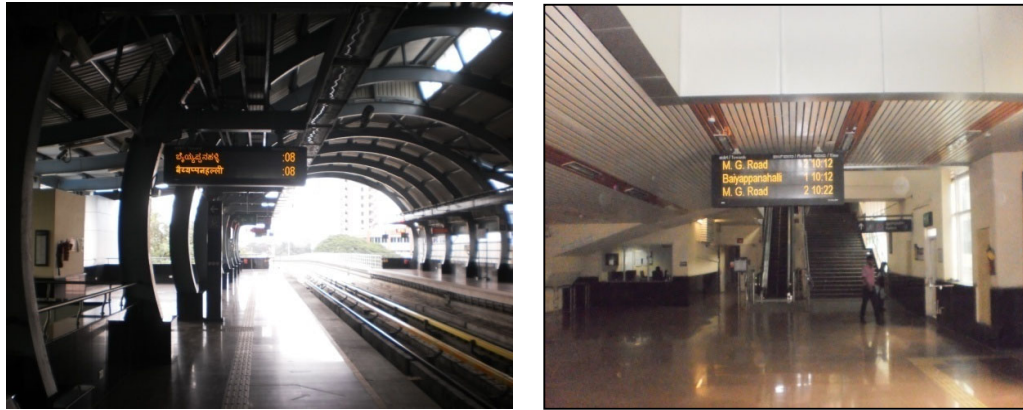
FIGURE 9.2: MASTER CLOCK

F. Passenger Information Display System

At all stations, suitable Electronic Passenger Information Display Boards preferably LCD/LED (Flat Panel) will be provided as shown in **FIGURE 9.3**. The PIDS shall be train actuated (controlled by signaling system) along with facility for manual inputs from the local station as well as the central location (OCC).

FIGURE 9.3: PASSENGER INFORMATION DISPLAY SYSTEM

Passenger Information display boards will be provided at convenient locations at all stations to provide Bilingual i.e. Hindi & English visual indication of the status of the running trains and will typically indicate information such as destination, platform numbers, arrival/departure time, and also special messages in emergencies. The boards will be provided at all platforms and concourses of terminal & junction stations as shown in **Figure 9.4**.

FIGURE 9.4: PIDS AT PLATFORM AND CONCOURSE

It is envisaged that Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit conversation between passengers and the drivers in case of any emergency.

G. Close Circuit Television

CCTV system should ensure real time full coverage, high quality surveillance of all public and selected areas such as tunnel cross passages, ancillary buildings, on board conditions for secure passenger management, crowd control and other emergency situations. Event reloading shall be possible for post video analysis. CCTV cameras shall also be provided in Operational rooms like OCC, SCR etc. A proper IP based recording and storing facility to record and store events for minimum of one month shall be ensured.

H. Central Voice Recording System (CVRS)

A centralized digital voice recording system will be provided at OCC to record all Two-way Telephone conversation, PA calls from station and OCC, Two Way Radio Conversation of all controllers , TOs , SCRs and other users in OCC and Depot. In addition all conversation of the Radio System including private calls of all subscribers including Controllers, TOs shall also be recorded. Arrangement of free space audio recording in OCC, SCRs and Driver Cab shall also be made available.

I. Central Fault Reporting System (CFRS)

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a CFRS / SCADA system which will help in reporting and diagnosing the faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance.

J. Access Control and Intrusion Detection System (ACIDS)

An Access Control and Intrusion Detection System (ACIDS) shall be provided for access management, alarm management and intrusion detection. The system shall include but not limited to the detection sensors/equipments, control switch, card readers, interface controllers, local and central ACS servers, display HMI, alarm printers, etc.

In addition to Access Control System there shall be a provision of attendance system using bio-metric (thumb or facial) access point reader at all stations, depot, OCC/BCC and RSS.

K. Office Automation & Information Technology Network (OA&IT)

The Office Automation (OA) and Information Technology (IT) network shall provide the network infrastructure for the operators and other administration/maintenance staff to handle office administrative works at all the stations, depots, OCC/BCC and RSS. All the administrative works shall be carried out on this network. This network shall be distinct from the communication network provided for the train operations.

L. Uninterrupted Power Supply

The uninterrupted power supply (UPS) of 60 KVA, 415 V $\pm$ 1%, 3 phase with Battery bank of 800AH capacity at each interlock station and 30 KVA with Battery bank of 300AH capacity at each non-interlock station will be provided for 2 hour back up.

The standards that will be adopted with regard to the Telecommunication system is shown in **TABLE 9.3**. These will conform to appropriate IRS/International standards.

TABLE 9.3: STANDARDS TO BE ADOPTED FOR TELECOMMUNICATIONS SYSTEM

Description	Standards
Transmission System	IP, GE (Giga Ethernet) based system for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall arranged in two different cables for path diversity.
Optical Fiber cable	OFC for underground environment shall be steel armoured and manufactured from Fire Retardant/resistance, Low Smoke and zero halogen materials. For elevated portion of corridor, it shall be steel armored and conforming to IRS specifications.
Public Address System	Passenger Announcement System shall be interfaced with signaling system for online update of train information. IEC 60268 as applicable or any equivalent international/National standard. Fire resistant Low Smoke Zero Halogen cable shall be used to maintain the circuit integrity in case of fire.
Telephone Exchange	IP based Electronic Exchange (IP PBX)
Passenger Display Information System	It shall be interfaced with signaling system for online update of train information. IEC as applicable or any equivalent international/National standard.
Synchronized Clock system	GPS based, master – slave system IEC 61588 or equivalent standard

Description	Standards
CCTV/ Camera	CCTV network shall be as per IEEE standards.
Redundancy (Major System)	Redundancy on Radio base station equipment including server level for all communication sub-system.
Environmental Conditions	All equipment rooms to be air-conditioned.
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and coordination. Card/module level replacement will be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

Chapter – 10

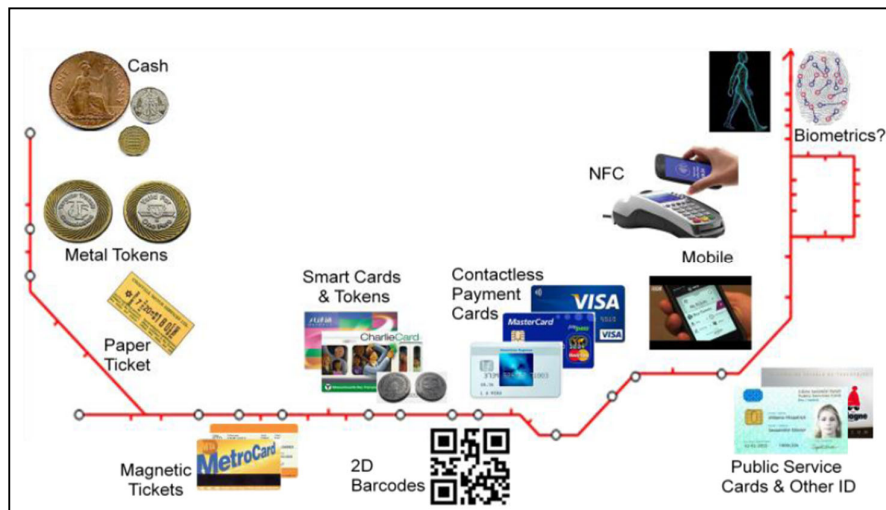
FARE COLLECTION SYSTEM

10. FARE COLLECTION SYSTEM

10.1. TICKETING & ACCESS CONTROL

Mass Rapid Transit System handles large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare collection system meets these requirements. Fare collection technology development is as shown in **Figure 10.1**

FIGURE 10.1:FARE COLLECTION TECHNOLOGY DEVELOPMENT



Keeping in view Metro Railways Automatic Fare Collection System and the fact that Contactless card/ token technology proves to be cheaper than other technologies in life cycle cost due to reduced maintenance as it has less wear and tear and is less prone to dusty environment, it is proposed to provide computer based automatic fare collection system with Contactless smart token/card type ticketing for the Gurgaon Metro.

The equipments for the same may be provided at each station viz. Automatic Fare Gates, Ticket Office Machines, Ticket Readers, Hand held device, Central and Station Computers, Passenger Operated Machines/Ticket Vending Machines (POMs/TVMs) and UPS. The typical AFC System Operation Process and Architecture is shown in **Figure 10.2** & **Figure 10.3** respectively.

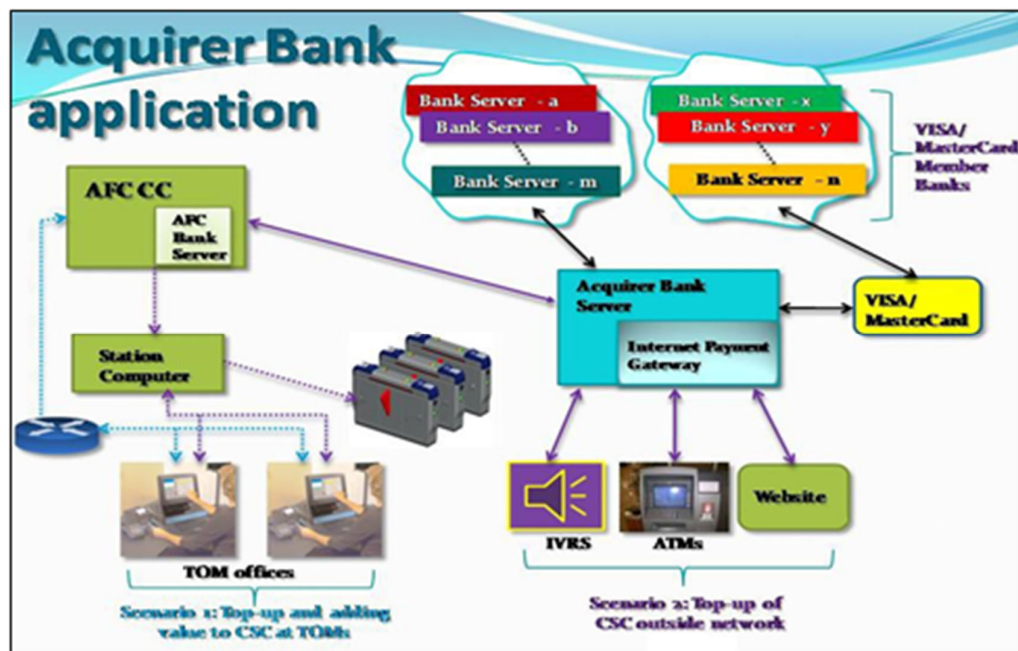
system shall also support offsite sales terminals also, wherein cards and tokens can be dispensed at locations outside MRT premises.

10.2. AUTOMATIC FARE COLLECTION SYSTEM IMPLEMENTATION OPTIONS

A. Bank operator: AFC Ticketing system

Recent developments in the mass transit and financial payments industries have created opportunities for convergence and collaboration. The Banks are thus, too keen to enter into the transit market. In the present dispensation the banks are only acting as a partner to distribute the combo cards. The ownership of card lies with bank, but the transit product on the card is owned by transit operator. Probably we can think of giving preferential treatment to passengers having links with acquirer Bank e.g. separate queue so that we reduce the rush at the counters. Banks will see this as value addition and probably will pay higher royalty. The Banking interface is shown in **Figure 10.4**.

FIGURE 10.4: BANKING INTERFACE



The scope of banks is to provide the following services:

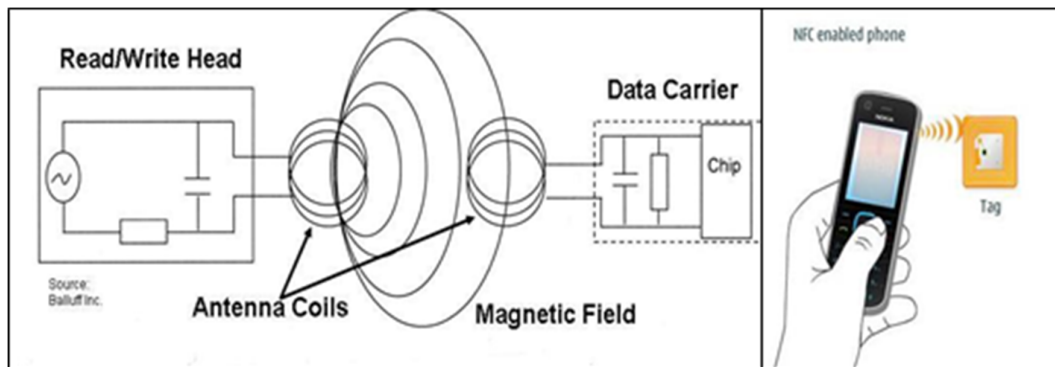
- Providing POS terminals at ticket counters and Automatic Ticket Vending machines
- Topping-up of smart cards at ATMs
- Topping-up of smart cards through Net banking and Mobile banking
- Topping-up of smart cards through Payment gateway at website

- Topping-up of smart cards through Auto-top up using Standing Instructions from Bank customers / commuter.

B. Near Field Communication (NFC)

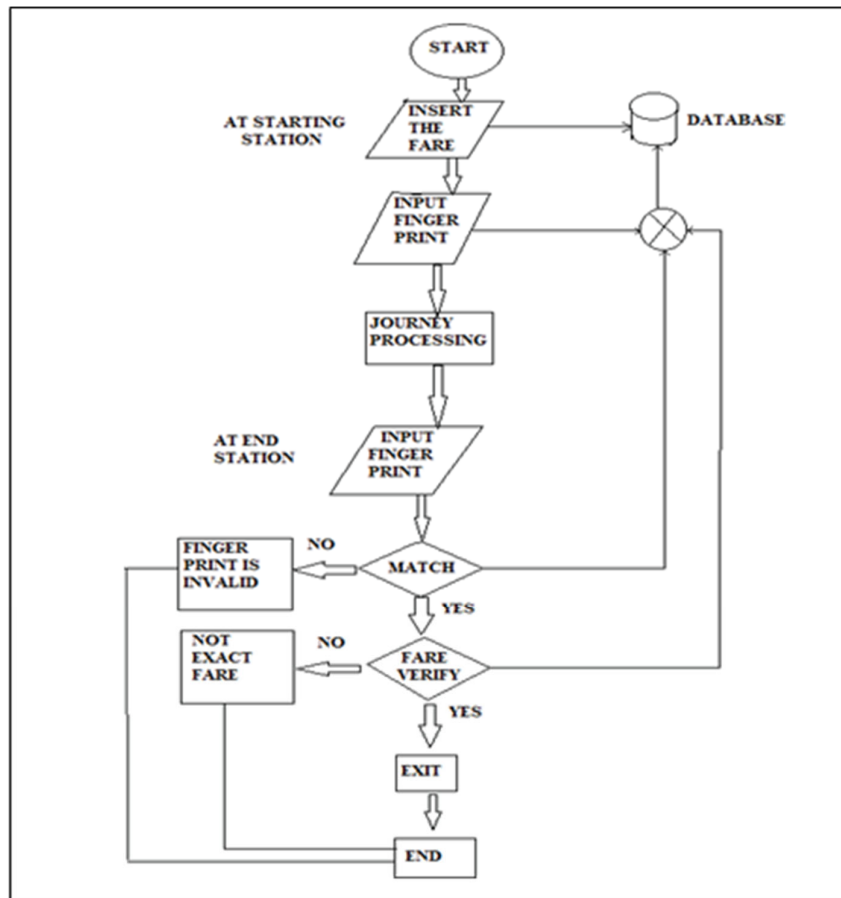
It is a Wireless communication technology based on inductive-coupling, enables data transfer between machines and Uses the concept of Radio Frequency Identification (RFID). RFID is a technology that does communication through radio waves, that exchanges data between an electronic tag put on an object and a reader. NFC works using magnetic induction between two loop antennas located within each other's 'near field' and its operating frequency is 13.56 MHz. data rate 106 kbit/s to 424 kbit/s. NFC use an initiator and a target; the initiator actively generates an RF field that can power a passive target. The near field communication is shown in **Figure 10.5**.

FIGURE 10.5: NEAR FIELD COMMUNICATION



C. Biometric System

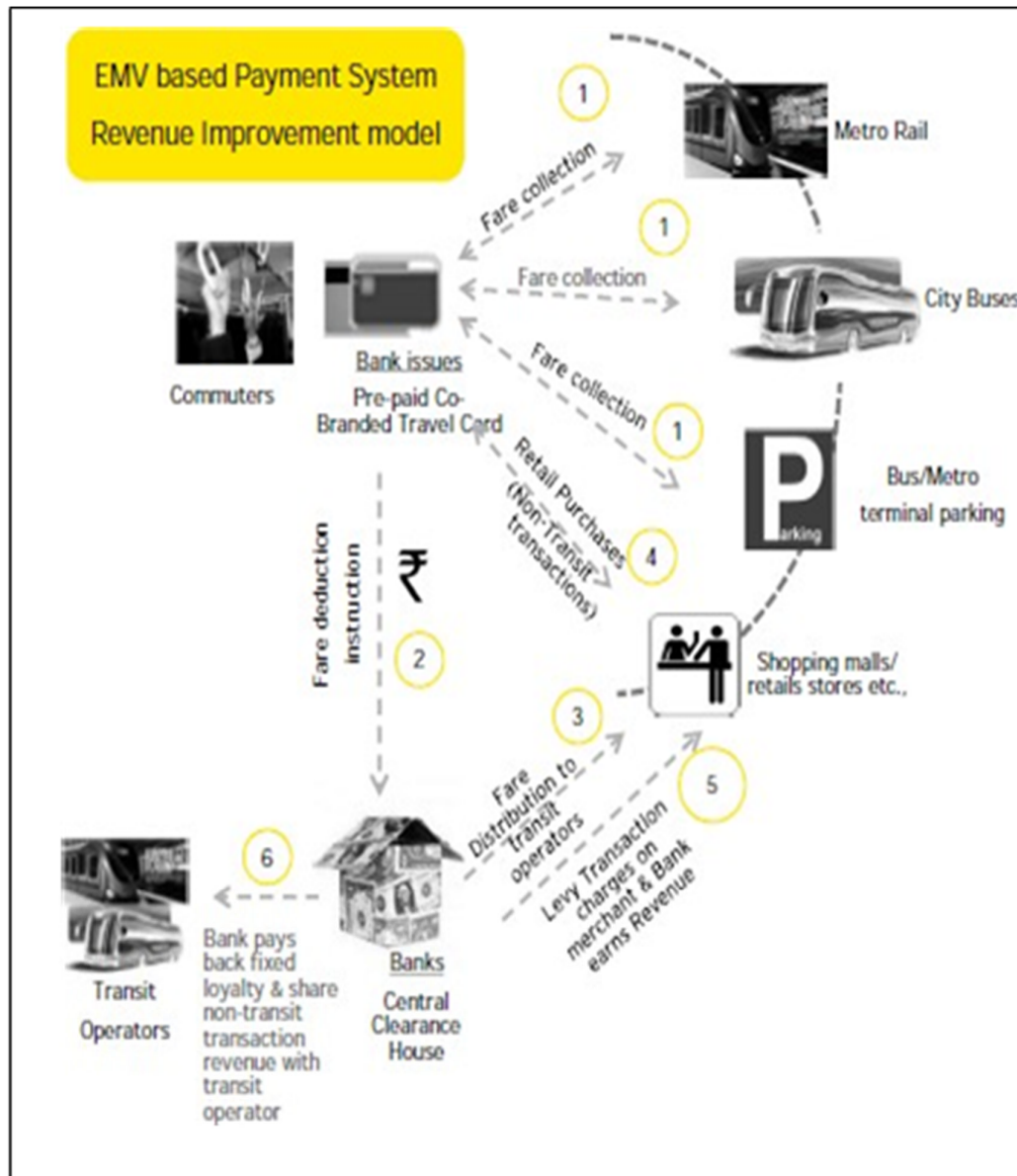
The biometric system may easily be applicable to Railway Ticketing System Management in three ways: First, it takes an image of fingers by the finger print scanner machine. Second, it keeps the image as record in an easily manageable database. Lastly, when the passenger come in front of the biometric gate and touch the finger print, it tries to identify and recognizes the finger print from the previous database. The biometric system flowchart is shown in **Figure 10.6**.

FIGURE 10.6: BIOMETRIC SYSTEM FLOW CHART

D. EMV Open Loop System

An EMV (Europay, Maser and Visa) a global standard is a credit or debit card with an embedded microchip designed to enable secure payment at compatible point of sale (POS) terminals. EMV cards can also support contactless payment through near-field communication (NFC) wireless connectivity. Transit Operator hires one or multiple financial institutions to issue a prepaid EMV enabled travel card to its commuters. The EMV based smart cards can be accepted within network of transit operator's terminals. The transit operators fare acceptance terminals would need EMV enabled card readers. The same card can be used on network of other payment methods at any merchant outlet. Model is convenient for a commuter as Transit Card and acts as an e-Wallet that can be used for all payment needs as single media. The EMV model also aids commuters to gain loyalty points for usage of cards on transit or non-transit network. The EMV based system is shown in **Figure 10.7**.

FIGURE 10.7: EMV BASED PAYMENT SYSTEM

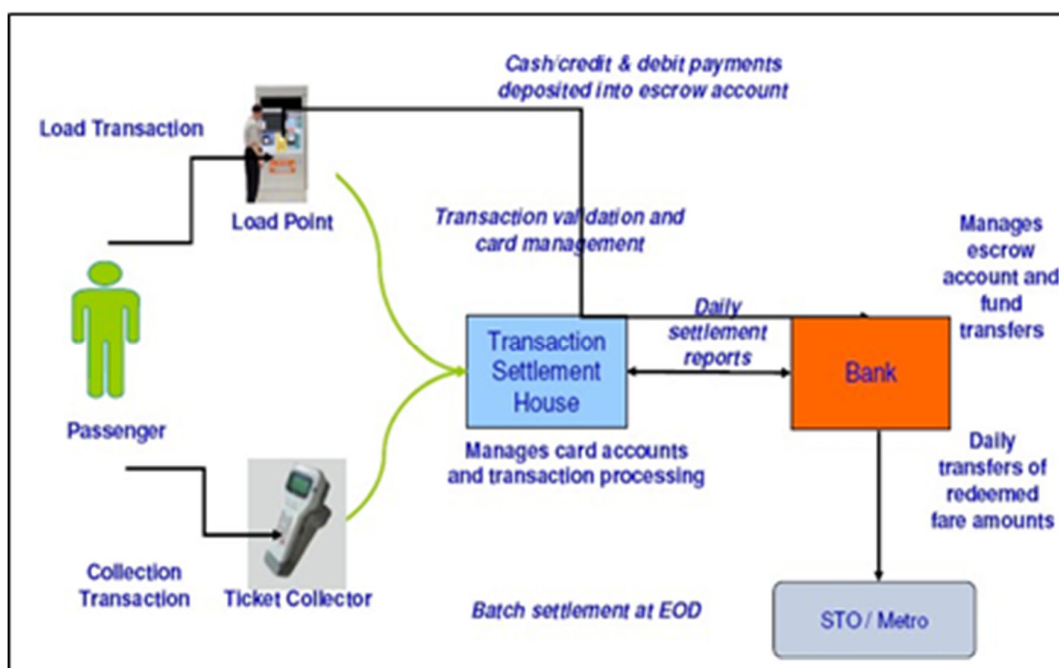


10.3. FARE SYSTEM INTEGRATION WITH OTHER TRANSPORT OPTIONS

Common Mobility Card

Common Mobility Card (CMC) Smart Card will provide Common Fare Collection System across different operators (both Government and Private) and different modes of public transport. Tipped as a nationwide interoperable transport card, the card aims to be a single point of transaction, applicable in state buses, MRT and even parking. The whole system overview is presented in **Figure 10.8**.

FIGURE 10.8: COMMON MOBILITY CARD OVERVIEW



10.4. AFC EQUIPMENT STANDARDS

The standard equipment proposed for AFC system are given in the **Table 10.1**.

Table 10.1: Standards proposed for AFC System

Equipment	Description
Fare media	Contactless smart token – For single journey. It will have stored value amount for a particular journey. Tokens will be captured at the exit gate. Contactless smart card – For multiple journeys.
Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: Entry Exit Reversible – can be set to entry or exit Differently abled – Wide reversible gate for differently abled people.

Equipment	Description
Station computer, Central computer and AFC Net work	All the fare collection equipments will be connected in a local area network with a station server controlling the activities of all the machines. These station servers will be linked to the central computer situated in the operational control centre through the optic fiber communication channels. The centralized control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
Ticket office machine (TOM/EFO)	Manned Ticket office machine may be installed in the stations for issuing EMV CSC, QR based paper tickets, recharge to EMV CSC and validation.
Ticket reader and portable ticket decoder	Ticket reader will be installed near EFO for passengers to check information stored in the token / cards.
Ticket Vending Machine (TVM)	Ticket Vending Machines (TVMS) having facility of issue of single journey tokens & recharge of travel cards using cash, debit/credit cards shall be installed in non-paid areas.
Mobile Application feature	The AFC Provider shall be responsible for developing a mobile application that shall be integrated with AFC system for the purpose of ticketing. Mobile Application that shall be developed by AFC Provider on to offer mobile ticketing services. As part of mobile platform, it should offer various value added services to its commuters like e- Commerce tie-ups, taxi sharing etc.
UPS (uninterrupted power at stations as well as for OCC).	Common UPS of S&T system will be utilized.
Maintenance philosophy	Being fully Contactless system, manpower requirement for maintenance is much less compared to other systems. However, adequate facilities to be provided similar to that of S&T systems.

Chapter – 11

ROLLING STOCK

11. ROLLING STOCK

11.1 ROLLING STOCK

The proposed Metro corridor for Gurugram is being planned having track integration with Rapid Metro. Since, the metro will use existing infrastructure, the rolling stock shall be similar to that of Rapid Metro. Rapid Metro is operational with 3 car trains having 2.8m wide coaches

Following important criteria is proposed for selection of rolling stock:

- Passenger comfort & safety
- Proven equipment with high reliability
- Energy efficiency
- Light weight equipment and coach body
- High rate of acceleration and deceleration
- Optimized scheduled speed
- Flexibility to meet increase in traffic demand
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost

The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems.

11.1.1 The technologies proposed for Gurugram Metro corridor will be similar to Rapid Metro. These technologies are discussed in paragraphs below:

i. Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs which may have to be carried out up to 4-5 times during the service life of these coaches. It is now standard practice to adopt stainless steel or aluminium car bodies. Rapid metro has adopted aluminium coach body. Thus, same is proposed for Huda City Centre to Sector 56 corridor.



ii. Bogies

Bolster less light weight bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000 km. The use of air spring at secondary stage may be considered with a view to

keeps the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. A smooth curving performance with better ride index will be ensured by provision of above type of bogies.

iii. Braking System

The brake system shall consist of –

- An electro-pneumatic (EP) service friction brake
- A fail safe, pneumatic friction emergency brake
- A spring applied air-release parking brake
- An electric regenerative service brake
- Provision of smooth and continuous blending of EP and regenerative braking

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology. The regenerative braking should have air supplement control to bear the load of trailer car.

iv. Propulsion System Technology

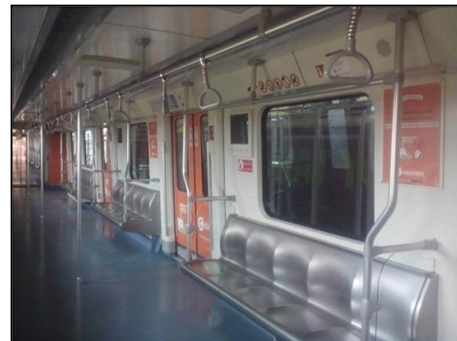
In the field of Electric Rolling Stock, DC series traction motors have been widely used due to its ideal characteristics and good controllability for traction applications. But these traction motors required intensive maintenance because of commutators and electro-mechanical contactors, resistors etc.

The brush less 3 phase induction motors has now replaced the D.C. series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase A.C. drive and VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

For Gurugram Mass Rapid Transit System, three phase AC traction drive with VVVF control is recommended for adoption.

v. Interior and Gang Ways

The passenger capacity of a car is maximized in a Metro System by providing longitudinal seats for seating and utilizing the remaining space for standing passenger. Therefore, all the equipment are mounted on the under frame for maximum space utilization. The gangways are designed to give a wider comfortable standing space during peak hours along with easy and faster passenger movement especially in case of emergency.



vi. Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach may be considered. These doors shall be of such dimensions and location that all the passengers inside the train are able to evacuate within least possible time without conflicting movement. Automatic door closing mechanism is envisaged from consideration of passenger safety.

vii. Air conditioning

With passenger loading of 6 persons/ m² for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, the air conditioning of coaches is considered essential. Each coach shall be provided with two air conditioning units capable of automatically controlling interior temperature throughout the passenger area at all times under varying ambient condition up to full load. For emergency situations such as power failure or both AC failures etc ventilation provision supplied from battery may be made.

viii. Cab Layout

The modern stylish driver panel shall be FRP moulded which give maximum comfort and easy accessibility of different monitoring equipment to the driver along with clear visibility. The driver seat may be provided at the left side of the cabin.

ix. Fire Protection System inside trains

All materials used for the construction of the car shall comply with International standard EN 45545 for fire and smoke. Fresh air intake to saloon area shall have smoke detection system to prevent entry of external smoke to the saloon area. Fire extinguishers shall be provided inside in train for emergency situations.

11.1.2 Broad Features of Rolling Stock

- a) Rolling Stock proposed for the corridor is similar to the Rapid Metro, Gurugram. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed are indicated in **Table 11.1**

TABLE 11.1: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC
2	Train Composition	3 Car: DMC+TC+DMC 6 Car: DMC-TC-MC-MC-TC-DMC
3	Coach construction	Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	750 V DC Third rail

b) Coach Dimensions

The coach dimensions proposed for Gurugram metro corridor are given in **Table 11.2**.

TABLE 11.2: COACH DIMENSIONS

Type of coach	Length	Width	Height
Driving Motor Car (DMC)	19.9 m*	2.8 m	3.88 m
Trailer car (TC)	19.9 m*	2.8 m	3.88 m

*Length Over Couplers

c) Passenger Carrying Capacity

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibule to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 3 persons per square meter of standing floor area in normal state, 6 persons in crush state of peak hour and 8 persons in dense crush state of peak hour.

The train composition is proposed as 3 - Car Train (DMC+TC+DMC). The carrying capacity of Metro Rail Vehicle is indicated in **Table 11.3**.

TABLE 11.3: CARRYING CAPACITY OF METRO RAIL

Description	Driving Motor Car (DMC)			Trailer Car (TC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	30	30	30	30	30	30	90	90	90
Standing	141	212	282	162	243	324	444	667	888
Total	171	242	312	192	273	354	534	757	978

Normal- 4 Per/ Sqm of standee area, **Crush**- 6 Per/ Sqm of standee area, **Dense Crush** – 8 Per/ Sqm of standee area.

d) Weight

The weights of motor cars and trailers are estimated in **Table 11.4**, considering the average passenger weight as 65 kg.

TABLE 11.4: WEIGHT OF MASS RAIL VEHICLES (TONS)

Description	DMC	TC	3 Car
TARE WEIGHT (Max.)	37.69	31.7	107.08
Passenger			
(Normal @ 4p/ m ²)	11.12	12.48	34.71
(Crush @ 6p/ m ²)	15.73	17.75	49.21
(Dense Crush @ 8p/ m ²)	20.28	23.01	63.57
Gross			
(Normal @ 4p/ m ²)	48.81	44.18	141.79
(Crush @ 6p/ m ²)	53.42	49.45	156.29
(Dense Crush @ 8p/ m ²)	57.97	54.71	170.65
Axle Load @ 6p/ m ²	13.36	12.36	
Axle Load @ 8p/ m ²	14.49	13.68	

The axle load @ 6 persons/ m² of standees works out in the range of 12.36T to 14.49T per coach. Heavy rush of passengers with loading @ 8 standees per sq. meter can be experienced occasionally during peak hours. It is recommended to design the coaches with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should therefore be designed for 16 T axle load.

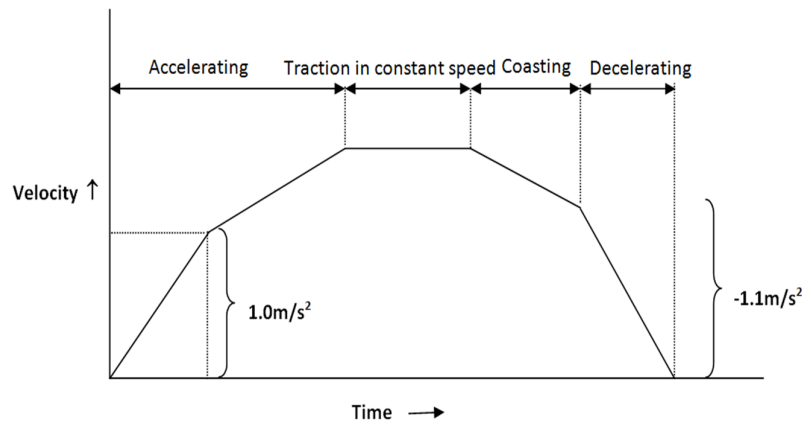
e) Performance Parameters

To achieve the desired schedule speed and running time between stations, the following values of acceleration and deceleration are recommended in consideration of riding comfort, adhesion and requirement of makeup time.

- Max. operating speed :90 kmph
- Max. Acceleration : 1.0 m/s²
- Max. Deceleration : 1.1 m/s² (Normal brake)
More than 1.3 m/s²(Emergency brake)

The velocity time operation curve is shown in **Figure 11.1**

FIGURE 11.1: SIMPLIFIED VELOCITY – TIME OPERATION CURVE



11.2 ROLLING STOCK REQUIREMENT

Rolling Stock requirement for different horizon years has been calculated based on the train operation plan. The calculation for the rake requirement of the corridor for different horizon years has been given in Chapter 8 – Train Operation Plan. The coach requirement for corridor is given in **Table 11.5**:

TABLE 11.5: ROLLING STOCK REQUIREMENT

Year	No. of Coaches
2026	117*
2031	219
2041	273

*Existing Rapid Metro system has total of 12 rakes i.e. 36 Coaches. Accordingly, in the initial year of operation (2026), additional 81 coaches will be required.

Chapter – 12

POWER SUPPLY AND TRACTION

12. POWER SUPPLY & TRACTION

12.1 CHOICE OF ELECTRIC TRACTION

Traditionally, electric traction has been used to meet the requirement of high acceleration, pollution free services and to achieve the optimum performance in urban, Sub-urban and main line rail transport system. Selection of an appropriate technology for traction system may be based on following factors:

Cost of the technology

- Previous experience & proven-ness
- Maintenance requirements
- Energy Efficiency
- Aesthetics, Economic viability & Sustainability

The Cost of traction power system depends upon the following factors:

- Maximum power demand of load
- Level of redundancy & reliability
- Land Cost
- Availability of technology and equipment at Competitive price



There are two standard and proven systems of electric traction for use in metro lines:

- 750 V DC Third Rail System
- 25 KV AC system

The merits and demerits of these systems are discussed below:

- **750 V DC Third Rail System**

750 V DC third rail system is the most primitive traction system which has been extensively used in metros and more than 60% of existing metro systems in the world utilize 600-750V DC third rail system. However, the traffic handling capacity of this system is limited to 60,000 PHPDT.

Kolkata, Bangalore Metro, Rapid Metro in Gurgaon, Kochi Metro and Ahmedabad Metro have 750V DC traction system. Kolkata Metro was built with the primitive technologies i.e. use of Steel third rail with top contact, non-air conditioned rakes with tunnel air conditioning and non-regeneration. New metro projects are using the

advanced technology with Al composite third rail, air conditioned coaches and VVVF control of traction motor with regenerative braking.

750 V DC third rail system offers the best aesthetic solution because of the absence of any overhead conductors and supporting structures. The 750V DC third rail needs very little maintenance since by virtue of its solid rigid design it is able to withstand passing of current collector devices of the train without any significant wear & tear. However maintenance of substation costs more as they are more in numbers.

Because of lower voltage, the 750V DC traction power system handles much higher operating current resulting into higher voltage drop and line losses along the third rail distribution system. This necessitates closer spacing of sub-stations, leading to higher cost of construction. The presence of live third rail at ground may be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.

In a third rail system, where the running rails are used as a return path, a part of the stray current leaks into the track structure. This current is called Stray current. The stray current corrosion is often encountered in dc-electrified systems and therefore, suitable measures are required for protection against corrosion of metallic components in the track-structures as well as metallic reinforcement and metal pipes etc in the vicinity of metro alignment. The civil structure should be compatible with 750V DC third rail traction system in view of mitigation of stray current.

- **25 KV AC System**

25 KV AC traction system has been adopted by Delhi, Jaipur, Chennai, Lucknow, Nagpur and Hyderabad metro rail corporations as well as Indian Railways. The system has the potential to carry large traffic (60,000-100,000) PHPDT and possibility of linking to mainline railways, if required.

In comparison to DC systems, the regeneration capacity for 25 kV AC system is more and the line losses are less. In case of 25kV AC traction, 100% recovery of regenerated energy is possible compared to 60% in case of 750 V DC if no special measures are taken to recover the regenerated energy. Energy saving on account of regenerative braking is about 25-35% of traction energy in case of 25kV AC traction as compared to about 20% in case of 750V DC traction.

Suitable measures are required for mitigation of electro-magnetic interference (EMI) caused by single-phase 25kV AC traction currents. 25kV AC train will require the heavy transformers to be carried in the motor coach which will increase the weight

and hence there will be an increase in the energy consumption. Unlike DC traction this system does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops, as a result, there is substantial reduction in costs. Overall cost of land and equipment's for 25kV ac traction system is significantly lower compared to that for 1500V dc or 750V dc traction system. In addition, it is widely used traction system on Indian Railways with availability of proven indigenous technology for all the components of 25 kV ac systems.



- **Recommendation for Gurgaon Metro Corridor**

The Gurgaon Metro corridor is proposed to be integrated with the existing Rapid Metro Line. In order to ensure the operational continuity, it is necessary that the new Metro corridor is proposed with a system which is similar to that of Rapid Metro. Rapid Metro has been provided with 750 V DC Third Rail Traction system with bottom current collection and track rail return current. Therefore, Gurgaon metro corridor is also proposed with 750 V DC Third Rail System.

12.2 PROJECTED POWER DEMAND

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications.

The power supply system is proposed to be designed for 34309 PHPDT (peak hour peak direction trips) for Huda City Centre to Cyber City and Spur to Dwarka Expressway. The Power supply system design has been conceptualized considering train operation with the combination of 3 car and 6 car rakes at peak period headway of 2.1 minutes during the design year i.e. 2041. The designed system shall ensure high reliability and adequacy of the system to meet unforeseen growth in traffic demand.

The ultimate (design) power requirement for this corridor will be conceptualized considering following norms, directives/ guidelines:

- Train operation with combination of 3 car and 6 car trains
- Peak period headway of 2.1 minutes during the design year

- Specific energy consumption of rolling stock – 75 KWh/ 1000 GTKM
- Regeneration @ 20%
- At grade/ Elev. station load – initially 200 kW, ultimate design 250 kW
- Depot auxiliary load – initially 1000 kW, ultimate design 1500 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, power demand estimation for the corridor is given in **Table 12.1**.

TABLE 12.1: POWER DEMAND ESTIMATION (MVA)

Year	2026	2031	2041
Traction	13.65	25.46	31.42
Auxiliary	8.87	10.27	11.67
Total	22.52	35.73	43.09

The calculations for the traction and auxiliary power demand estimation are shown in **Annexure 12.1**. However, this requirement has been worked out based on the conceptual design and therefore, needs to be reaffirmed and fine-tuned by conducting necessary simulation study during detailed design stage of project implementation.

12.3 SOURCES OF POWER SUPPLY OF POWER SUPPLY

12.3.1 Need for High Reliability of Power Supply

The proposed corridor is being designed to cater to about 34309 passengers per direction during peak hours (PHPDT). Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are already low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

In order to ensure high reliability of power supply, feed from more than one Receiving Substation (RSS) has been planned. Under normal circumstances, each RSS will feed specific section of the corridor. In case of emergency condition i.e. when one RSS fails, the other RSS will feed the section of the RSS under outage. Therefore, it is essential that the sources of supply and connected transmission & distribution

networks are reliable and have adequate built in redundancies.

12.3.2 Sources Of Power Supply

Gurgaon City has 220kV, 66kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridor. Keeping in view of the reliability requirements and considering the complete length of corridors, two receiving Sub-stations are proposed to avail power supply for traction as well as auxiliary services from the Haryana Vidyut Prasaran Nigam Limited (HVPVL) grid sub-stations through cable feeders for the proposed corridor. The Grid Substations which have been identified near the alignment are given in **Table 12.2**

TABLE 12.2 : SOURCES OF POWER SUPPLY

Grid sub-station	RSS of Metro Authority	Approx. Dist. GSS to RSS
Sector 52 GSS (220/66 kV)	Sector 45 RSS (66/33 kV)	03 km
Daulatabad GSS (440/220/66 kV)	Krishna Chowk RSS (66/33 kV)	07 km

The HT power supply from grid substations at 66 kV will be stepped down to 33 KV at each RSS and fed to Traction cum Auxiliary substations located at stations. 33 kV cable will be laid from RSS along viaduct and will consist of two separate networks i.e. Traction network and Auxiliary network. Each network will consist of two cables, each of one having the possibility to be fed from each RSS. The two circuit will loop in – loop out at alternate TSS and ASS. In Traction Substations, the 33 kV power supply will be stepped down and rectified by transformer rectifier set to 750 Volts D.C. and fed to 3rd rail for traction purpose. However, type of rectifier rating of transformer etc. may be firmed up during detailed design stage. The average spacing of traction sub stations is 2~3 Km.

The Auxiliary substations (ASSs) are proposed to be provided at every station to meet the station auxiliary load requirements. In the Auxiliary Substations, 33 KV is stepped down to 415 Volts for lighting, Air conditioning and Ventilations, Pumps, Elevators, Escalators, AFC, PSD, Signaling and Telecommunication etc. The entire power supply system & auxiliary power supply system will be monitored and controlled from a centralized Operation Control Center (OCC) using a SCADA system. The summary of expected power demand at various sources is given below in **Table 12.3**.

TABLE 12.3 : POWER DEMAND PROJECTION FOR VARIOUS SOURCES

Name of RSS	Peak Demand – Normal (MVA)			Peak Demand – Emergency (MVA)		
	2026	2031	2041	2026	2031	2041
Sector 45 RSS (Huda City Centre to Basai Village)						
Traction	6.02	10.21	12.50	9.16	16.49	20.29
Auxiliary	4.20	4.87	5.54	8.87	10.27	11.67
Sub – Total	10.22	15.08	18.04	18.03	26.76	31.96
Krishna Chowk RSS (Basai Village to Cyber City)						
Traction	3.14	6.28	7.79	9.16	16.49	20.29
Auxiliary	4.67	5.40	6.13	8.87	10.27	11.67
Sub – Total	7.81	11.67	13.91	18.03	26.76	31.96

In normal conditions, Sector 45 RSS will feed the section from Huda City Centre to Basai Village and Krishna Chowk RSS will feed from Basai Village to Cyber City. In case Sector 45 RSS fails, the feed can be extended from Krishna Chowk RSS. In case of failure of Krishna Chowk RSS, then Sector 45 RSS will feed from Huda City Centre to Cyber City i.e complete length of the Corridor.

The equipment rating of the RSS cum TSS will be determined considering the normal as well as emergency situation. When one RSS fails, the traction supply will be maintained by extending feed from adjoining RSS. However, in case of total grid failure, all trains may come to a halt but emergency lighting, fire, hydraulics and other essential services can be catered to by stand-by UPS/ DG sets. Typical receiving sub-station is presented in **Figure 12.1**.

FIGURE 12.1: TYPICAL HIGH VOLTAGE RECEIVING SUB– STATION

Based on emergency demand expected at each RSS (Table 12.3), 2 nos. power transformers of 66/33 kV, 25/31.5 MVA capacity each at Sector 45 RSS and Krishna Chowk RSS are proposed to meet the traction and auxiliary power requirements of the corridor. Indoor type Gas Insulated Substation (GIS), which offers the advantage

of considerable saving in space requirement as well as reduced maintenance, is proposed for each Receiving cum Traction substation. Each of three RSS/ TSS would require land plot of about size 50m x 60m (3000 m²).

FIGURE 12.2: GAS INSULATED SUB-STATION



The existing Rapid Metro corridor is being fed by RSS in maintenance Depot near Sector 54 Station. The existing RSS has two Power Transformers of 66/11 KV rating and 25/31.2MVA capacity. The 11 kV cable is laid along the track to provide the supply to the traction and auxiliary substations located at stations. The existing RSS will take care of the requirements of Rapid Metro corridor. Two additional RSS (as mentioned in **Table 12.2**) are proposed to meet the power demand of the proposed Metro corridor. The possibility of integration of power supply networks of the two systems i.e. the existing rapid metro system and the new Gurgaon metro corridor may be explored at the detailed design stage.

33kV switchgear shall be rated for 1250 A being standard design. 33kV XLPE insulated FRLSOH cable ring network is proposed for Aux. ring main network, which shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations.

The capacities of the equipments have been worked out based on the conceptual design. Therefore, these may be required to be revised and fine-tuned during detailed design stage of project implementation.

12.4 TRACTION POWER SUPPLY

Traction sub-stations (33kV/ 750V DC)

Traction sub-stations (33kV/ 750V DC) (**Figure 12.3**) are required to be set up for feeding 750V DC power supply to the third rail. In order to cater to traction load as per design criteria, it is proposed to provide traction sub-stations (TSS) at an approximate distance of about 2 – 3 Km. The TSS along with Auxiliary Sub-Stations (ASS) will be located at station building itself at mezzanine or platform level inside a room.

As per conceptual design, Traction transformer-rectifier set 33kV/ 292-292 (750V DC) are proposed to be 2 MVA rated capacity with 12 pulse rectification similar to system adopted in BMRCL with overload requirement of 150% for 2 hours with four intermittent equally spaced overloads of 300% for 1 minute, and with one 450% full load peak of 15 seconds duration at the end of 2 hour period. However, type of rectifier rating of transformer etc. may be firmed up during detailed design stage.

Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. 2x2.6 MVA transformer-rectifier set shall be provided in the proposed TSS. One rectifier transformer will be able to meet the power supply demand and the second set will be standby.

The traction transformer-rectifier set shall produce 750V DC nominal output voltage with 12-pulse rectification so as to minimize the ripple content in the output dc voltage. The IEC 60850 and BS EN 50163 international standard envisages the minimum and maximum voltages of 500V and 900V respectively for 750V DC traction system and therefore, the dc equipment shall be capable of giving desired performance in this voltage range.

Each TSS will have IGBT based inverters to convert excess energy during regeneration to AC and this excess energy will be utilized by auxiliary system.

33kV XLPE insulated FRLSOH cable ring network is proposed for Auxiliary ring main network, which shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations.

FIGURE 12.3: TYPICAL TRACTION SUBSTATION

The above capacities of equipments have been worked out based on the conceptual design. Therefore, these may be required to be revised and fine-tuned during detailed design stage of project implementation.

12.5 AUXILIARY POWER ARRANGEMENTS

12.5.1 The auxiliary power will be required for:

- Lights & fans for station
- Service buildings
- Foot over bridges/ Subways.
- Maintenance depots
- Air-conditioning
- Lifts
- Escalators
- Water Supply Pumping stations – for washing, toilets as well as fire protection measures.
- Equipment – Signaling, Telecom Automatic Fare Collection etc.

Auxiliary sub-stations (ASS) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 200 kW in the initial years and is likely to reach 250 kW in the horizon year. The average load considered for elevated station will have to be fine tuned to suit station requirement during detailed design stage.

FIGURE 12.4: TYPICAL INDOOR AUXILIARY SUB-STATION

Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 400 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. Apart from stations, separate ASS is required at each depot with 2x1500 kVA auxiliary transformers to cater to depot load.

12.5.2 E&M Systems

a) LT Power Distribution

33 kV ring main cables running all along the route shall feed each ASS by loop in loop out arrangement. The 33 kV power supply is stepped down to 415 V, 3 phase for distribution to the consumption points (service utilities) viz. Elevators, Escalators, Light & power sockets, Fire system, HVAC system and Signal & Telecom system etc.

The power distribution system shall be designed by using low voltage power cable run on the cable tray, raceway and conduit as suitable to supply power to various loads within station and buildings. The low voltage power distribution cables shall comply with IEC 60502 or other applicable international standard. Fire resistant cables shall be used for safety purpose and comply with the performance requirements of IEC60331 and BS 6387.

b) Illumination System

For Illumination generally, all lighting fixtures shall be applied with 240V, single phase 50Hz power supply. The type and quality of fittings and their luminous intensity shall relate to the space being illuminated and will take into account the effect of architectural space concept and colour scheme as per IS 3646.

The LED lights offer advantages over conventional fluorescent lighting on account of Energy savings, lower life cycle cost, longer life span, rugged nature etc. Considering the benefits of LED light fixtures over the conventional/ fluorescent fixtures, the use of LED light fixtures is recommended at elevated and underground stations of the corridor and the office buildings of the depot. However, the conventional fluorescent light fittings may be adopted at selected locations wherever payback period for additional cost of LED light is much higher or non availability of efficient and proven LED light fixtures such as Medium/ High Bay lighting of high wattage (250W – 400W) in depot.

c) Lifts and Escalators

Lifts and escalators shall be provided at each station for the convenience of the passengers. The power supply for the operation of lifts and escalators is fed from the Auxiliary substation at each station. The details of lifts and escalators is given in Station planning chapter.

d) Fire Detection and Alarm System

The Fire Detection & Alarm System shall be in conformance to the applicable NFPA standard or Other International Standards & also comply with the codes of practice, standards, regulations and requirements of the Statutory Authorities. The coordination of Fire Detection & Alarm System with the following services should be verified, tested, and validated as a complete system before implementation-

- i. Fire Detection & Alarm System,
- ii. Public Address & Voice Alarm System,
- iii. Emergency Lighting System,
- iv. Conveying Systems (Lifts & Escalators),
- v. HVAC systems (AHUs / fire dampers / staircase pressurization fans / chillers, motorized dampers / exhaust fans etc),
- vi. Fire Fighting Systems (Fire Pumps / Sprinkler Valves),
- vii. Automatic Doors,
- viii. Traction SCADA,
- ix. E&M SCADA,
- x. Rolling Shutters,
- xi. Networking of main fire alarm system, at station to the station control room, and backnet Interface on TCP/IP for third party systems.
- xii. Systems not listed above but that requires interfacing with the Main Fire Alarm System.

e) Fire suppression**• Portable Fire Extinguishers**

The portable fire extinguishers shall be installed at all the stations in compliance with relevant BS EN Codes and codes of practice, standards, regulations & requirements of the Statutory Authorities. All the covered areas should be provided with suitable type of fire extinguishers. In the Concourse and Platform areas Fire Extinguishers shall be provided in a central location inside a suitably sized cabinet of approved construction. The location and design of the extinguisher cabinets provided shall comply fully to the local fire authority requirements.

Extinguishers shall be conspicuously located in positions where they will be readily accessible and immediately available in the event of fire. They shall be located near to room exits, corridors, stairways, lobbies and landings. Extinguishers shall be installed at a height of 1 m above the floor level and shall be placed in a manner such that the extinguisher operating instructions face outward.

• Wet Mains System

The Fire Fighting wet mains system shall be based on BS- 9990: 2006, BS-9999: 2008 & National Building Code. The system shall comprise pipe work, breeching inlets, landing valves, automatic air release valves, fire hose cabinets and fire hose reels etc.

The wet mains system is charged by the Fire pumps set. The fire pump set shall have dual power supply and the system shall be designed to achieve a pressure of 3.5 Bar at the remote fire hydrant point. The system will draw water from the fire water storage tank provided near station building based on the NBC requirements.

• Fire Hose Cabinets

The Fire Hose Cabinets shall be provided as per NBC and fire authority regulations in internal and external public areas of the station.

• Fire Hose Reels

The hose reels shall meet the requirements of BS 5306.1: 2006 & BS EN 671 – 3:2004. Hose-reel shall be provided in such a way that it covers the entire Concourse / Platform areas with suitable number of fire hose cabinets. The hose reels system will be based on direct feed from the Fire Water Wet mains. Hose-reels shall be of the swing-recessed type. Each hose-reel shall be an integral unit consisting of a stop valve, reel, hose, and shut-off assembly. It shall be designed so as to facilitate the swift withdrawal of the hose in any direction with the reel axis horizontal.

- **Gas Flooding System**

Gas Flooding System is proposed to be provided for protection of the equipments in electrical Auxiliary sub-stations and S&T Equipments in Depot Control Centre/ Operational Control Centre. The design of the system shall be in conformance to NFPA standards.

12.5.3 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the RSSs or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 180 kVA at all elevated stations to cater to the following essential services:

- Lift operation
- Essential lighting
- Signaling & telecommunications
- Firefighting system
- Fare Collection system

Silent type of DG sets, which have low noise levels and do not require separate room for installation, are proposed. In addition, UPS with adequate power backup may be installed for the very essential lighting load.

12.6 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fibre cables provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 750V DC switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system. The SCADA system is presented in **Figure 12.5**.

FIGURE 12.5: SCADA SYSTEM

12.7 ELECTROMAGNETIC INTERFERENCE (EMI) & ELECTROMAGNETIC COMPATIBILITY (EMC)

Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc. Two earth conductors – Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with track. All the concrete and metallic structures, structural reinforcement, running rails etc. will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE on the section. Similar arrangements have been adopted on Delhi Metro as well.

Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signalling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/ EMC and Earthing & Bonding plan require to be developed during design stage.

12.8 STRAY CURRENT CORROSION PROTECTION MEASURES

Concept of DC Stray Current Corrosion

In DC traction systems, bulk of return current finds its path back to the traction sub-station via the return circuit i.e. running rails. The running rails are normally insulated to minimize leakage of currents to the track bed. However, due to leaky conditions, some current leakage takes place, which is known as 'stray current'. The current follows the path of least resistance. Return current deviates from its intended path if

the resistance of the unintended path is lower than that of intended path. The stray current may flow through the unintended path of metallic reinforcements of the structure back to the sub-station. It is also possible that part of the stray current may also flow into soil, where it may be picked up by metallic utilities and discharged back to soil and then to near the sub-station.

DC stray currents cause corrosion of metallic structure where it leaves the metal. Pitting and general form of corrosion are most often encountered on dc electrified railways.

Measures for Protection against Stray Current Corrosion

Earthing & bonding and protection against stray current corrosion are inter-related and conflicting issues. Therefore, suitable measures are required to suppress the stray currents as well as the presence of high touch potentials. Safety of personnel is given preference even at a cost of slightly increased stray currents.

Following measures are required to restrict the stray current:-

- i. Decreasing the resistance of rail-return circuit
- ii. Increasing the resistance of rail to ground insulation

Whenever buried pipes and cables are in the vicinity of dc systems, efforts shall be made to ensure that metal parts are kept away as far as practicable to restrict stray current. A minimum distance of 1 meter has been found to be adequate for this purpose.

Generally, three types of earthing arrangements (viz. Earthed System, Floating System & Hybrid Earthing System) are prevalent on metros worldwide for protection against stray current corrosion. Traditionally, earthed system was used by old metros. Hybrid earthing system is being tried on experimental basis on few new metros. Floating system has been extensively used by recent metros. As per the trends world over, floating system (i.e. traction system with floating negative) is proposed which reduces the dc stray current to considerable level. The arrangement shall comply with following latest CENELEC standards:-

- EN 50122-1:- Railway Applications (fixed installations) protective provisions relating to electrical safety & earthing
- EN 50122-2:- Railway Applications (fixed installations) protective provisions against the effects of stray currents caused by dc traction system

12.9 SOLAR ENERGY HARNESSING SYSTEM

12.9.1 Introduction

The solar mission, which is part of the National Action Plan on Climate Change has been set up by Govt. of India to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options.

Considering the futuristic technology and potential for solar power generation, Delhi Metro has recently implemented roof top grid connected solar power systems at selected locations of elevated stations and maintenance depot. Metro Railways under implementation in different cities of the country viz. Jaipur, Lucknow, Nagpur etc. are also exploring the possibilities of harnessing solar photovoltaic energy.

With the downward trend in the cost of harnessing solar energy and appreciation for the need for development of solar power, provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations/ sheds and buildings is proposed for Gurgaon MRTS.

12.9.2 Solar PV Power Generation Potential

The roof top on the elevated stations of Gurgaon Metro corridor and the different sheds and buildings of the depot viz. Stabling, Inspection and Heavy Repair Shed, Administrative Building, Training Centre, DCC/OCC Building etc is proposed to be used for SPV installation at suitable orientation and inclination to optimize the solar energy potential. The roof of the sheds should be south facing to maximize the Solar power generation in depot. The solar power would be used locally to the extent of load in the building and the generation over and above the requirement of the building would be fed into the grid.

The average raw sunshine available which can be harnessed for the power generation depends on the geometrical coordinates of the place. The intensity of solar radiation varies with time of the day. The combined effect of these factors and the additional complication of the wobble of the seasons is that the average raw power of sunshine per square meter of south-facing roof in India is roughly 100 to 120W/m².

Based on the solar radiation intensity in the city of Gurgaon, the peak solar power generation of Gurgaon Metro corridor is expected to be about 50 kWp for the elevated stations and about 500 kWp for the stabling depots.

The power generation depends upon various factors such as the intensity of the solar radiation, the net useable area available on the roof top, the obstructions due to shadow or the shading factor, the orientation of the solar panels, efficiency of the solar cells etc. The solar power generation potential in Gurgaon Metro corridor is required to be reviewed and finalized during detail design stage.

12.10 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O&M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system includes the following energy saving features:

- i. Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.
- ii. Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to overhead conductor to be consumed by nearby trains.
- iii. Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (operation or maintenance hours etc).
- iv. Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.
- v. The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.
- vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc).
- vii. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

Annexure 12.1

Traction and Auxiliary Power Requirement for Gurgaon Metro

(A)	TRACTION LOAD				
(i)	Huda City Centre to Basai Village		2026	2031	2041
1	Average speed (KMPH)	S	34	34	34
2	Headways (Min.)	H	3.5	1.9	1.9
3	Mean distance between two trains (km)		2.0	1.1	1.1
4	Nos of trains per hour (Frequency)	N	17.0	31.0	31.0
5	Specific energy consumption (KWh/Thou GTKM)	SEC	75	75	75
6	Gross tonnage of 3 car rake	T	170.65	170.65	210.27
7	Section Length (km)	D	11.64	11.64	11.64
8	Power factor of load	PF	0.9	0.9	0.9
9	Max. demand on TSS (KW)		5066	9238	11383
10	Energy Saving on the account of Regeneration @20%		1013	1848	2277
11	Net Demand		4053	7391	9106
	Max. demand on TSS in KVA		4503	8212	10118
	Max. demand on TSS in MVA assuming 5 % energy loss and 0.9 pf		4.73	8.62	10.62
(ii)	Basai Village to Sector 56				
1	Average speed (KMPH)	S	34	34	34
2	Headways (Min.)	H	4.3	2.1	2.1
3	Mean distance between two trains (km)		2.4	1.2	1.2
4	Nos of trains per hour (Frequency)	N	14.0	28.0	28.0
5	Specific energy consumption (KWh/Thou GTKM)	SEC	75	75	75
6	Gross tonnage of 3 car rake	T	170.65	170.65	211.6825
7	Section Length - Direction 1 (km)	D1	23.65	23.65	23.65
8	Section Length - Direction 2 (km)	D2	21.96	21.96	21.96
9	Power factor of load	PF	0.9	0.9	0.9
10	Max. demand on TSS (KW)		8172	16344	20273
11	Energy Saving on the account of Regeneration @20%		1634	3269	4055
12	Net Demand		6537	13075	16219
	Max. demand on TSS in KVA		7264	14528	18021
	Max. demand on TSS in MVA assuming 5 % energy loss and 0.9 pf		7.63	15.25	18.92
(iii)	Basai Village to Sector 101 (Spur)				
1	Average speed (KMPH)	S	34	34	34
2	Headways (Min.)	H	20.0	20.0	20.0
3	Mean distance between two trains (km)		11.3	11.3	11.3
4	Nos of trains per hour (Frequency)	N	3.0	3.0	3.0
5	Specific energy consumption (KWh/Thou GTKM)	SEC	75	75	75
6	Gross tonnage of 3 car rake	T	170.65	170.65	170.65
7	Section Length (km)	D	1.78	1.78	1.78

9	Power factor of load	PF	0.9	0.9	0.9
10	Max. demand on TSS (KW)		137	137	137
11	Energy Saving on the account of Regeneration @20%		27	27	27
12	Net Demand		110	110	110
13	Depot Traction Load		1000	1250	1500
14	Total Traction load of the corridor		1110	1360	1610
	Max. demand on TSS in KVA		1233	1511	1788
	Max. demand on TSS in MVA assuming 5 % energy loss and 0.9 pf		1.29	1.59	1.88
(B)	AUXILIARY LOAD				
1	Load of each elevated stations (KW)		200	225	250
2	Nos of at grade/elevated station		27	27	27
3	Load of each U/G stations (KW)		1500	1750	2000
4	Nos of U/G stations		0	0	0
5	Load of shed (KW)		1000	1250	1500
6	Total load of the stations & 2 Depot (KW)		7600	8800	10000
7	Power factor of the load		0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)		8444	9778	11111
	Max. Power demand of stations and Depot (MVA) assuming 5 % energy loss and 0.9 pf		8.87	10.27	11.67
	Total Max. power Demand Traction + Aux. (MVA)		21.44	34.03	41.04
	Net demand (MVA) considering 5% distribution loss		22.52	35.73	43.09

Chapter – 13

VENTILATION AND AIR CONDITIONING SYSTEM FOR RAIL BASED SYSTEM

13. VENTILATION AND AIR CONDITIONING SYSTEM

13.1 ALIGNMENT ANALYSIS AND NEED FOR VENTILATION

The proposed corridor of **Gurgaon** Metro has been planned as completely elevated corridor. The air conditioning and ventilation requirement in the elevated stations of the corridors is mainly for the ancillary spaces such as staff room, equipment rooms etc. It is essential to maintain an acceptable environment for the operating and maintenance personnel, to prolong the life of equipment by proper control of temperature, pressure, and humidity, and to mitigate possible gas accumulation.

13.2 DESIGN PARAMETERS

Gurgaon city experiences four distinct seasons - spring (February - March), summer (April - August), fall/autumn (September - October) and winter (November - January), along with the monsoon season setting in towards the latter half of the summer. Summers are typically hot and humid and winters are cold and foggy. The outside temperature which shall be considered for the design of the air conditioning systems is given below:

Ambient Temperature

Summer: 43.3°C (DB), 23.9°C (WB)

Winter: 7.2°C (DB), 5.0°C (WB)

Inside Conditions: Summer and Monsoon: $23.0 \pm 1^\circ\text{C}$

Fresh Air: As per ASHRAE

13.3 STATION VENTILATION AND AIR CONDITIONING OF ANCILLARY SPACES

13.3.1 Station Air Conditioning

Variable Refrigerant Volume (VRV) system shall be provided for the air conditioning of the rooms inside the station area. The VRV air conditioning system shall consist of modular condensing units connected to multiple indoor units, each having the capability of individual set point control.

Generally, following rooms of the elevated station are provided with the air conditioning units:

- Station control room
- Ticket office
- EFO
- Signal Maintenance room
- Signal Equipment room
- Telecom equipment room
- UPS (S&T) room

Ancillary spaces such as staff room, equipment plant room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/ humidity. Provision of air conditioning systems is essential for the equipment rooms viz. signaling equipment rooms, telecom equipment rooms. The equipments kept inside these rooms are low voltage devices which are temperature sensitive. These are designed to operate normally at some specified temperatures. Therefore, temperature control inside the rooms is required for the reliable and proper functioning of the equipments. Other areas which are required to be air conditioned can be decided as per the consumer specific requirements.

13.3.2 Ventilation Requirements at Elevated Stations

Ventilation shall generally be envisaged for the following rooms

- TSS/ASS Room
- Toilets
- Pump Room
- DG set room
- Battery rooms

Suitable exhaust systems shall be installed in the rooms. Fresh air louvers may be provided in ASS/TSS room for the fresh air intake. Ventilation shall be provided in all the rooms as per the relevant standards. The ventilation requirements i.e. the required number of air changes per hour for different rooms inside the station area shall be in accordance with the ASHRAE standards.

Chapter – 14

MAINTENANCE FACILITIES

14. MAINTENANCE FACILITIES

14.1 DEPOT LOCATION AND APPROACH TO MAINTENANCE

The Maintenance facilities for HUDA City Centre to Sector-56 and Spur to Dwarka Expressway is proposed to be undertaken at existing depot of Rapid Metro at Sector 55, Gurgaon and the new stabling depot at Sector-101 for about 91 rakes of 3 cars and for maintenance and repairs of the rolling stock operational on corridor. The depots have the infrastructure to maintain rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signaling & Telecomm.; Automatic Fare Collection etc.

The following aspects of the depot are covered in the planning of the facilities:

- Conceptual design and layout of Servicing Shed and Workshop to provide maintenance facilities and stabling facilities for Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

14.1.1 Maintenance Philosophy

The outline of maintenance philosophy followed would be as below:

- Typical Maintenance schedules being followed by Bangalore Metro and Delhi Metro have been considered for determining the requirement of lines in depot.
- Unit replacement and to get essential repairs to major equipments done by the OEMs.
- Automation with state-of-the-art machinery to ensure quality and reliability. Labor intensive procedures will be kept to the minimum.
- Maintenance staff shall be given special training to develop high-level skills in their trade to ensure quality and productivity in their performance.
- Adequate facilities for the stabling have been provided at the depot.
- To maintain high degree of cleanliness, Automatic washing plant has been proposed for cleaning of rakes.

14.1.2 Planning of Maintenance Facilities Setup

The Rolling Stock requirements in different horizon years for the proposed corridors are indicated in **Table 14.1**.

TABLE 14.1: RAKE REQUIREMENT FOR DIFFERENT HORIZON YEARS

Corridor	Year	2026	2031	2041
HUDA City Centre to Sec-56	Headway (minute)	4.3	2.1	2.1
	No. of Cars/Train	3	3	3/6
	Rakes Required	36	70	88
	Cars Required	108	210	264
HUDA City Centre to Sector 101	Headway (minute)	20	20	20
	No. of Cars/Train	3	3	3
	Rakes Required	3	3	3
	Cars Required	9	9	9

All the systems and infrastructure on the proposed corridors has been conceptualized considering 3 car trains operating at 4.3 minute headway for HUDA City Center to Sec-56, and 20 minute headway, HUDA City Center to sector 101 Gurgaon in Year 2026.

14.1.3 Rolling Stock Maintenance Needs

➤ Maintenance schedule

Servicing requirements shall be determined from Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;
- Wheels (Re-discing / re-axling is planned at workshop only);
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;
- Batteries;
- Rolling stock air conditioning;
- Brake modules;
- Vehicle doors, windows and internal fittings.

The modern and fully equipped facilities are to be provided that meet these requirements efficiently and in full. In meeting these requirements, it is assumed that the average daily distance travelled by each rolling stock unit is approximately 300 km. The maintenance schedule shown in **Table 14.2** below has been followed for the conceptual design:

TABLE 14.2: PROPOSED MAINTENANCE SCHEDULE

Type of Schedule	Interval	Work content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Internal cleaning / mopping of floor and walls with vacuum cleaner.	Stabling Lines
A Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub - systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
B Service Check	15,000 Km (approx. 45 days)	Detailed inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km (approx. 3.5 years)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km (approx. 7 years)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

14.1.4 Washing needs of Rolling Stock

The Metro trains are maintained to a high degree of cleanliness and therefore needs the maintenance schedule as mentioned in **Table 14.3**.

TABLE 14.3: SCHEDULE OF CLEANING

S. N.	Kind of Inspection	Maintenance Cycle	Time	Maintenance Place
1.	Outside Cleaning (wet washing on automatic washing plant)	3 Days	10 mins	Automatic washing plant of Depot Single Pass
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area, Floor, walls inside/outside and roof Manually)	30 days	3 Hrs	Automatic washing Plant & washing line

14.2 DESIGN OF DEPOT FACILITIES AND DEPOT LAYOUT PLANS

14.2.1 Depot Layout Plans

The rake induction and withdrawal from depot to the open line will have to be so planned that the headway of open line is not affected. For this purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line should be created. The stabling area should be interlocked with the open line so that the induction of train from the stabling can be done without loss of time. The rake washing can be done at automatic coach washing plant provided at the entry of depot i.e. before rake is placed on stabling lines.

The other movements in the depot, viz from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. Emergency re-railing lines have been provided from which emergency rescue vehicles can be dispatched to open line in the event of any emergency. To cater to the peak requirements, all trains would be in the service, only trains under maintenance would be in the shed. However, during the off-peak hour in daytime, approximately half of the trains will be withdrawn from the service. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night. Tower wagon shall be housed inside the Auxiliary workshop cum emergency rerailing building along with the Accident Relief Train.

The Depot layout with facility of minor repair and one line for inspection is provided separately at Sec-101.

The Sec-101 stabling Depot layout plan is placed at **Annexure 14.1** for HUDA City Centre to Sector-56 & Spur to Dwarka expressway.

14.2.2 Infrastructure Facilities Planned at Depot

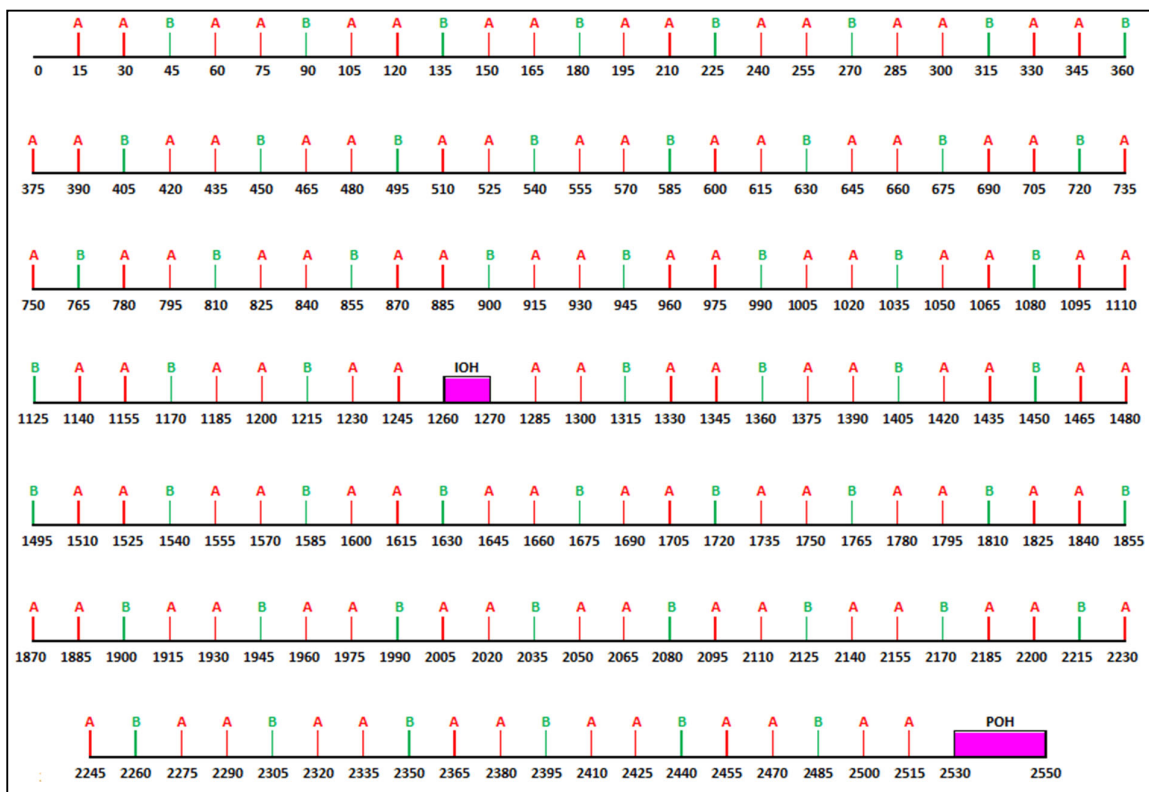
a) Inspection Lines and Workshop Lines in Depot

As per the frequency of inspections as indicated in maintenance schedule (**Table 14.2**), the visits of rakes to Depot are as shown below in **Figure 14.1**.

To assess the number of lines required to maintain the rakes, following assumptions are made:

- i) For Washing of rakes, an automatic washing plant is proposed. Hence, no separate washing line is needed exclusively for washing. However, one line is provided for heavy cleaning (Manual cleaning of Floor, walls inside/outside and roof).
- ii) In a day, two rakes are taken for 'A check' on a pit line.
- iii) In a day, one rake is taken for 'B checks' on a pit line.
- iv) Based on the number of holidays as given below, total numbers of working days are taken as 300 for calculating the requirement of lines.
 - No. of days of Public holidays in a year : 13
 - No. of Sundays in a year : 52
 - No. of available working days in a year : $365 - 65 = 300$ days.

FIGURE 14.1: RAKE VISITS TO DEPOT AND WORKSHOP



As against above requirement, the infrastructure provided for schedule inspection of the rakes is indicated in **Table 14.4**.

TABLE 14.4: INSPECTION AND WORKSHOP LINES PROVIDED FOR CORRIDOR

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising (for 91 rakes)	Line Occupancy	Lines Required (3 car length)	Lines Provided (3 car length)
Inspection Shed						
A Service Check	112	16	1456	2 rakes/ day	2.43	2
B Service Check	54	7.71	701.61	1 rakes/ day	2.34	2
Adjustment line for minor repair/testing after POH						4
Inspection Lines Provided						4
Workshop Shed						
IOH	1	0.14	12.74	1 rake 10 days	0.85	1
POH	1	0.14	12.74	1 rake 20 days	1.70	2
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						1
Workshop Lines Provided						4

Based on the calculations indicated in **Table 14.4**, existing depots of Rapid Metro at Sector 55 and Cyber City, Gurgaon will be used for maintenance of 91 rakes of 3 car. Facility of minor repair and inspection is also provided at the stabling Depot planned at Sec-101.

The depot have the facilities for maintenance/services to complete fleet of rolling stock to meet the requirement of future extensions of the corridor (if any). It will also ensure adequacy of system to meet unforeseen growth of traffic beyond the horizon year.

b) Stabling Facilities for Rakes

The rake requirement for HUDA City Centre to Sec-56 and Spur to Dwarka Expressway is 91 rakes of 3 car for ultimate design year. 28 number 6 car length of stabling lines (each) have been provided at the Depot planned at Sec-101, so as to stable two rakes of 3 car in each line i.e 56 rakes of 3 car. At a given time, two rakes would remain under inspection line. The remaining rakes will be stabled as per the table below.

S. No.	Location of Stabling Line	Stabling Line No.
1	Rapid Metro depot at sec-55 Gurgaon Stabling Line	12
2	Rapid Metro depot at sec-55 Gurgaon Inspection Bay	1
3	Rapid Metro depot at sec-55 Gurgaon workshop Bay	1
4	Rapid Metro at Cyber City Gurgaon stabling	1

S. No.	Location of Stabling Line	Stabling Line No.
5	Rapid Metro at Cyber City Gurgaon Inspection bay	1
6	Rapid Metro at Cyber City Gurgaon workshop bay	1
7	HUDA City Centre Station	2
8	HUDA City Centre Stabling line	4
9	Sector 56 Station	2
10	Sector 56 Station Stabling line	4
11	Sector 101 Station	2
12	Sector 101 Station Stabling line	2
	TOTAL	33

14.2.3 Depot cum Workshop Planning

As per the dimensions of the Rolling Stock, the approximate length of 3-car trains would be 57.8 m (approx). However, in the design of the Inspection shed, workshop lines and stabling lines at depot, length of 3-car train is taken in consideration.

i) Stabling Lines in Depot

For the design of the stabling lines in the depot, following approximate lengths have been taken in consideration:

- Length of one 3-car rake= 57.8 m
- Gap between two 3 car trains= 15m
- Free length at outer end (front end) of the rake (for cross pathway, Signal and Friction buffers)= 5m
- Free length at outer end (rear end) of the rake (for cross pathway, Signal and Friction buffers on front side)= 10m
- Total length of Stabling line = (c)+(a)+(b)+(a)+(d)= 5m + 57.8m+ 15m + 57.8m + 10m = 145.6m say 150m

Considering the car width of 2800 on Standard Gauge, 4.6m Track Centre is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include a pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection.

ii) Inspection Lines in Depot

For the design of the Inspection Bay Lines in the depot, following approximate lengths have been taken in consideration:

- Length of one 3-car rake= 57.8 m (approx)
- Gap between two 3 car trains= 15m
- Cross path at each end = 5 m
- Total length of Inspection line = (c)+(a)+(b)+(a)+(c)= 5+ 57.8+15+57.8+5 = 140.6m say 140m

There would be lighting below rail level to facilitate under frame inspection. Ramps of 1:8 slopes, 3 meter wide have been provided with sunken floor system for movement of material for the cars. Further, 3.5 m cross pathways are left at each end for movement of material by fork lifter/ Leister/ Hand trolley. Stinger system shall be provided for 750V DC traction power supply to the rolling stock. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply is made available on each inspection shed columns. Air-circulators have been provided on each column.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will have arrangement close by for cleaning of HVAC filter under high pressure water jet.

iii) Workshop in depot

The size of the workshop shed in depot is for 3 car rake and an additional covered space have been provided in the depot to cater for offices cum maintenance sections, costly item store, locker room, toilet etc. Following equipment repair/overhaul facilities are planned in the workshop.

- Body furnishing.
- Bogie.
- Wheels.
- Traction Motor
- Axle box and axle bearing
- Battery.
- Air compressor.
- Air conditioning equipments
- Brake equipment.
- Door actuators.
- Control and measuring equipments.
- Pneumatic equipments
- Dampers and Springs
- Couplers/ Gangways



Cross track equipped with bogie turntables have been provided for movement between bays.

iv) Pit Wheel Lathe

A separate building is planned for housing pit wheel lathe (PWL) for Depot which is approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re-profiling of wheels within the depot along with space for depot of scrap. Mobile wheel turning lathe having improved, demand oriented vehicle



maintenance with short rolling stock downtimes and considerably high efficiency in maintenance is proposed to be provided in Depot.

v) Auxiliary Workshop Cum Emergency re-railing Shed

Since the workshop cum depot is designed optimally, it would not be wise to waste its capacity in maintaining the other than passenger Rolling Stock vehicles. Carrying these vehicles to the inspection shed affects the Rolling Stock maintenance as shunting is also involved. Therefore, other vehicles like rail cum road vehicle, tower



wagons, etc. may be housed and given required inspection attention in a separate shed called Auxiliary Workshop Cum Emergency re-railing Shed, for which one line have been provided in the depot. However, for the heavy lifting needs, these vehicles may be taken to main workshop for required attention.

vi) Car Delivery Area

The newly procured coaches, which are transported by road, shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

vii) Automatic Coach Washing Plant (AWP)

Provision has been made for rolling stock exterior surfaces to be washed using a fully automated Train Washing System with a throughput capacity of approximately six

trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided.

viii) Test Track

A test track is provided in depot beside workshop. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

ix) Internal Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

x) Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/information in vogue. These offices should have an attached cycle/scooter/car stand facility for convenience of the train operating staff.

xi) Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

xii) Operation Control Centre and Depot Control Centre

Control of train operation will be done centrally from Operations Control Center (OCC), which will house Traffic Control Centre, SCADA System for Traction Power Control & Monitoring, SCADA System for Auxiliary Power, VAC Control & Monitoring, Telecommunication, CCTV Control & Monitoring etc. Movement of trains inside depot shall be controlled from Depot Control Centre (DCC) located inside the depot.

xiii) Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

- i. Close to the depot entry.
- ii. Close to the stabling lines.
- iii. Close to the Workshop/ IBL.

b) Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

xiv) Watch Towers

There shall be provision of adequate number of watch towers for the vigilance of depot boundary.

xv) Power Supply

An auxiliary substation of 2500 KVA capacity has been planned for catering to the power supply requirement of the depot. Details of connected load, feeder may be worked out during detailed designing stage.

xvi) Standby Power Supply

The standby power supply is proposed through silent DG set of 2X320 KVA adequate capacity to supply all essential loads without over loading.

xvii) Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depot at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

xviii) Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depot for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the underground reserves.

xix) Plant And Machinery

Plant and machinery proposed for the maintenance facilities have been listed in

Annexure- 14.2. Some of the major equipments used in the Maintenance are given in figure below:



Synchronized Pit jack



Mobile Pit jack

SECTOR-101 STABLING DEPOT LAYOUT



Annexure 14.2**LIST OF MAJOR PLANT AND MACHINERY FOR MAINTENANCE**

S. No.	PLANT & MACHINERY	Depot
A.	Material Handling	
	Travelling over head EOT cranes for workshop 15/2T	2
	Travelling over head EOT cranes for workshop 3.2T	2
	Travelling over head EOT cranes for inspection bay 1.5T	2
	Travelling over head EOT cranes for Auxiliary shed 5T	1
	Synchronized pit jacks system for 3 car lifting	1
	Car body stands for keeping 3 car shells	24
	Dummy bogies	3
	Mobile lifting jacks-15T	12
	Mobile lifting jacks 10T	12
	Battery powered locomotive	2
	Road mobile Crane 5T cap	1
	Fork lift truck 3T cap	2
	Fork lift trucks 2T cap	2
	Pallet trucks	2
	TATA Truck	1
	Scissors type lifting trolley - 2T capacity	2
	Hydraulic trolleys - 2T capacity	2
B.	Wheel shop	
	500T wheel press	1
	Vertical boring m/c (Turret Lathe)	1
	Surface Wheel Lathe	1
	Axle turning lathe	1
	Axle UST inspection machine	2
	Radial drill m/c	1
	Induction Heater	2
	Bearing/Coupling Extractor	2
C.	Bogie shop	
	Bogie wash plant	1
	Bogie static load testing m/c	1
	Shock absorber testing m/c	1
	Spring scragging & testing m/c	1
	Magnaflex crack detector	1
	Glowcheck crack detector	1
D.	Rotating m/cs	
	Baking Oven	1
	Dynamic balancing	1
	Traction motor test console	1
	Motor compressor test bench	1
	Tan Delta testing instrument	1
E.	Other m/cs	
	Re-railing equipment	1
	Mobile Wheel Turning Lathe	1

S. No.	PLANT & MACHINERY	Depot
	Chip crusher and conveyor for pit wheel lathe	1
	Automatic Washing plant for Metro cars.	1
	High-pressure washing pump for front and rear end cleaning of	1
	Turn table for one car	1
	Turntable for bogies	2
	Driving Cab Simulator	1
	Painting booth for separate parts	1
	Floor cleaning machine	4
	Welding equipments	2
	Compressor 500Cfm	2
	Stinger system for traction power supply	1
	DG set 320 KVA	3
	Battery charger	2
F.	Machine shop	
	Guillotine Shearing m/c	1
	Shearing, punching & cropping	1
	Universal tool cutter & grinder	1
	Vertical surface grinder	1
	Centre lathe 2m bed	1
	Centre lathe 1m bed	1
	Radial drill m/c	1
G.	Test Benches/Instruments	
	Pneumatic test bench	1
	Brake test bench	2
	SPM test bench	2
	Door test bench	2
	Inverter test bench	1
	Other test benches (MCB, RMPU etc.)	1
	Oscilloscope	1
H.	Furniture/material storage/Small tools	
	Vertical storage system for DCOS store	1
	Computer MMIS with LAN connectivity	1
	Storage racks	LS
	Industrial furniture	LS
	Electric and pneumatic tools	LS
	Measuring and testing equipments	LS
	Tool kits	LS
	Mobile safety steps	10

Chapter – 15

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

15. ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT

15.1. EXISTING SCENARIO

15.1.1. Environmental Baseline

The objective of Environmental Impact Assessment (EIA) is to ascertain the baseline environmental conditions, assess the impacts as a result of the proposed project during various phases of the project cycle and recommend measures to mitigate adverse impacts due to the project. Environment includes water, land, air, ecology, noise and socio – economic issues. The baseline data on above parameters has been collected from desk research, secondary sources and field studies. Primary monitoring of air, water, soil, noise and survey of flora was carried out in the Month of June and November 2018 and August 2019 and socioeconomic survey was carried out in the month of November 2018 and August 2019. A scoping matrix was formulated to identify the attributes likely to be affected due to the development of proposed project and is presented in **TABLE 15.1**

TABLE 15.1: SCOPING MATRIX

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
A. Land Environment	
Construction Phase	Increased soil erosion
	Pollution by construction spoils
	Solid waste from worker colonies, construction sites
B. Water Resources & Water Quality	
Construction Phase	Water quality impacts due to disposal of wastewater from worker camps and construction sites, spoils.
	Depletion of groundwater resources
Operation Phase	Drainage, water requirement, and Disposal of waste water
C. Air Pollution	
Construction Phase	Impacts due to emissions generated by construction machinery
D. Noise Pollution	
Construction Phase	Noise due to operation of various equipment
	Noise due to increased vehicular movement
Operation Phase	Noise from Metro operation
	Noise due to DG sets

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
E. Ecology	
Construction Phase	Removal of vegetation cover/loss of biomass
F. Socio-Economics	
Construction Phase	Improved employment potential during project construction phase
	Development of allied sectors leading to greater employment
	Pressure on existing infrastructure facilities
Operation Phase	Increase in employment opportunities in direct and indirect sectors
	Increased revenue from business development

The general environmental attributes pertaining to the proposed metro project along with parameters to be collected and its frequency are presented in **TABLE 15.2.**

TABLE 15.2: ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

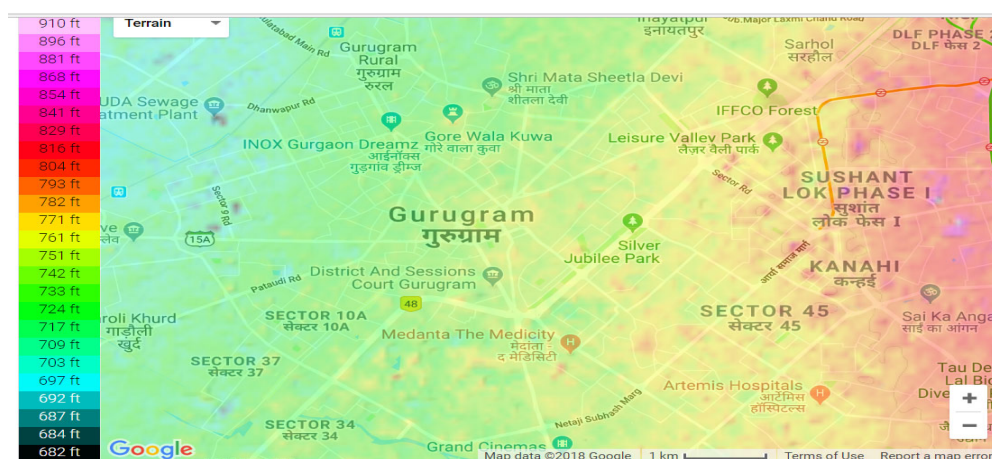
S. NO.	ATTRIBUTE	PARAMETER	FREQUENCY	SOURCE
LAND ENVIRONMENT				
1	Soil	Soil Characteristics	Once	Field studies/ literature review
2	Geology	Geological History	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
4	Water Quality	Physical, Chemical and Biological parameters	One Season	Field studies/ literature review
AMBIENT ENVIRONMENT				
5	Ambient Air Quality	PM _{2.5} , PM ₁₀ , SO ₂ , NO ₂ , CO, HC, O ₃ , Pb, and NH ₃	24hr for two days in one Season	Field Studies
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Last five Year/Available	India Meteorological Department/ literature review
7	Noise	Noise levels in dB (A)	24hrfor two days in one Season	Field studies
SOCIO-ECONOMIC				
9	Socio-economic aspects	Socio-economic characteristics	Once	Field Studies, Literature review
ECOLOGY				
10	Ecology	Flora & Fauna	Once	Literature and Field observations

15.1.2. Land Environment

The land environment primarily consists of Physiography, soil, geology & minerals, and land use pattern.

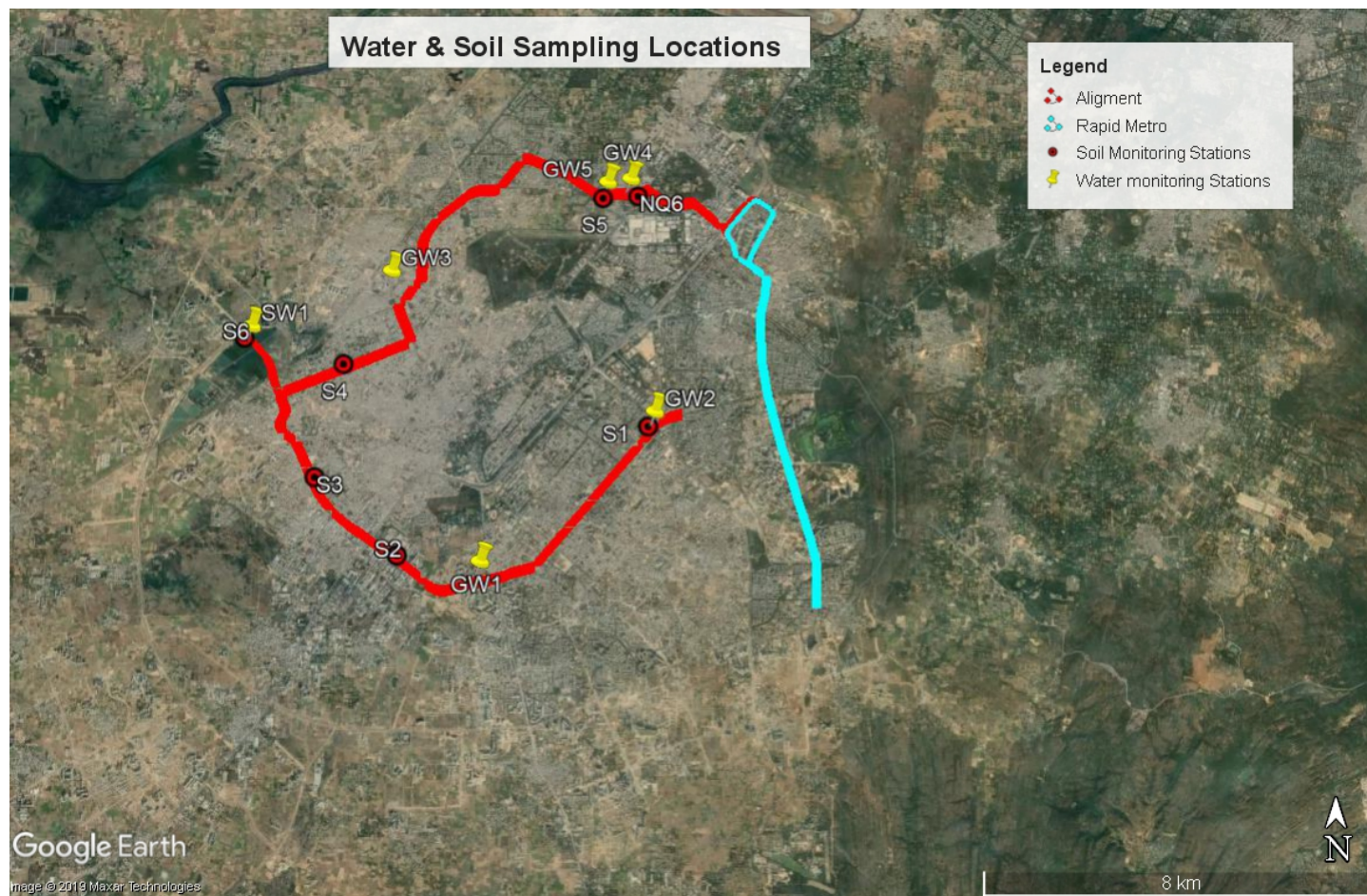
Physiography: The average land elevation is 217 metres (712 ft.) above sea level ranging from 190 m to 280 m. The district comprises of hills on the one hand and depressions on the other, forming irregular and diverse nature of topography. Firojpur-Jhirka-Delhi ridge forms the western boundary and Delhi ridge forms the eastern boundary of the district. The district has a rolling and plain terrain and is interspersed by extensions of Aravalis. Aravali ranges offshoot along the western part of the district and further upto the national capital, Delhi in the north-east. District is divided in two parts in terms of physiography which are Gurgaon plain and Sohna undulating plain with Aravalli offshoots. Gurgaon plain spreads over northern and north western parts of Gurgaon tehsil and whole of Pataudi Tehsil. The region is quite homogeneous to Sahibi plain of Rewari district. Sohna undulating plain with Aravalli offshoots extends over parts of Sohna and Gurgaon tehsils. Due to offshoots of Aravalli ranges, the region is undulating. Topographic map of the study area is given in **FIGURE15.1.**

FIGURE15.1: TOPOGRAPHICAL MAP OF STUDY AREA



Source: Gurgaon Elevation Map

Soil: The soil of the Gurgaon District is classified as tropical and brown soils, stinging in the north western extreme, northern and north eastern parts of the district and water logged and salt affected soils in the southern parts of the district. The soils are medium textured loamy sand is the average texture in Gurgaon and Sohna blocks. In Pataudi and Sohna blocks the organic content of soils is lowest, just up to 0.20 per cent (very low category). In the rest of the district, organic contents are 0.2 to 0.40 percent and falls in low category. Six soil samples were collected along the corridors, location details are provided in **TABLE 15.3** and sampling location map is shown in **FIGURE 15.2.**

FIGURE 15.2: MONITORING LOCATION MAP FOR WATER AND SOIL

Sampling Location - Soil: 1) South City Phase-I 2) Gurgaon Technology Park; 3) Sector-10; 4) Sector-7 5) Tau Devi Lal Smriti Udhyan 6) Basai Depot **Water:** 1) Subhash Chowk 2) South City Phase-I; 3) Bhimgarh kheri; 4) Aggarwal sweets 5) Tau Devi Lal Smriti Udhyan 6) Basai Lake

The laboratory analysis results so obtained are reported in **TABLE 15.4**. The soils are mainly silty in texture. Organic matter content in soils varies from 0.13% to 0.38%. Available phosphorous varies from 8.44-59.37kg/hect. Orthophosphate content varies from 11.59-182.06 mg/kg.

TABLE 15.3: SAMPLING LOCATIONS FOR SOIL

S. No.	Location code	Location name
1.	S1	South City, Phase-I
2.	S2	Gurgaon Technology Park, Infocity-I
3.	S3	Sector-10
4.	S4	Sector -7
5.	S5	Tau Devilal Smriti Udyan
6.	S6	Sector 101 Depot

TABLE 15.4: RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLE

S. No.	Parameter	Unit	S1	S2	S3	S4	S5	S6
1.	pH	-	7.96	7.52	7.37	7.82	7.81	7.52
2.	Chloride	mg/kg	126.23	276.43	108.65	157.98	371.52	1275.05
3.	Available Phosphorous	Kg/hect.	28.78	28.22	59.37	8.44	96.03	117.63
4.	Total Zinc as Zn	mg/kg	41.62	48.39	36.26	34.97	32.85	29.37
5.	Manganese	mg/kg	125.89	256.07	169.90	124.75	284.55	387.26
6.	Total Lead	mg/kg	42.17	42.11	30.64	25.50	27.59	34.71
7.	Total Copper	mg/kg	20.45	24.14	23.18	22.12	BDL	BDL
8.	Organic Carbon	%	0.30	0.15	0.38	0.13	0.28	0.26
9.	Water Soluble Sulphate	mg/kg	88.54	50.90	82.21	140.00	102.55	153.41
10.	Boron	mg/kg	1.12	1.26	1.35	1.56	0.43	1.16
11.	Iron	mg/kg	1042.4	1068.1	1164.5	1254.6	1,552.88	1691.39
12.	Nickel	mg/kg	BDL	BDL	BDL	BDL	64.10	91.59
13.	Bicarbonates	mg/kg	238.75	325.53	162.44	320.43	2729.73	1676.37
14.	Calcium	mg/kg	90.82	127.98	66.05	132.10	6446.87	4977.65
15.	Magnesium	mg/kg	40.08	53.86	23.80	47.59	829.79	2295.48
16.	Sand	%	11.65	4.55	7.37	7.15	24.61	36.94
17.	Silt	%	83.68	85.67	87.45	84.52	61.14	52.36
18.	Clay	%	4.50	9.78	5.46	8.33	14.25	10.7
19.	Sodium	mg/kg	48.94	74.93	49.90	118.89	263.59	13206.60
20.	Potassium	Kg/hect	67.96	78.33	76.01	80.56	592.69	591.66
21.	Sulphur	Kg/hect	66.20	38.06	61.47	104.68	34.18	51.13
22.	Organic matter	%	0.51	0.26	0.61	0.22	0.48	0.45
23.	Orthophosphate	mg/kg	39.40	38.68	182.06	11.59	131.49	161.06
24.	Carbonates	mg/kg	4.62	3.54	4.41	5.52	BDL	BDL
25.	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL
26.	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL
27.	Cadmium as Cd	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL

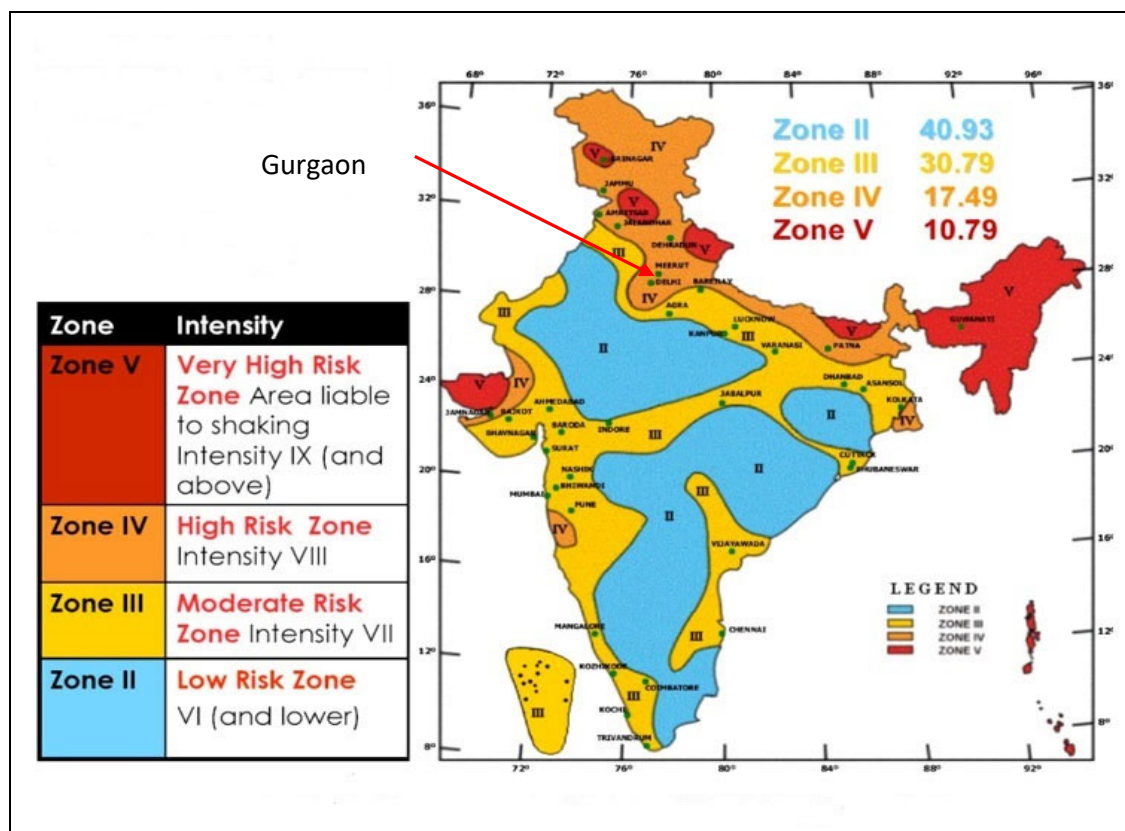
S. No.	Parameter	Unit	S1	S2	S3	S4	S5	S6
28.	Molybdenum	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL
29.	Available nitrogen	Kg/hect	81.53	87.71	87.71	87.71	93.69	150.17
30.	Phosphate	Kg/hect	88.37	86.63	81.28	26.12	294.53	360.77

Geology and Minerals: The Gurgaon district is occupied by quaternary alluvium and pre-cambrian meta-sediments of Delhi Super Group. The alluvium comprises of thick beds of fine to coarse-grained sand with alternating layers of thin clays.

Landuse: The geographical area of Gurgaon is 1,25,400 Ha, out of which agriculture land is 85000 Ha (67.78%), built up area 22567.13 Ha (18%), wasteland 15190 Ha (12.11%), Forest 2381.55Ha (1.90%), water bodies 199.32(0.16%) and others 62 Ha (0.05%). Among all the districts of Haryana Sub-Region, Gurgaon has maximum area under built up area i.e. 18% of the total area of the district which is much higher than any district of the sub-region. It indicates the urbanization and industrialization in the district is maximum. Major crop of the district is wheat and minor crop is bajra.

Seismicity: In the seismic zoning map of India prepared by Bureau of Indian Standards (BIS) the area of Gurgram and its neighborhood lies in Zone IV as shown in **FIGURE 15.3.**

FIGURE 15.3: SEISMIC ZONING MAP OF GURGAON



15.1.3. Water Environment

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the needs of in its various stages of the project cycle and also to assess the impact of the project activities on water environment.

Hydro-geological Characteristics: Quaternary alluvium consisting of sand, clay and silt is the major part of the project district. Sandy layers at various depth form major water bearing horizons above the crystalline basement. In Udyog Vihar and city area the depth of first aquifer varies from 34 to 43 mbgl. However, in industrial area of Manesar top most aquifer can be encountered at 20m. The thickness of sandy layer is limited. The drawdowns are generally high indicating absence of high potential ground water bearing aquifers. The tube wells in the depth range of 45 to 90 mbgl has yield of 129 to 606 lpm. The pre monsoon depth to water level in the district ranges from 3.30 mbgl to 79.70 mbgl. During the post monsoon the water level ranges between 3.05 mbgl to 77.55 mbgl.

Drainage: Because of topographic diversity, the streams do not flow in any uniform direction and there is no perennial river also. The Sahibi Nadi, which rises in the Sewar hills of Jaipur makes its presence in Gurgaon Tehsil before losing itself in the topographic depression of Jhajjar tehsil. Owing to its long passage through arid and sandy areas, the stream flows with strength only during rainy season. The Indori Nadi originates from Aravalli hills in Rajasthan near village Indauri flowing in northern direction. After passing through many villages of the district it joins Sahibi Nadi near Pataudi. Apart from above nadis, Badshahpur, Mehandwari, Kasan, Manesar and Landoha nallah play during heavy rains. To control these nadis/nallahs, 3 bunds are constructed at Indori Nadi and its tributaries in Haryana state and 3 bunds in Rajasthan state and water channelized through drains.

Water Quality: Water quality includes the physical, chemical and biological characteristics of water. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for use.

In order to assess the baseline water quality status of the study area, Six samples along the corridors were collected in the project area. The sample locations from which water sample were collected are shown in **FIGURE 15.2** and description of water sample locations are given in **TABLE 15.5**. The samples were analyzed for physical and chemical constituents for the purpose of domestic and irrigation use. The results of water analysis are compared with CPHEEO manual for Drinking Water Specifications and IS 10500-2012. The results of analysis are presented in **TABLE 15.6**.

TABLE 15.5: DESCRIPTION OF WATER QUALITY MONITORING LOCATIONS

S. No.	Location No.	Location	Type
1	GW1	Subhash Chowk (Near Prachin Mata Mandir)	Ground Water (Bore well)
2	GW2	South City phase –I (Near Red light)	Ground Water (Bore well)
3	GW3	Bhimgarh kheri (Near railway station)	Ground Water
4	GW4	Agarwal sweets (Near railway station)	Ground water (Bore well)
5	GW5	Tau Devilal Smriti Udyan	Ground Water
6	SW1	Basai Lake	Surface Water

TABLE 15.6: PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES IN PROJECT AREA

S. No.	Parameters	GW1	GW2	GW3	GW4	GW5	SW1	Detection limit	Acceptable/ Permissible Limit*
1.	pH at 25°C	7.80	8.25	8.10	8.19	8.21	9.16	-	6.5-8.5/NR**
2.	Turbidity, NTU	<0.1	<0.1	<0.1	<0.1	<0.1	62.2	-	1.0/5.0 Max.
3.	Total Dissolved Solids, mg/l	698	345.0	1488.0	215.0	430	2390	-	500/2000 max
4.	Aluminium as Al, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.01	0.03/0.2 max
5.	Free Ammonia (as NH ₃), mg/l	>0.1	<0.1	>0.1	<0.1	<0.1	>0.1	-	-
6.	Barium (as Ba), mg/l	BDL	0.0032	BDL	BDL	BDL	BDL	0.002	0.7 max/ NR
7.	Boron (as B), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.02	0.5/1.0 Max
8.	Calcium as Ca, mg/l	77.4	47.6	111.0	30.0	49.1	40.8	-	75/200 Max.
9.	Chloride as Cl, mg/l	82.0	52.1	332.5	17.4	89.3	1013.0	-	250/1000 Max.
10.	Copper as Cu, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.05/1.5 Max.
11.	Fluoride as F, mg/l	<1.0	<1.0	>1.0	<1.0	<1	>1.0	-	1.0/1.5 Max.
12.	Free Residual Chlorine, mg/l	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	-	0.2/1.0 Max.
13.	Iron as Fe, mg/l	BDL	BDL	BDL	BDL	BDL	0.25	0.1	1.0 Max./ NR
14.	Magnesium (as Mg), mg/l	45.8	8.4	91.6	12.1	23.6	87	-	30/100 Max.
15.	Manganese as Mn, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.1/0.3 Max.
16.	Nitrate as NO ₃ , mg/l	12.9	6.7	24.9	BDL	1.7	1.3	1.0	45 Max./ NR
17.	Phenolic Compounds (as C ₆ H ₅ OH), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.001	0.001/0.002 Max.
18.	Selenium (as Se), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.01 Max./ NR
19.	Silver (as Ag), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.01 Max./ NR
20.	Sulphate as SO ₄ , mg/l	31.0	BDL	133.6	38.0	44.2	68.3	5.0	200/400 Max.
21.	Sulphide (as S), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.05	0.05 Max./ NR
22.	Total Alkalinity as CaCO ₃ , mg/l	462.7	323.4	573.3	74.6	125.6	778.9	-	200/600 Max.
23.	Total Hardness as CaCO ₃ , mg/l	381.0	154.0	653.0	124.0	219.0	459	-	200/600 Max.
24.	Zinc as Zn, mg/l	0.21	BDL	BDL	0.039	BDL	0.15	0.02	5/15.0 Max.
25.	Cadmium (as Cd), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.003 Max./ NR

S. No.	Parameters	GW1	GW2	GW3	GW4	GW5	SW1	Detection limit	Acceptable/ Permissible Limit*
26.	Cyanide (as CN), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.02	0.05 Max./ NR
27.	Lead as Pb, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.01 Max./ NR
28.	Mercury (as Hg), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.0002	0.001 Max./ NR
29.	Nickel, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.02 Max./ NR
30.	Total Arsenic as As, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.01 Max./ NR
31.	Total Chromium (as Cr), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	0.05 Max./NR
32.	Total Suspended Solids, mg/l	9.0	7.0	9.0	11.0	6	157	-	-
33.	Vanadium (as V), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.002	-
34.	Ammonical Nitrogen (as N), mg/l	>0.1	<0.1	>0.1	<0.1	<0.1	>0.1	-	0.5 Max./NR
35.	Total Kjeldahl Nitrogen (as N), mg/l	13.5	7.1	25.8	0.06	1.9	6.6	0.03	-
36.	Chromium (as Hexavalent Chromium), mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.1	-
37.	Oil and Grease, mg/l	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	-
38.	Dissolved Oxygen, mg/l	7.0	7.2	6.7	7.3	6.9	5.9	-	-
39.	Chemical Oxygen Demand, mg/l	12.0	8.0	16.0	8.0	8.0	165	-	-
40.	Biochemical Oxygen Demand (3 day 27 °C), mg/l	6.0	4.0	7.0	3.0	3.0	48	-	-
41.	Total Phosphate as P, mg/l	BDL	BDL	BDL	BDL	BDL	3	0.1	-
42.	Dissolved Phosphate (as P), mg/l	BDL	BDL	BDL	BDL	BDL	3	0.1	-
43.	Sodium as Na, mg/l	84.0	82.0	270.0	15.7	58	655	2.0	-
44.	Potassium as K, mg/l	2.5	3.9	8.5	3.2	4.8	53	2.0	-
45.	Nitrate Nitrogen , mg/l	2.9	1.5	5.6	BDL	0.4	0.3	0.2	-
46.	Total Nitrogen, mg/l	13.5	7.1	25.8	0.06	1.9	6.6	0.03	-
47.	Organic Phosphorus, mg/l	BDL	BDL	BDL	BDL	BDL	BDL	0.00001	-
48.	Coliform Count, MPN/100 ml	9	16	6	9	1	>18	-	Shall not be detectable in any 100 ml sample
49.	Fecal Coliform, MPN/100 ml	6	6	3	6	1	>18	-	-
50.	Total Coliform Organism, cfu/100 ml	14	6	9	1	70	24X103	-	-

*(Acceptable limit/Permissible limits as per IS 10500-2012)

The result of water samples analysis indicates that all parameters are within the permissible limit. Coliform was detected, that confirm the human and fecal contamination. Results for location SW1 have been compared with the CPCB surface water quality criteria. Comparing the values of pH, DO, BOD and total coli form with 'Use based classification of surface waters' published by Central Pollution Control Board; it can be seen that the surface water is not fit for any kind of use as specified by CPCB.

15.1.4. Meteorology and Air Environment

Meteorology is an important parameter in environmental impact assessment study. It is responsible for the movement of air and air pollutants. Meteorological data like mean rainfall, relative humidity, maximum & minimum temperature of the Delhi for a period of 2015-2016 are given in **TABLE 15.7 & Table 15.8**. It is depicted from the table that temperature of the district varies from 8.2°C – 40.9°C. May is the hottest month of the year. Temperature decreases appreciably in June but remains steady thereafter till September. Climate becomes cool in the month of December and continues till February.

TABLE 15.7: METEOROLOGICAL DATA (TEMPERATURE & RELATIVE HUMIDITY)

Month	Mean Temperature (Deg. Cent)				Relative Humidity (%)			
	2015		2016		2015		2016	
	Max	Min	Max	Min				
January	17.9	8.2	21.6	9.1	93	69	96	70
February	25.9	12.2	25.7	10.9	87	54	86	49
March	28.2	15.3	31.5	17.3	83	56	76	45
April	34.5	20.9	38	23.4	69	41	46	23
May	40.9	25.8	40.1	26.8	46	29	52	36
June	38.6	26.4	39.5	28.7	63	46	65	47
July	34.7	26	34.5	27.2	79	67	83	75
August	34.6	26.8	34.5	26.8	81	68	83	72
September	36.1	26	35	25.7	69	47	76	57
October	34.4	20.7	34.2	20.6	73	51	72	50
November	28.8	14.6	29.7	12.9	83	60	79	54
December	23	9	27.1	9.4	90	63	93	65

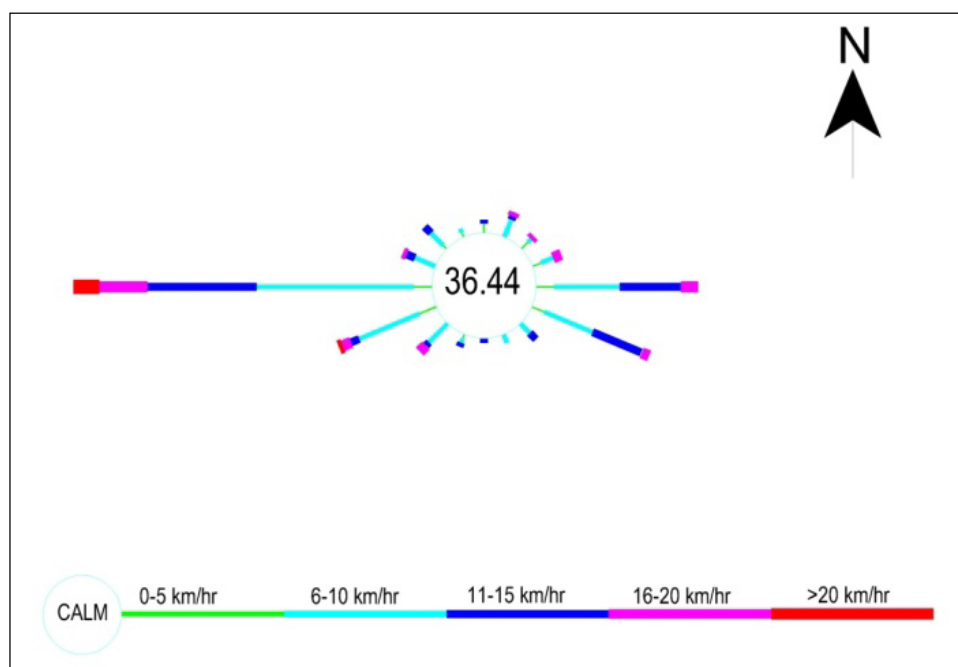
Source: Delhi statistical hand book 2017

The latest rainfall data for the year 2016-2017 is given in **Table 15.8** which depicts the highest rainfall i.e. 292.5 mm in the month of July 2017. During November, December, January Zero rainfall was recorded. Wind-rose diagrams for year 2012 are given in **FIGURE 15.4**. Predominant wind direction is westerly.

TABLE 15.8: AVERAGE RAINFALL (MM)

Month/Year	Rainfall (mm)					
	2015			2016		
	Normal rainfall	Rainy days	Total Rainfall	Normal rainfall	Rainy days	Total Rainfall
January	21.7	4	24.1	21.7	0	0
February	18	0	1.8	18	0	1.3
March	15.9	6	97.4	15.9	3	32
April	12.2	2	27.7	12.2	0	0
May	19.7	0	3.1	19.7	4	24.3
June	65.5	4	61.7	65.5	3	34.5
July	210.6	10	235.2	210.6	15	292.5
August	247.7	9	181.6	247.7	10	122.7
September	125.1	1	22	125.1	3	75
October	28	0	0.4	28	0	2
November	5.6	0	1.1	5.6	0	0
December	9	0	0	9	0	0

Source: Delhi statistical hand book 2017

FIGURE 15.4: WIND ROSE DIAGRAM

Air Quality: Six monitoring stations selected at strategic locations along the corridors are given in **TABLE 15.9**. The monitoring result for ambient air quality is presented in **Table 15.10**. The monitoring stations were selected to generate the representative samples for air quality covering residential, institutional and industrial area along the corridors. Locations map for air monitoring stations are shown in **Figure 15.5**. The

monitoring was done in the month of June and November 2018.

TABLE 15.9: AMBIENT AIR QUALITY MONITORING LOCATION

S. No.	Location Code	Monitoring Location	Coordinates
1.	AAQ1	Near HUDA city metro station	28°27'41.50"N, 77° 4'3.99"E
2.	AAQ2	Near Subhash Chowk	28°25'43"N, 77°2'10"E
3.	AAQ3	Near Pataudi Chowk	28°26'42"N, 76°59'5.7"E
4.	AAQ4	Near Gurgaon Railway Station	28°29'13"N, 77°0'44"E
5.	AAQ5	Near Columbia Asia Hospital	28°30'37"N, 77°2'29"E
6.	AAQ6	Near Sector 22 Chowk	28°30'7"N, 77°4'2"E

FIGURE 15.5: MONITORING LOCATION MAP FOR AIR AND NOISE

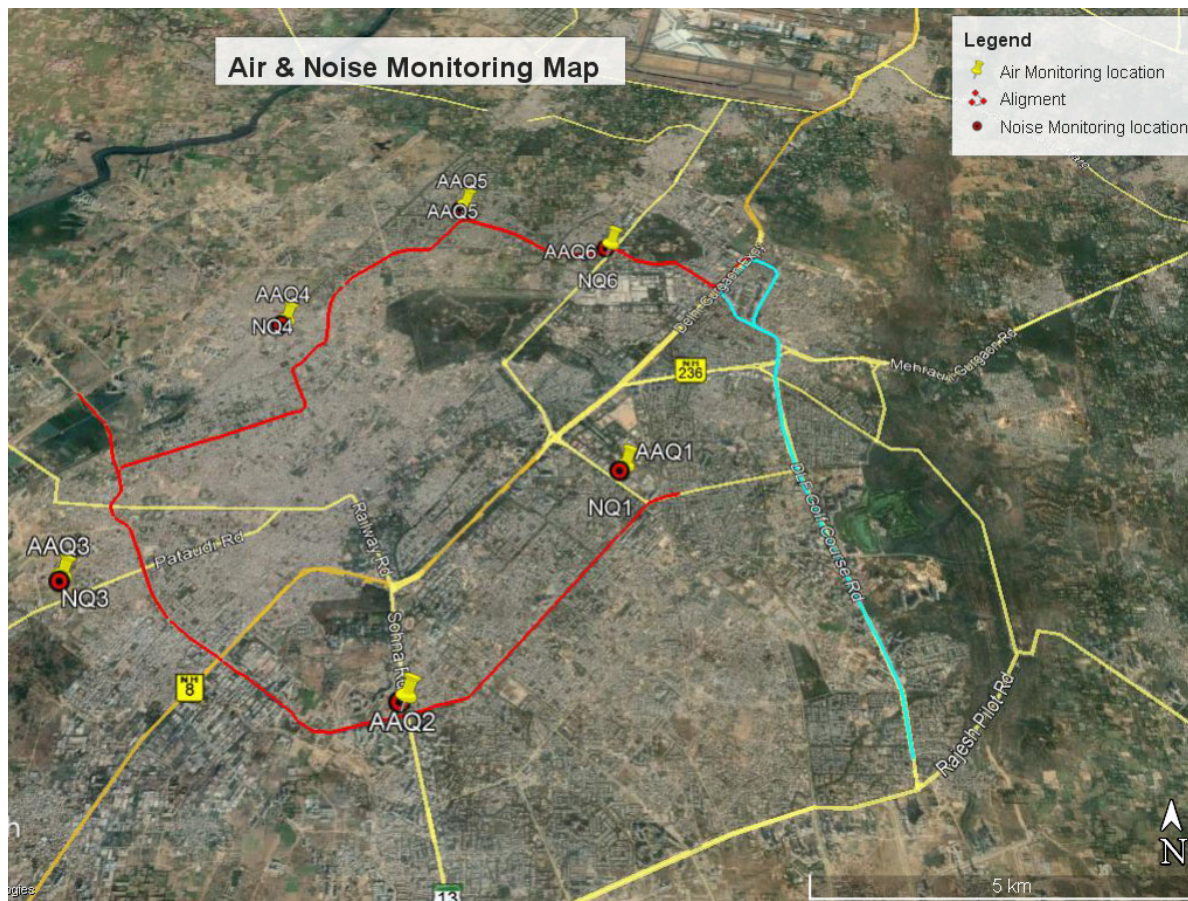


TABLE 15.10: AIR QUALITY RESULT

S. No.	Parameters	Locations	Scheduled	Concentration of Pollution($\mu\text{g}/\text{m}^3$)	CPCB standards $\mu\text{g}/\text{m}^3$
1.	Particulate matter (PM_{10})	AAQ1	A	256.97	100
			B	179.37	
		AAQ2	A	172.49	
			B	112.58	
		AAQ3	A	144.02	
			B	181.42	
		AAQ4	A	129.74	
			B	177.94	
		AAQ5	A	381.44	
			B	216.28	
2.	Particulate Matter ($\text{PM}_{2.5}$)	AAQ1	A	104.17	60
			B	103.33	
		AAQ2	A	95.83	
			B	78.33	
		AAQ3	A	74.56	
			B	96.67	
		AAQ4	A	62.5	
			B	104.17	
		AAQ5	A	174.62	
			B	92.1	
3.	Sulphur Dioxide (SO_2)	AAQ1	A	10.94	80
			B	10.42	
		AAQ2	A	6.14	
			B	8.66	
		AAQ3	A	29.58	
			B	8.33	
		AAQ4	A	9.93	
			B	10.31	
		AAQ5	A	14.04	
			B	6.9	
4.	Nitrogen Dioxide (NO_2)	AAQ1	A	26.62	80
			B	29.88	
		AAQ2	A	23.43	
			B	23.09	
		AAQ3	A	11.83	
			B	25.13	

S. No.	Parameters	Locations	Scheduled	Concentration of Pollution($\mu\text{g}/\text{m}^3$)	CPCB standards $\mu\text{g}/\text{m}^3$
		AAQ4	A	27.76	
			B	28.98	
		AAQ5	A	49.12	
			B	19.07	
		AAQ6	A	46.79	
			B	21.09	
5.	Carbon Monoxide (CO)*	AAQ1	A	0.72	4 [#]
			B	0.87	
		AAQ2	A	0.64	
			B	0.67	
		AAQ3	A	0.83	
			B	0.58	
		AAQ4	A	0.62	
			B	0.66	
		AAQ5	A	1.23	
			B	0.86	
		AAQ6	A	1.21	
			B	0.9	

[#]Co concentration in mg/m^3

PM₁₀ concentration observed during the period ranged from in 129 $\mu\text{g}/\text{m}^3$ to 381.44 $\mu\text{g}/\text{m}^3$. PM_{2.5} concentration ranges from 62.5 $\mu\text{g}/\text{m}^3$ to 154.91 $\mu\text{g}/\text{m}^3$. The result of air quality monitoring compared with National Ambient Air Quality Standard (NAAQS) and found that the PM₁₀ & PM_{2.5} is exceeding the permissible limits at all location. Whereas other parameters like SO₂, NO₂, CO are within the permissible limits.

15.1.5. Noise Environment

The hourly noise monitoring was carried out for two days for 24 hours each at weekday and weekend along the alignment. Noise monitoring locations are given in **TABLE 15.11**. The result was analysed to evaluate Leq, L₁₀, L₅₀, L₉₀, L_{day}, L_{night}, L_{DN}, L_{MAX} and L_{MIN} which are depicted in **TABLE 15.12**. The Ambient Noise Quality criteria laid down by CPCB has been given in **TABLE 15.13**.

TABLE 15.11: NOISE MONITORING LOCATIONS

S. No.	Location Code	Monitoring Location	Coordinates
1	NQ1	Near HUDA City Centre metro station	28°27'41.50"N, 77°4'3.99"E
2	NQ2	Near Subhash Chowk	28°25'43"N, 77°2'10"E
3	NQ3	Near Pataudi Chowk	28°26'42"N, 76°59'5.7"E
4	NQ4	Near Gurgaon Railway Station	28°29'13"N, 77°0'44"E
5	NQ5	Near Columbia Asia Hospital	28°30'37"N, 77°2'29"E
6	NQ6	Near Sector 22 Chowk	28°30'7"N, 77°4'2"E

TABLE 15.12: AMBIENT NOISE LEVEL MONITORING RESULT

Monitoring Location	Schedule #	L _{eq}		L ₁₀	L ₅₀	L ₉₀	L _{max}		L _{min}		L _{day}	L _{night}	L _{DN}
		Day Time*	Night Time*				Day Time	Night Time	Day Time	Night Time			
NQ1	A	67.02	45.07	50.29	66.30	69.20	81.2	64.3	50.0	39.5	68.15	48.36	66.61
	B	75.72	50.35	67.48	74.53	80.01	83.2	67.5	57.3	40.0	76.29	55.35	74.70
NQ2	A	68.25	55.76	64.39	66.55	70.51	79.3	68.9	62.4	31.7	68.66	57.97	68.44
	B	65.01	48.43	50.02	65.45	68.72	69.5	57.5	50.0	38.7	65.13	50.45	64.05
NQ3	A	78.04	65.87	62.09	75.05	83.23	99.8	78.5	60.2	40.1	83.17	66.39	81.84
	B	79.67	69.63	50.79	58.55	88.11	95.2	79.7	50.0	43.2	82.97	83.73	70.90
NQ4	A	74.39	54.55	60.78	72.60	78.62	79.7	69.8	60.0	39.6	74.63	56.81	73.21
	B	71.87	49.18	53.06	66.1	78.11	79.7	64.6	50.0	37.5	72.88	52.82	71.33
NQ5	A	72.28	62.50	55.7	64.7	76.8	79.6	65.8	54.7	40.6	71.19	60.50	72.35
	B	74.39	51.98	60.78	72.6	78.62	79.7	61.5	60.0	39.6	74.63	53.26	73.02
NQ6	A	70.17	52.91	63.8	66.95	72.6	84.3	68.5	63.2	45.2	68.97	50.75	68.79
	B	66.11	51.71	57.99	67.55	69.71	70.3	57.6	50.3	36.2	67.21	51.12	66.40

*Day Time -6AM -10 PM, Night Time- 10 PM-6AM # A- Weekday B- Weekend

TABLE 15.13: AMBIENT NOISE STANDARDS CRITERIA

Area Code	Category of Area	Limits in dB (A) Leq	
		Day time*	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone**	50	40

Source: CPCB guideline (as per The Noise Pollution (Regulation and Control) Rules, 2000)

* Day time is from 6.00 AM to 9.00 PM, **Silence Zone is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts.

The noise level monitoring results are exceeding the permissible limit specified for residential and commercial area.

15.1.6. Ecology

An ecological study is essential to understand the impact due to project development activities on flora and fauna of the area. The project site is located in urban area and no wildlife is envisaged. To have a general understanding of the forest in Haryana & ecology of the within project area, brief information about forest in Haryana is given below.

Forest: The state of Haryana has a recorded forest area of 1,559 km² which constitutes 3.53% of its geographic area. As per legal status Reserve Forest constitutes 15.97%, Protected Forests 74.28% and un-classed Forests 9.75% (FSI, 2009) 5 FSI (2009) State of Forest Report 2009, Ministry of Environment and Forests, Government of India). Most of the roadside plantations in the State have been notified as Protected Forests.

The State has 5 different forest types as per Champion and Seth's classification system (1968), belonging to two type group's viz. Tropical Dry Deciduous and Subtropical Pine Forests. Forestry activities in the state are dispersed over rugged Shivalik Hills in north, Aravalli hills in south, sand dunes in west, wastelands, saline-alkaline lands and waterlogged sites in the central part of the state.

Flora: Trees survey has been conducted along the proposed alignment from HUDA city metro station to cyber city station end. Tree survey was carried out at proposed alignment, depot and station locations. About 1,042 trees have been enumerated along the proposed alignment, depot and station locations. It is expected that these trees are likely to be affected due to construction of proposed project. No rare or endangered species of trees has been noticed during field studies. Tree enumeration in alignment, stations & depot is given in **Table 15.14**.

The type of species observed is Gulmohar (*Delonix regia*), Devils tree (*Alstonia scholaris*), (Pipal) *Ficus religiosa* and Neem (*Azadirachta indica*) etc. No rare or endangered species of trees have been noticed during field studies.

Tree enumeration was carried out along the proposed alignment. Most of the trees exist along the road boundary and median. The predominant tree species along the corridors are Neem (*Azadirachta indica*), Devils tree (*Alstonia scholaris*), Papdi, Shisham (*Dalbergia sisoo*), Shirash (*Albizia lebbek*) along the alignments. List of common trees observed in the study area is given in **Table 15.15**.

TABLE 15.14: TREE ENUMERATION IN ALIGNMENT, STATIONS & DEPOT

S. No	Section & station	Number of trees
1.	Start to Huda City Centre station	2
2.	HUDA City Centre station	2
3.	HUDA City Centre to Sector-45	61

S. No	Section & station	Number of trees
4.	Sector -45 station	15
5.	Sector -45 station to Cyber Park	53
6.	Cyber Park Station	21
7.	Cyber Park Station to District Shopping Centre, Sector-47 station	51
8.	District Shopping Centre, Sector-47 station	6
9.	District Shopping Centre, Sector-47 station to Subhash chowk station	13
10.	Subhash chowk station	13
11.	Subhash chowk station to sector-48	27
12.	Sector-48 station	25
13.	Sector-48 station to Sector-27A	75
14.	Sector-72A	12
15.	Sector-72A to Hero Honda chowk	37
16.	Hero Honda chowk station	4
17.	Hero Honda chowk station to Udyog vihar phase-6	17
18.	Udyog vihar phase-6 station	23
19.	Udyog vihar phase-6 to Sector-10	6
20.	Sector-10 station	5
21.	Sector-10 station to Setor-37	7
22.	Setor-37 station	2
23.	Setor-37 station to Basai village	14
24.	Basai village station	9
25.	Basai village station to Sector-9	20
26.	Sector-9 station	27
27.	Sector-9 station to Sector-7	21
28.	Sector-7 station	10
29.	Sector-7 station to Sector-4 station	10
30.	Sector-4 station	21
31.	Sector-4 station to Sector-5 station	27
32.	Sector-5 station	1
33.	Sector-5 station to Ashok Vihar	54
34.	Ashok Vihar station	1
35.	Ashok Vihar station to Sector-3	0
36.	Sector-3 station	15
37.	Sector-3 station to Bajghera Road	0
38.	Bajghera Road station	12
39.	Bajghera Road station to Palam vihar extension	4
40.	Palam vihar extension station	17
41.	Palam vihar extension to Plam vihar station	10
42.	Plam vihar station	24
43.	Plam vihar station to Sector-23 A	2
44.	Sector-23 A Station	42
45.	Sector-23 A Station to Sector-22 Station	10
46.	Sector-22 Station	29
47.	Sector-22 Station to Udyog Vihar Phase-IV	55
48.	Udyog Vihar Phase-IV	12
49.	Udyog Vihar Phase-IV to Udyog Vihar Phase-V	21

S. No	Section & station	Number of trees
50.	Udyog Vihar Phase-V station	14
51.	Udyog Vihar Phase-V station to Cyber city station	16
52.	Cyber city station	3
53.	Cyber city station to end	26
54.	Connection to Depot	7
55.	Depot - Sector 101	31
Total		1042

TABLE 15.15: LIST OF PREDOMINANT TREE OBSERVED IN THE STUDY AREA

S. No	Botanical name	Common name
1.	<i>Ficus religiosa</i>	Pipal
2.	<i>Ailanthus excelsa</i>	Indian Tree of Heaven
3.	<i>Ficus recemosa</i>	Umbar /Umbar
4.	<i>Eucalyptus sp</i>	Nilgiri /safeda
5.	<i>Pongamia pinnata</i>	Karanj
6.	<i>Albizia lebbeck</i>	Siras
7.	<i>Leucaena leucocephala</i>	Subaool
8.	<i>Alstonia scholaris</i>	Devils tree
9.	<i>Delonix regia</i>	Gulmohar
10.	<i>Dalbergia sisoo</i>	Shisam

Note: - R- Rare, E- Endangered, T-Threatened; **Source:** - Primary field survey

Fauna: The fauna reported in the city are mainly avifauna (highest diversity) followed by mammals. The commonly reported avifauna in the study area during primary survey, with higher diversity are Common crow, Myna, Eagle, Sparrow, Babbler, Pigeon, Drongo, Sparrow, etc. During primary survey no wild mammals are reported in the study area. Based on secondary information like interaction with the local, wild mammals like Indian mongoose and five striped squirrel are reported. List of fauna observed in the study area is given in **Table 15.16**.

Ecological sensitive area: The project site is located in city area. Sultanpur National Park and bird sanctuary is a notified bird sanctuary at a distance of 8.85 km from nearest boundary of proposed project site but Ecological Sensitive Zone (ESZ) of Sultanpur bird sanctuary is 5km.

TABLE 15.16: DETAILED STATUS OF FAUNA RECORDED IN STUDY AREA

S. No.	Zoological name	Local name	Schedule as per WPA 1972	IUCN Status
Birds				
1.	<i>Corvus splendens</i>	House crow	IV	LC
2.	<i>Columba livia domestica</i>	Pigeon	IV	LC
3.	<i>Acridotheres tristis</i>	Indian mynah	IV	LC
4.	<i>Gyps bengalensis</i>	White-rumped Vulture	Sch I (Part III)	CE
5.	<i>Sarcogyps calvus</i>	Red-headed Vulture	Sch I	CE

S. No.	Zoological name	Local name	Schedule as per WPA 1972	IUCN Status
6.	<i>Neophron percnopterus</i>	Egyptian Vulture	Sch I	EN
7.	<i>Aquila nipalensis</i>	Steppe eagle	Sch I	EN
8.	<i>Sterna acuticauda</i>	Black-bellied tern	Sch I	EN
9.	<i>Clanga clanga</i>	Great Spotted Eagle	Sch I	VU
10.	<i>Aquila heliaca</i>	Eastern Imperial Eagle	Sch I	VU
11.	<i>Clanga hastata</i>	Indian spotted Eagle	Sch I	VU
12.	<i>Grus antigone</i>	Sarus Crane	IV	VU
13.	<i>Marmaronetta angustirostris</i>	Marbled Teal	Sch I	VU
14.	<i>Aythya ferina</i>	Common Pochard	Sch I	VU
15.	<i>Ciconia episcopus</i>	Woolly-necked stork	IV	VU
16.	<i>Psittacula eupatria</i>	Alexandrine parakeet	Sch I	NT
17.	<i>Limnodromus semipalmatus</i>	Asian dowitcher	Sch I	NT
18.	<i>Threskiornis melanocephalus</i>	Black-headed ibis	Sch IV	NT
19.	<i>Ephippiorhynchus asiaticus</i>	Black-necked stork	Sch IV	NT
20.	<i>Limosa limosa</i>	Black-tailed godwit	Sch IV	NT
21.	<i>Calidris ferruginea</i>	Curlew sandpiper	Sch I	NT
22.	<i>Numenius arquata</i>	Eurasian curlew	Sch I	NT
23.	<i>Coracias garrulus</i>	European roller	Sch I	NT
24.	<i>Aythya nyroca</i>	Ferruginous duck	Sch I	NT
25.	<i>Phoeniconaias minor</i>	Lesser flamingo	Sch IV	NT
26.	<i>Vanellus vanellus</i>	Northern lapwing	Sch I	NT
27.	<i>Anhinga melanogaster</i>	Oriental darter	Sch IV	NT
28.	<i>Mycteria leucocephala</i>	Painted stork	Sch IV	NT
29.	<i>Circus macrourus</i>	Pallid harrier	Sch IV	NT
30.	<i>Falco chicquera</i>	Red-necked falcon	Sch I	NT
31.	<i>Vanellus duvaucelii</i>	River lapwing	Sch I	NT
32.	<i>Sterna aurantia</i>	River tern	Sch I	NT
Reptiles				
1.	<i>Calotesvescicolor</i>	Common garden lizard	Sch IV	LC
2.	<i>Ptyas mucosa</i>	Rat snake	Sch II	LC
Mammals				
1.	<i>Funambulus palmarum</i>	Squirrel	IV	LC
2.	<i>Mus musculus</i>	Mouse	V	LC

CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC-Least count

Depot: One stabling depot is located near Sector-101. The area required is 5.50 ha.

Ecology of Depot: Depot in Sec-101 is in a low lying area. A luxuriant growth of water-hyacinth (*Eichhornia crassipes*) is recorded from depot site.

15.1.7. Archaeological Sites

No archaeological monuments/sites are located on or along the proposed corridor.

15.2. ENVIRONMENTAL NORMS AND REGULATIONS

The following laws and norms are relevant to this project:

- EIA Notification 2006 with Amendment
- Environment (Protection) Act, 1986
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules 2003 and Forest (Conservation) Amendment Rules, 2014
- Punjab Land Preservation Act, 1990
- The Indian Wild Life (Protection) Act 1972 and The Wildlife (Protection) Amendment Act 2002
- The Air (Prevention and Control of Pollution) Act 1981, amended 1987.
- The Air (Prevention and Control of Pollution) (Union Territories) Rules 1982, 1983 (Consent to establish and operate)
- The Water (Prevention and Control of Pollution) Rules 1975 (Consent to establish and operate)
- National Ambient Air Quality Standards November 2009
- The Water (Prevention and Control of Pollution) Act 1974 & its amendment
- Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012
- Noise Pollution (Regulation and Control) Rules, 2000 amendment in 2010
- Solid Waste Management Rules , 2016 & Its amendment
- Construction and Demolition Waste Management Rules , 2016 & its amendment
- Hazardous and Other Wastes (Management and Tran boundary Movement) Rules ,2016 & its amendment
- Plastic Waste Management Rules, 2016 & its amendment.
- E-Waste (Management) Rules, 2016.
- The Ancient Monuments and Archaeological sites and Remains (Amendment and Validation Act) 2010 with Ancient Monuments and Archaeological Sites and Remains (Amendment) Bill, 2017.
- Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015
- The Metro Railways (Operation and Maintenance) Act 2002 as amended vide The Metro Railways (Amendment) Act 2009 (disaster management)
- Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013(RTFCTLARR Act).

15.3. DETAILED ENVIRONMENT IMPACT ASSESSMENT

15.3.1. Positive Environmental Impacts

Based on project particulars and existing environmental conditions, positive potential impacts have been identified that are likely to result from the proposed metro project and where feasible within the scope of this report these are quantified. The positive environmental impacts are listed below:

- Employment opportunities
- Benefits to economy
- Traffic congestion reduction, quick service and safety
- Traffic Noise Reduction
- Reduction of Traffic on Road
- Less Fuel consumption
- Reduced Air pollution

1. Employment Opportunities

The civil works of the project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. During peak construction phase about 1,015 local labours will be employed. In post-construction phase, people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment. In addition to these, more people would be indirectly employed for allied activities.

2. Benefits to Economy

The project will streamline and facilitate movement of public from different parts of Gurgaon. These corridors will yield saving due to reduction in road traffic and reduction in number of buses, usage of private vehicles. Reduction in fuel consumption, vehicle operating cost and travel time of passengers was observed. It is likely that trade, commerce and allied services will benefit from better connectivity.

3. Traffic Noise Reduction

Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively. Introduction of Metro Rail is likely to lead to reduction in road vehicular traffic which ultimately reduces noise level.

4. Reduction of Traffic on Road

The reduction in number of road vehicles due to shift of ridership from road to Metro gives benefits to economy by reduction in Vehicle Operating Cost (VOC), Fuel Consumption, Pollution Load, Accidents and Travel Time etc. On implementation of the project, the consumption of petrol, diesel and CNG will get reduced. The estimated number of vehicle trips that will be reduced due to construction of Gurgaon Metro are given in **TABLE 15.17**.

TABLE 15.17: REDUCTION IN DAILY VEHICLE TRIPS

S. No	Mode	Daily Vehicle TRIPS Reduced due to Metro in Horizon years			
		2026	2031	2041	2051
1	Car	307532	505447	603564	720726
2	2W	1406472	2311624	2760351	3296184
3	Auto	868452	1427355	1704430	2035290
4	Bus	753287	1238074	1478406	1765391

5. Reduced Fuel Consumption

Based on number of vehicle kilometre reduction, reduction in fuel (diesel and petrol) consumption is reported in **TABLE 15.18**. The saving of Diesel and Petrol will directly benefit the country in monetary terms. Net saving on fuel expenditure at current price level is given in Table 5.19.

TABLE 15.18: FUEL SAVED PER YEAR

Year	Diesel (Lakh litre)	Petrol (Lakh litre)	CNG (Kg/yr)
2026	0.98	2.31	1.04
2031	1.13	2.67	1.20
2041	1.38	3.26	1.46
2051	1.68	3.97	1.79

TABLE 15.19: SAVING IN FUEL EXPENDITURE PER YEAR (RS. Lakh)

Year	2026	2031	2041	2051
Diesel	64.39	74.56	90.94	110.9
Petrol	169.20	195.93	238.99	291.4
CNG	60.65	70.18	85.60	104.4

6. Reduced Ambient Air Pollution

Compared to other modes of transport, the metro is least polluting and can be classified as an environment friendly technology since no air emissions are involved in running and operating the metro trains. The major vehicular pollutants that define the ambient air quality are: Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons and Carbon dioxide. In addition to the above pollution, un-burnt products like aldehydes, formaldehydes, acrole in, acetaldehyde and smoke are by products of vehicular emissions. The reduction of air pollutants with the present corridors are presented in **TABLE 15.20**.

TABLE 15.20: POLLUTION REDUCTION (TONS/YEAR)

POLLUTANTS	2026	2031	2041	2051
Carbon Monoxide	21.64	25.06	30.56	37.26
Hydro-Carbons	8.29	9.60	11.71	14.27
Nitrogen Oxide	4.35	5.03	6.14	7.48
Particulate Matter	0.69	0.80	0.98	1.19
Carbon Dioxide	904.04	1046.60	1276.57	1556.32
SO ₂	0.05	0.06	0.07	0.09

Cost of Human Health saving from lifecycle emissions of PM_{2.5} and cost of carbon capture from lifecycle emissions of GHG caused by gasoline and diesel is worked out (Climate change and health costs of air emissions from bio-fuels and gasoline, Jason Hill et al, PNAS, 2008) at rate of Rs 5.82 per liter and Rs.6.42 per liter in **TABLE 15.21** for period up to year 2041.

TABLE 15.21: LIFE CYCLE SAVINGS FROM EMISSIONS (Rs. LAKH)

Year	Fuel (Petrol and Diesel) in Lakh Litters	Cost of Human Health (Rs Lakh) saving from lifecycle emissions of PM _{2.5}	Cost of carbon capture (Rs Lakh) savings from lifecycle emissions of GHG
2026	9.29	54.05	59.63
2031	10.75	62.59	69.04
2041	13.12	76.34	84.21
2051	15.99	93.07	102.66

15.3.2. Negative Environmental Impacts

Based on project particulars and existing environmental conditions potential negative impacts likely to result from the proposed development are quantified. Negative impacts are listed under the following headings:

- Impacts due to Project Location
- Impacts due to Project Design
- Impacts due to Construction
- Impacts due to Project Operation
- Impacts due to Depot

1. Impacts due to Project Location

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Displacement and loss of livelihood of Project Affected People (PAPs)
- Change of Land use
- Impact on/loss of wildlife/trees/forest/wetland
- Utility/Drainage Problems
- Impact on archaeological monuments and
- Impact on Local Transport Facilities

a. Displacement and loss of livelihood of Project Affected People (PAPs)

People who have their properties along the alignment will be affected due to the acquisition of land for proposed Gurgaon Metro. Detail of which is given in the section of social impact assessment.

b. Change of Land use

Land will be required permanently for Stations, Depot, Ramp and running section. Both government and private land will be acquired for the project the detail of which is given in the section on Civil Engineering.

c. Loss of Trees

The proposed corridors are in urban/city area and will not pass through any forests. There are approximately 1042 trees along the corridor and depot site. These trees are likely to be felled during construction. Trees are major assets in purifications of urban air, which by utilizing CO₂ from atmosphere, release oxygen into the air. With removal of these trees, the process for CO₂ conversion will get effected and the losses are reported below:

- i) Total number of Trees : 1,042
- ii) Decrease in CO₂ absorption due to loss of trees : 3,126 kg/year
- iii) Decrease in Oxygen production due to tree loss : 11,462 kg/year

d. Utility/Drainage Problems

The proposed Metro corridors are planned to run through the urban area above the ground i.e. elevated. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Plans and cost of such diversions are covered in the section on Civil Engineering.

e. Impact on Archaeological Monuments

No archaeological monuments/sites and heritage assets are located along the corridors.

f. Impact on Local Transport Facilities

The metro rail has been proposed to cater the additional demand of present and future traffic requirement. Hence, no loss of job to the existing transport facilities is anticipated. The drivers of local transport facilities like buses, taxis, autos and rickshaws may be utilized to cater the requirement of transport from metro stations to work place and vice-versa. Additional employment opportunities are also anticipated due to the proposed metro.

2. Impacts due to Project Design

a. Right of Way

Alignment and stations are predominantly elevated, visual intrusion will be experienced. Noise during operation will be higher, elevated stations result in reduced energy consumption compared to underground stations. Stations give rise to accumulation of passengers and likely congestion especially in case commercial development is resorted to.

b. Alignment, Stations, Track design and Architecture

An alignment with less number of curves and radius - which is desirable rather than minimum, optimal station spacing, track with elastic fittings result in decrease in energy consumption, wear & tear and noise & vibration. Elevated metro with sleek structural elements provides aesthetically appealing structures. The spatial design of station has significant impact on safety of passengers, time spent in ingress & egress from station and energy consumption in stations.

c. Inter Modal Integration

Physical and operational integration of metro with other modes especially walk, public transport and intermediate public transport (hired modes) is found to increase ridership and decrease congestion inside and outside the stations.

d. Use of Energy and Water at stations and depots

Consumption of energy for climate control, lighting and other facilities at stations is significantly reduced by proper design of passenger flow inside stations, space & facilities inside stations and multimodal integration facilities outside stations.

e. Risk Due to Natural Hazards

Engineering construction shall be done so as to meet codal provisions. No other natural hazards such as due to climate change are foreseen.

3. Impact Due to Project Construction

The most likely negative impacts related to the construction works are:

- Soil erosion and pollution
- Traffic diversion and risk to existing buildings
- Muck disposal and Debris Disposal
- Dust Generation and Air Pollution
- Increased water demand
- Impact due to labor camp
- Welfare of labor on site
- Safety of labor
- Impact due to Supply of Construction Material

- Impact due to construction near Archaeological Monuments
- Impact on Ground water and Surface water quality
- Noise and Vibration

a. Soil Erosion and Pollution

Minor incidence of soil erosion due to runoff from unprotected excavated areas may result especially when erodibility of soil is high. Land subsidence is anticipated at stations which will be constructed by cut and cover method.

b. Traffic Diversion and Risk to Existing Buildings

During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road. Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction of various corridors under Metro Rail Project network. Such plans and their cost form part of the section on Engineering. As part of pre-construction/construction activities building condition survey will have to be conducted cost of which is not included in EMP.

c. Dust Generation and Air Pollution

Air pollution occurs due to excavation, loading and unloading of construction materials, and emissions from vehicles, construction equipment and DG sets etc. It also occurs at sites of muck disposal, debris disposal and pre-casting yards. Air pollution especially particulates are found to cause diseases of brain, heart, lungs and kidneys.

During the period of construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: CO, HC, NO_x, PM, CO₂ and VOC will be about 23 tons, 0.7 tons, 47 tons, 1 tons, 2945 tons and 0.7 tons respectively. Such transportation is estimated to result in fugitive dust emission of about 6 tonnes during the period of construction.

d. Increased Water Demand

The water demand will increase during construction phase. Water requirement for construction is of the order of 446 KLD.

e. Labour Camp

During construction phase waste water will be generated from the labour camps. Improper disposal of wastewater can pollute the surface water and ground water.

Construction workers are more prone to infectious diseases due lack of sanitation facilities (water supply and human waste disposal) and insect vectors. However; this phenomenon will be temporary and restricted to close vicinity of construction site. During peak construction time 1,015 persons are required to work. Estimated water requirement comes out to be about 71.05 KLD. Quantity of waste water and solid waste generated will be about 56.84 KLD and 304.5 Kg per day respectively. Sewage and municipal solid waste generated from labour camp will be treated before disposal.

f. Welfare of Labour on construction site

Facilities such as shelter at workplace, canteen, first aid and day crèche are statutory requirement and essential to productivity.

g. Safety of Labour

Safety of labor during construction on elevated sections is a statutory requirement and also has impact on progress of work.

h. Impact due to Supply of Construction Material

Construction material such as aggregate and earth are sourced from approved quarries such that environmental impacts as well as wastage of natural resources are minimized and mitigated.

i. Impact on Ground and Surface Water Quality

Ground water contamination can take place if chemical substances get deposited in soil and are leached by water and percolate to the ground water table. Surface water source can be contaminated if untreated construction wash water is let in from construction sites.

j. Impact on Archaeological Monument/ Site and Heritage Assets

No Archaeological Monuments/sites and heritage assets will be disturbed.

k. Noise pollution

For noise prediction various combinations of equipment were assessed for different construction activities i.e Viaduct, Elevated Station, Construction Yard, Depot as listed in **TABLE 15.22**. For Prediction of Noise levels (leq), Model of US Department of Transportation has been used. No ground attenuation has been considered as ground was assumed to be undisturbed, consolidated and hard. Usage factor (number of hours of operation of different equipment) as per construction practices in metro projects in India and standard (FHWA, USA) noise emission levels of

equipment are taken. Estimation of noise levels has been done upto a distance of 3000ft (914 m). Distances have been worked out (**Table 15.23**) upto which noise levels due to combination of equipment are equal to or less than average base line monitored noise levels i.e 71.3 dB(A). These levels are typical and will vary with specifications of the equipment, usage pattern, number of construction agencies, existing structures/trees which act as barrier to noise transmission.

TABLE 15.22: CONSTRUCTION EQUIPMENT NOISE EMISSION LEVEL

Particular	Equipment	Equipment Noise level (in Leq dBA at 50 ft)	Number of hours of operation	Predicted Noise level (Leq) dB(A) at 50 ft
Case 1				
Viaduct Activity 1	Press Pile	70	0.5	69.07
	Auger drill	84	0.5	
	Generator	81	0.5	
Viaduct Activity 2	Rotatory Hydraulic rig	84	5	78.95
	Generator	81	5	
Viaduct Activity 3	Chiseling	88	2	78.00
	Generator	81	2	
Case 2				
Viaduct	Impact Pile Driver	101	12	98.01
	Crane	88	1	
Case 3				
Elevated Station Activity 1	Press Pile	70	0.5	69.07
	Auger drill	84	0.5	
	Generator	81	0.5	
Elevated Station Activity 2	Rotatory Hydraulic rig	84	5	78.95
	Generator	81	5	
Elevated Station Activity 3	Chiseling	88	2	78.00
	Generator	81	2	
Case 4				
Elevated Station	Impact Pile Driver	101	12	98.01
	Crane	88	1	
Case 5				
Construction yard	Concrete mixer	85	24	91.98
	Truck	88	24	
	Truck	88	24	
Case 8				
Depot	Dumper	76	24	92.21
	Dumper	76	24	
	Grader	85	24	
	Grader	85	24	
	Compactor	82	24	
	Compactor	82	24	
	Dozer	85	24	
	Dozer	85	24	

Considering typical noise from a range of activity, sensitive receptors (i.e. labour

colonies) should be located beyond 340 meters from the noise generating source location during construction activities.

TABLE 15.23: DISTANCE AT WHICH LEQ ≤ AMBIENT NOISE LEVEL

S. No.	Cases	Distance (m) At Which Leq ≤ 71.3 dB(A)(Without Shielding)
1.	Viaduct Activity 1	15.24
2.	Viaduct Activity 2	36.56
3.	Viaduct Activity 3	33.52
4.	Viaduct	335.28
5.	Elevated Station Activity 1	15.24
6.	Elevated Station Activity 2	36.58
7.	Elevated Station Activity 3	33.52
8.	Elevated Station	335.28
9.	Construction yard	164.59
10.	Depot	167.64

I. Vibration

Operation of construction equipment (Pile driver, Hydromill, Large bulldozer, Truck, Hammer) and construction technique will generate ground vibration. Maintenance operations and traffic traveling on roadways can also be a source of such vibration. If its amplitudes are high enough, ground vibration has the potential to damage structure or disrupt the operation of vibration sensitive equipment. Vibration source levels for typical construction equipment are listed in **TABLE 15.24**

TABLE 15.24: VIBRATION SOURCE LEVELS FOR CONSTRUCTION EQUIPMENT

Equipment		PPV at 25 ft (in/sec)	Approximate L _v [#] at 25 ft
Pile Driver (impact)	upper range	1.518	112
	Typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	Typical	0.170	93
Calm shove drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	85
Jackhammer		0.0345	79
Small bulldozer		0.003	58
# RMS velocity in decibels (VdB) re 1 μin/sec			

Peak particle velocity (PPV) of the equipment adjusted for the distance (D) has been estimated conservatively (no mitigation measures) at different distances and presented in **Table 15.25**. Threshold criteria are listed in **TABLE 15.26**. These criteria

for monuments are more stringent than those prescribed in UK, Germany, Switzerland and Japan.

TABLE 15.25: ESTIMATED VIBRATION LEVELS FOR DIFFERENT CONSTRUCTION EQUIPMENT (PPV in/sec)

Equipment		Distance (m)									
		5	10	15	20	25	30	35	40	45	50
Pile Driver (Impact)	Upper Range	2.86	1.01	0.55	0.36	0.25	0.19	0.15	0.13	0.11	0.09
	typical	1.21	0.43	0.23	0.15	0.11	0.08	0.07	0.05	0.04	0.04
Pile Driver (sonic)	Upper Range	1.38	0.49	0.27	0.17	0.12	0.09	0.07	0.06	0.05	0.04
	typical	0.32	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01
Clam shovel drop (slurry wall)		0.38	0.13	0.07	0.05	0.03	0.03	0.02	0.02	0.01	0.01
Large Bulldozer		0.17	0.06	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Loaded Trucks		0.14	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.00
Jackhammer		0.066	0.023	0.013	0.008	0.006	0.004	0.004	0.003	0.002	0.002
Small Bulldozer		0.006	0.002	0.001	0.001	0.001	0.000	0.0003	0.0002	0.0002	0.0002

TABLE 15.26: GUIDELINE VIBRATION DAMAGE THRESHOLD CRITERIA

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Source: *Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013*

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous / frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Where sonic pile driver is used the vibration level will be within permissible limit at

10 m. In case impact pile is used for hard rock than the vibration level will be within the permissible limit at 15 m. If significant impacts due to vibration are expected, mitigation measures have to be implemented and building condition survey have to be conducted before, during and after construction.

4. Impacts Due to Project Operation

The project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise Pollution
- Vibration
- Water supply and sanitation at Stations
- Traffic congestion
- Impact due to Depot

a. Noise Pollution

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. There are number of sensitive receptors like School, College, Hospital, Temple, near the alignment. The major impacts on sensitive receptors during operation phase will be noise and vibration. Noise prediction has been done and is presented in the **TABLE 15.27**. For noise predictions following assumptions are considered.

- Average train speed of 34 km/hr,
- 5#car per train,
- SEL ref 82 and no noise barriers is presented

TABLE 15.27: NOISE LEVELS AT DIFFERENT DISTANCES DURING OPERATION

Distance (feet)	Project Noise Level in dB (A)	Cumulative Noise					
		Ch:71.298- ch:5482	Ch:5428- Ch:9900	Ch:9900- 10965	Ch:10965 - Ch:15709	Ch:15709- 20200	Ch:20200- 23100
10	66	76.6	72.0	82.1	76.8	76.9	72.9
20	61.5	76.2	70.8	82.0	76.5	76.6	72.1
30	58.9	76.1	70.4	81.9	76.4	76.5	71.9
40	57	76.1	70.2	81.9	76.4	76.5	71.8
50	55.5	76.1	70.1	81.9	76.3	76.4	71.7
60	54.4	76.0	70.1	81.9	76.3	76.4	71.7
70	53.4	76.0	70.0	81.9	76.3	76.4	71.7
80	52.5	76.0	70.0	81.9	76.3	76.4	71.7
90	51.7	76.0	70.0	81.9	76.3	76.4	71.6
100	51	76.0	70.0	81.9	76.3	76.4	71.6

At an average speed of 34km/h, with 3 car per rack, noise level for spur and main line as follows:

It is observed from the result that cumulative project noise level will be equal to or less than the ambient noise level at all location. A great part of the alignment from sector-4 to Basai village passes through the residential area which lies approx. 30 m away from the proposed alignment. Cumulative noise for this stretch will be lesser than the ambient noise. Further, the project noise generated from running of train will be equal to or less than the ambient standards. So, Noise barrier are not recommended for the section. However, during operations, actual monitoring will need to be carried out to ensure that the standards are being met. If noise level is found to be higher than the prescribed limit, noise barrier will need to be placed.

Further, the noise barrier would be recommended in certain location with high sensitivity like hospitals, schools falling near the elevated section. Details of the noise barrier proposed for the proposed corridor are given in **TABLE 15.28**.

TABLE 15.28: NOISE BARRIER

S. No.	Location	Chainage in m	Length of Barrier
1	Rotary Public school	22400-22480	80
2	Columbia Asia Hospital	20078-20150	72
3	Presidium School	18660-18700	40
4	Blossom school	17301-17354	53
5	Sec-5	14800-15100	300
5	ESIC Hospital	13000-13211	211
6	Vidya Medical Center	11803-11900	97
7	Green wood public school	11650-11800	150
8	Fortis Hospital	145-195	50
Sub- Total			1,053

b. Vibration

During operation phase the sources of the vibration and noise induced by the trains are mainly the rolling stock, track and the interaction between them. The vibration of the transit structure excites the adjacent ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the remainder of the building structure. The intensity of vibration depends on operational and vehicle parameters, track system, geology and condition of receiving building. Primary effect of ground borne vibration will be rattling of window panes and rumble noise which cause annoyance to the occupants.

Damage to structures is a possibility in case of trains passing within 7.5 m from normal buildings or unreinforced structures or between 15m to 30m from historical buildings or buildings in poor condition; heavy truck traffic within 30m, major construction within 60m, freight trains within 90m or pile driving within 180m can cause disruption of operation of sensitive instrumentation.

As per RDSO Guidelines 2015 for vibration studies of Metro Projects, screening distances for vibration are prescribed (**TABLE 15.29**). Accordingly vibration studies have to be conducted along the corridors to determine the extent of impacts. If significant impacts are expected mitigation measures have to be implemented and building condition survey have to be conducted before and during construction.

TABLE 15.29 SCREENING DISTANCES (IN METER) FOR VIBRATION ASSESSMENT

Type of Project	Critical Distance for Land Use Categories Distance from Right-of-Way or Property Line		
	Category 1	Category 2	Category 3
Conventional Commuter Railroad	183	61	37
Rail Rapid Transit	183	61	37
Light Rail Transit	138	50	30
Intermediate Capacity Transit	61	30	15
Category 1: Buildings where vibration would interfere with interior operations including concert halls and TV studios Category 2: Residences and buildings where people normally sleep including theaters and auditoriums Category 3: Institutional land uses with primarily day time use			

Source: Guidelines for Noise and Vibrations, MRTS, RDSO, Ministry of Railways, September 2015

c. Water Supply and Sanitation

The water demands will be on station for drinking and toilet primarily of staff, station cleaning and AC chiller. Water demand is calculated and presented in **TABLE 15.30**. Daily sewage flow is considered as 80% of the flushing water requirement hence total sewage generated will be 488 KLD.

TABLE 15.30: WATER REQUIREMENT

S. No.	Particular	Water Demand at Each Station Main line (KLD)	Water Demand For Main line	Water Demand for Spur line	Total Water Demand (KLD)
1	At Stations for Drinking purpose	6.000	156	6	162
2	In Elevated stations for AC, cleaning, chiller and other purposes	16.600	431.6	16.6	448.2
Total					610.2

d. Traffic congestion

Upon operation of metro services passenger rush at stations will increase resulting in congestion around stations.

5. Impacts Due to Depot

Impacts anticipated due to stabling Depots located at Sec-101 and Udhog Vihar Phase-V are:

- Water supply
- Sewage and Effluent disposal
- Oil Pollution
- Noise Pollution
- Surface drainage
- Solid Waste
- Cutting of trees

a. Water Supply

Water supply will be required for different purposes in the depot. A three day cycle is assumed for outside cleaning (wet washing on automatic washing plant) and thirty day cycle for outside heavy cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area, Floor, walls inside/outside and roof manually). Water quantity required in the depot for train maintenance purpose is estimated at 50.40KLD. During operation Approx. 100 staff will be working in each depot. Water requirement for staff working in depot is calculated as 14 KLD. Water demand will be met from supply water by Municipal Corporation. Water demand for horticulture will be met from recycled water.

b. Sewage and Effluent

About 40.32 KLD of Effluent and 11 KLD of Sewage will be generated from Depot. The wastewater will be treated and will be recycled to use at depot horticulture purpose. The remaining domestic waste /sewage generated at the Depot will be collected at one suitable point inside the depots from where it will discharge to the nearest manhole of existing sewerage system.

c. Oil Pollution

Oil spillage during change of lubricants, cleaning and repair processes in the maintenance Depot cum workshop for maintenance of rolling stock should be trapped in oil and grease traps and disposed off to authorised collectors, so as to avoid any underground/ surface water contamination.

d. Noise Pollution

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence

the magnitude of rail - wheel noise.

e. Surface Drainage

In case of filling in low-lying area of depot sites, the surface drainage pattern may change.

f. Solid Waste

In addition to solid waste different types of waste will be generated during operation phases from depot and which will consist of waste oil, waste tube lights/LED's, batteries, rubber, plastic, various ferrous/non-ferrous scrap, wooden scrap, paper waste, empty plastic cans/drums, brake blocks etc. Solid waste will be generated from the Depot sites which will be taken by the cleaning contractor weekly and recycled/disposed of at waste disposal sites.

g. Loss of Ecology

38 trees need to be felled at Depot.

15.4. ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plan is presented in two sections:

- Mitigation measures and
- Enhancement measures

15.4.1. Mitigation Measures

- i. Compensatory Afforestation
- ii. Right of Way, Alignment, Track design and Architecture
- iii. Construction Material Management
- iv. Precasting yards and Material stockpiling
- v. Safety Management Measures
- vi. Labour Camp
- vii. Welfare of labour
- viii. Safety of labour
- ix. Energy Management
- x. Hazardous Waste Management
- xi. Water Pollution Management
- xii. Environmental Sanitation
- xiii. Utility Plan
- xiv. Protection of Archaeological Monuments
- xv. Air Pollution Control Measures
- xvi. Noise Control Measures
- xvii. Vibration Control Measures
- xviii. Traffic Diversion/Management
- xix. Soil Erosion Control

- xx. Muck Disposal
- xxi. Construction and Demolition Waste Management
- xxii. Draining of Water from Tunnel
- xxiii. Water Supply, Sanitation and Solid Waste management
- xxiv. Management Plan for Depot
- xxv. Training
- xxvi. Environment Division
- xxvii. Disaster Risk Management

i. Compensatory Afforestation

It is found that about 1042 trees are likely to be lost along the corridor, station box and depot. It is proposed to plant ten saplings for each tree to be cut. Hence, total 10420 trees need to be planted. Cost of afforestation is taken as Rs. 750000/- per ha. Compensatory afforestation cost thus will be about **Rs 70.34 Lakh**. The native plant species and miscellaneous indigenous tree species are recommended for afforestation. List of trees for plantation is given in **Table 15.31**.

Location for afforestation will be decided by HMRTC in consultation with the GMC as well Forest Department such that displacement does not become necessary. The Department of Forests is responsible for the conservation and management of trees/forest in the project area.

TABLE 15.31: LIST OF TREES FOR PLANTATION

S. No.	Botanical name	Common name
1.	<i>Alstonia scholaris</i>	Alstonia
2.	<i>Azadirachta indica</i>	Neem
3.	<i>Ficus virens</i>	Pakad
4.	<i>Acacia nilotica</i>	Babul
5.	<i>Tectona grandis</i>	Sagwan
6.	<i>Cassia fistula</i>	Amaltas
7.	<i>Alianthus excelsa</i>	Aadu
8.	<i>Holoptelea integrifolia</i>	Papdi
9.	<i>Dalbergia sisoo</i>	Shisham
10.	<i>Delonix regia</i>	Gulmohar
11.	<i>Albizia lebbek</i>	Siris
12.	<i>Albizia amara</i>	Krishna siris
13.	<i>Kigelia pinnata</i>	Balamkheera
14.	<i>Ficus bengalensis</i>	Bargad
15.	<i>Ziziphus mauritiana</i>	Beri
16.	<i>Ficus racemosa</i>	Gular
17.	<i>Morus alba</i>	Shahtoat
18.	<i>Ficus religiosa</i>	Pipal
19.	<i>Terminalia arjuna</i>	Arjuna
20.	<i>Casearia graveolens</i>	Chila
21.	<i>Melia azadirach</i>	Bakan
22.	<i>Phoenix dactylifera</i>	Khajur
23.	<i>Cordia dichotoma</i>	Lasoda

ii. Right of Way, Alignment, Track design and Architecture

Alignment has been kept elevated where adequate width of right of way on roads is available. Geometric design of the alignment will be such as to optimize curvature. Track design will incorporate welded rails and elastic fittings. Viaduct and elevated stations shall be shaped to minimize visual intrusion.

iii. Construction Material Management

The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the officer of the HMRTC required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor shall be responsible for management of such construction material during entire construction period of the project.

iv. Pre casting Yards and Material Stockpiling

Sites for casting of structural concrete elements and material stockpiling will be decided before start of construction. Land for these sites will be temporarily acquired such that displacement of persons is not involved to the extent possible.

v. Safety Management Measures

Prior to the construction, identification of safety hazard would be made by Project Authority to establish the safety programmes following rules, regulations and guidelines. The comprehensive safety programmes will include deployment of a full time safety engineer who will prepare safety plan/schedule for their implementation during construction and operation. The personnel working would wear protective headgear, footwear and other special garments that applicable code requires. The weatherproof first aid boxes will be made available at appropriate locations.

vi. Labour Camp

In accordance with the Construction Contract the Contractor shall provide the following facilities at the labour camps: (temporary) living accommodation, sanitation facilities like toilets and drains, health awareness campaigns, facilities for water supply and waste water treatment and solid waste management. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

vii. Welfare of Labour on construction site

In accordance with the construction contract the Contractor will be required to provide shelter at workplace, canteen facilities, first aid facilities, day crèche facilities on work sites.

viii. Safety of labour

Construction works shall be executed as laid down in the Safety Health and Environment (SHE) manual prepared by the Contractor and approved by PIU.

ix. Energy Management

The contractor shall use and maintain equipment so as to conserve energy. Measures to conserve energy include but not limited to the following: use of tools, plant and equipment of correct specifications; energy efficient motors and pumps; efficient lamps; optimal maintenance. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

x. Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall obtain authorization from State Pollution Control Board. Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc. Hazardous Waste needs to be stored in a secure place and adequately labelled and packaged. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection.

xi. Water Pollution Management

Wastewater generated from the site during the construction contains suspended materials, spillage and washings which can pollute surface and ground water; such washings shall be led through separate drains into precipitation chambers before discharge into the sewage drain to the standards prescribed for disposal.

xii. Environmental Sanitation

Environmental sanitation also referred to as Housekeeping is the act of keeping the working environment cleared of all construction material/debris, scraps and used material/items, thereby providing a first-line of defence against accidents and injuries. General environmental sanitation shall be carried out by the contractor and

ensured at all times at work site, construction depot, Batching Plant, stores, offices and toilets/urinals.

xiii. Utility Plan

The proposed Metro alignment runs along major arterial roads of the city which serves Institutional, Commercial and Residential areas. Large number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. already exist along the proposed alignments. These utility services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- In case of underground utility services running across the alignment, the spanning arrangement of the viaduct may be suitably adjusted.

xiv. Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) along haul roads and emission from vehicles and construction machinery. Mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any

transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.

- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.
- The temporary dumping areas shall be maintained by the Contractor at all times until excavate is re-utilized for backfilling or as directed by Employer.
- The Contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During dry weather, dust control methods must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The Contractor shall design and implement blasting techniques so as to minimize dust, noise, and vibration generation and prevention fly rock.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xv. Noise Control Measures

There may be an increase in ambient noise level due to construction. The exposure of workers to high noise levels can be minimized by job rotation, automation, protective devices and soundproof compartments, control rooms etc. Cost is to be included in the project engineering cost. Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.

Cost of noise barriers required to be deployed during operation is estimated as part of EMP cost. Noise barriers are recommended along the curved portion of the

viaduct and at sensitive area of the viaduct which is provided near to the Rotary public school (80m), Columbia Asia Hospital (72 m), Presidium school (40m), Blossom School (53m), Sec-5 (300m), Green wood public school (150 m), ESIC Hospital (211), Vidya Medical Center (97m), Fortis Hospital (50m) during operation. The estimated cost of noise barrier is about **Rs.147.42 lakh**

xvi. Vibration Control Measures

Building survey need to be carried out before construction and Operation. Vibration can be reduced by proper design and maintenance of track and rolling stock. In case of ballastless track, the following are some measures for vibration damping: resilient soft base plates between rail and track slab; resilient rubber between the base plate and track slab; soft elastic fastening system. Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.

xvii. Traffic Diversion/Management

In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

- All construction workers should be provided with high visibility jackets with reflective tapes at most of viaduct/tunneling and station works or either above or under right-of-way.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

Various construction technologies like cut and cover can be employed to ensure that traffic impedance is minimized. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

During operation decongestion scheme should involve taxi and auto rickshaw stands, a halting space for public buses, drop off-pick up for owned modes. Parking space at stations if any is to be planned well.

xviii. Soil Erosion Control

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of

temporary berms, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation may be involved. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. In general, construction works are stopped during monsoon season. To manage land subsidence measures including maintaining adequate distance of the trench from existing structures adjacent to the trench, measures to support the walls of the trench as well strengthen soil underneath adjacent structures will be required.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xix. Muck Disposal

The excavated material shall be graded such that part can be re-used in construction; balance will be disposed. Before excavation, the Contractor will be required to test the soil quality including heavy metals and the results will be compared with standards. If the soil is contaminated, disposal will be done with due treatment or isolation of such muck.

Disposal sites will be identified by Project Authority in consultation with GMC such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. The following activities will be involved for muck disposal:

- Material will be stock-piled with suitable slopes
- Material will be stabilised each day by watering or other accepted dust suppression techniques. The muck shall be filled in the dumping site in layers and compacted mechanically.
- Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top and covered with vegetation.

xx. Construction and Demolition Waste Management

Construction and Demolition (C&D) waste is part of solid waste that results from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, river sand, soil etc.) and energy, reduce transportation over long distances for dumping, and reduce space occupied at landfill sites. C&D waste generated from metro construction has potential use after processing, grading solid waste and recycling. Part of this waste will be hazardous in nature.

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transport recyclable materials to construction sites.
- Sale of metal scrap and other saleable waste to authorized dealers.
- Identification of intended transport means and route.
- Obtaining permission, where required, for treatment of the hazardous component and its disposal.
- The treatment and disposal sites will be identified in consultation with local agencies such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Before dumping, recyclable material will be removed. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.

xxi. Water Supply, Sanitation and Solid Waste Management

Water requirement for construction will be met through by treated water. Drinking water and raw water requirement for elevated stations can be provided from municipal source in consultation with local agencies. Non-hazardous municipal solid waste generated in stations will be collected and transported to local municipal bins and hence to disposal site by municipality.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xxii. Rain water Harvesting

To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and into the underground tanks. A recharge tank shall be constructed at suitable distance. The water collected will percolate down to the subsoil through numerous layers of sand, gravel and boulders. Total elevated length of the corridor is about 28.50 km it includes the Main corridor (HCC-Cyber city) and spur line. Average annual rainfall of Gurgaon is 642 mm. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of elevated stations and elevated section is estimated as 1,62,073 cubic meter per year. Total estimated cost for the rainwater harvesting for the corridor will be 564.3 lakh it includes the main Corridor (**Rs 518.7 Lakh**) & spur line (**Rs 45.6 Lakh**).

xxiii. Management Plan for Depot

The management plan for depot site includes:

- Water Supply

- Oil Pollution Control
- Sewage/Effluent Pollution Control
- Solid waste disposal
- Surface Drainage
- Green belt development
- Rain water harvesting and
- Recycling of treated waste water

Water supply: Water will be required for operation and functioning of depot which will be through municipal supply.

Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. The tank may be designed for a detention period of 5 to 15 minutes. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Sewage/Effluent Pollution Control: Sewage will be generated from depot which could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream. Similarly effluent is likely to be generated from Depots it will be pretreated and it will be further treated in the packaged type sewage treatment plant. The estimated cost of Treatment Plant is about **Rs 50 Lakh**.

Solid Waste Disposal: The solid waste generated from the Depot will be taken by the cleaning contractor weekly and recycled/treated and disposed of at designated waste disposal sites. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Surface Drainage: The area should have proper drainage. The Storm water of the depot will be collected through the drains. Rain water harvesting pits shall be provided at different locations in the drains and for surplus storm water, the drainage system should be connected to a nearby disposal site. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

Rain water harvesting: To augment storage of groundwater, it is proposed to construct roof top rainwater harvesting structure in Admin block. Rainwater harvesting potential of depots is calculated as 1,419 cubic meter per year. The estimated cost for 2 rainwater harvesting pit at depot is **Rs 30 Lakh**.

Recycling of treated waste water: Wastewater generated from depot is proposed to be collected through separate lines for treatment. The treated waste water will be recycled for horticulture work of the depots.

xxiv. Training

The training for engineers and managers will be impacted by HMRTC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. Apart from training, programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such programmes is estimated as Rs 4.95 Lakh details are given in **TABLE 15.32**

TABLE 15.32: COST FOR TRAINING PROGRAMME

S. No.	ITEM	Cost (Rs.)
1	Curriculum Development and course preparation 1 month Rs.30000/month	30,000
2	1 Extension Officer (1 year) Rs.20, 000/month	24,0000
3	Instructor 5 sessions of 10 days each Rs. 30,000/session	1,50,000
4	Demonstration/Presentation Aids	50,000
5	Material etc	25,000
Total		4,95,000

xxv. Establishment of Environmental Division

It is recommended that HMRTC establishes an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and an Environment Engineer. The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it should report directly to Chief Engineer of the project authority. Progress of the division should be reviewed by an Environmental Advisor once in a year. The environmental Advisor should be an experienced expert familiar with environmental management in similar projects. Costs for the first ten years (including 10% annual increase has been) given **TABLE 15.33**. The estimated cost for the corridor is **Rs 228 Lakh**.

TABLE 15.33: COST OF ESTABLISHMENT OF ENVIRONMENTAL DIVISION

S. No.	Particulars	In Rupees (Lakh)
1.	Environmental Engineer (1No.)	5.4
2.	Assistant Environmental Engineer (1No.)	3.6
3.	Office Maintenance	1.8
4.	Office furnishing & Miscellaneous Expenditure	3.5
Total Cost for One Year		14.3
Total Cost for Ten Years with 10% annual increase		228

xxvi. Disaster Risk Management

Disaster risk is the combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage. The main opportunity in reducing risk lies in reducing exposure and vulnerability. Disaster Risk Management includes the following actions:

- Reduction and prevention: Measures to reduce existing and avoid new disaster risks, for instance relocating exposed people and assets away from a hazard area. In case of mass transit like Metro such measures are not actionable.
- Mitigation: The lessening of the adverse impacts of hazards and related disasters. For instance implementing strict land use and building construction codes. This aspect is accounted for in design and construction of the project.
- Transfer: The process of formally or informally shifting the financial consequences of particular risks from one party to another, for instance by insurance. This is not yet available.
- Preparedness: The knowledge and capacities of governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of hazard events or conditions, for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Risk Management process¹ comprises the following stages:

- Description of the system that is at risk
- Identify the potential hazards or sources of risk (the list of initiating events or scenarios of events leading to the undesired outcome – technological and human)
- Risk analysis to estimate the likelihood of the scenarios or events occurring and each scenario's consequence
- Compare and rank the various risk drivers
- Action plan in response to the identified major risks
- Regular monitoring, review and updation of the process.

1. For example, the system at risk needs to be defined as to include inter-modal integration.

2. Examples of potential hazards are fire risk or security alarms or failure of train control or motive power or passenger doors / escalators / platform screen doors on trains or in stations; staff training and work environment; inadequate maintenance.
3. Action plan shall include the following.
4. Procedures and Records
5. Evaluation of progress and effectiveness of EMP and EMoP, response to inquiries, complaints and requests for information surveillance, incident reporting, corrective and preventive actions, emergencies, training and emergency exercises, response to emergencies,
6. Identification of resources: Sources of repair equipment, personnel, transport and medical aid for use during emergency will be identified.
7. Emergency systems: Back-up systems for ventilation, communication and train control, lighting etc. shall be established.
8. Evacuation procedures: Evacuation procedures will be prepared in consultation with local administration and notified. To ensure coordinated action, an Emergency Action Committee shall be constituted.
9. Communication System: Primary and back-up system shall be put in place

Review and Updation: Drawing inputs from the incident reporting system the Action Plan shall be reviewed at pre-decided intervals and upon occurrence of defined ``trigger events`` and suitably updated.

15.5. ENVIRONMENTAL MONITORING PLAN AND ENVIRONMENT MANAGEMENT SYSTEM

15.5.1. Environment Monitoring Plan

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. Environmental monitoring should be an integral part of works towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation phases of the project. The following parameters are proposed to be monitored: Air quality, Water and soil Quality, Noise and Vibration, Ecology, Workers Health and Safety.

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. Estimated cost for Environmental monitoring during the construction and

operation phases is about 72 lakh and 10 Lakh respectively.

15.5.2. Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels, water, soil quality and ecology. At this stage it is not possible to visualize the exact number of locations where environmental monitoring must be carried out. However keeping a broad view of the sensitive receptors and also the past experience an estimate of locations has been made and are summarized in **TABLE 15.34**. These numbers could be modified based on need when the construction actually commences.

TABLE 15.34: CONSTRUCTION STAGE MONITORING SCHEDULE

Parameter	Frequency per year	Locations	Years
Air Quality	2x24 hours, 2 times in a month	8	5
Noise	2x24 hours, 2 times in a month	8	5
Water	Once in six month, twice in a year	8	5
Soil	Once in six month, twice in a year	8	5

i. Water Quality

The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. Water quality should be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

ii. Air Quality

Air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter (PM_{2.5} and PM₁₀), SO₂, NO_x, CO and HC. The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of HMRTC.

iii. Noise

The noise will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of HMRTC.

iv. Ecological Monitoring

The project authority shall monitor the status of ecology/trees along the project corridors at least 4 times in a year during construction phase in order to maintain the ecological environment.

v. Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring.

Any reoccurring incidents such as irritations, rashes, respiratory problems etc. shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans.

vi. Operation Phase

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, vibration, water and ecology during operation phase of the project. The parameters monitored during operation will be Particulate Matter (PM_{2.5} and PM₁₀), SO₂, NOX, CO and HC for air. Water quality parameters that will be monitored will be as per BIS:10500.

The monitoring schedule is presented in **TABLE 15.35**. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency under the supervision of HMRTC. Project Operator i.e. HMRTC will be responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE 15.35: OPERATION STAGE MONITORING SCHEDULE

Parameter	Frequency	Locations	Years
Air Quality	2x24 Hour, in a week for each season, three seasons in a year	4	3
Noise	24 hours, in a week for each season, three seasons in a year	4	3
Water	Once a year	3	3
Waste Water	Once in 4 months	1	3
Soil	Once a year	3	3

15.5.3. Formation of Environment Management System (EMS)

Environment Management System is intended to facilitate implementation, tracking and reporting of mitigation and monitoring measures proposed for the project. Roles and responsibilities are summarized in **TABLE 15.36** and **TABLE 15.37**.

TABLE 15.36: CLEARANCES/PERMISSIONS FOR PROPOSED METRO CORRIDORS

S. No	Clearance/Permission	Act/ Rules/ Notifications	Remarks
1.	Environmental Clearance	EIA Notification 2006 & further amendments	Required from SEIAA if commercial development is more than 20,000 sq.m is proposed.
2.	Forest Clearance	Forest (Conservation) Act 1980	Not required
3.	Wildlife Clearance	The Wildlife (Protection) Act, 1972	Not required
4.	CRZ Clearance	Coastal Regulation Zone Notification, 2011	Not required
5.	Change in Land Use	Town Planning Department, Haryana	HUDA
6.	Wetland conservation and Management	Wetlands (conservation and Management) Rules 2017	Not required
7.	Permission for tree cutting/felling of trees	Punjab Land Preservation Act ,1900	DFO
8.	Consent for construction near ASI and Heritage Structures	The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010 with Ancient Monuments and Archaeological Sites and Remains (Amendment) Act, 2017	Not required
9.	Height Restriction	Aircraft Act 1934 with Aircraft (Amendment) Act, 2007 (44 of 2007)& Ministry of Civil Aviation (Height Restrictions for Safeguarding of Aircraft Operations) Rules, 2015 that are further amended in 2018.	Not required
10.	Protection of Air Quality, Consent to Establish, Consent To Operate for batching plants, material yards, depot from SPCB	Compliance to National Ambient Air Quality Standards Air (Prevention and Control of Pollution) Act, 1981 amended in 1987; Air (Prevention and Control of Pollution) Rules, 1981	HSPCB
11.	Protection of Water Quality Compliance to National water Quality Standards Treatment and discharge of sewage Consent to Establish, Consent to operate	Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981	HSPCB
12.	Handling, storage, treatment and disposal of hazardous material (fuel)/ waste like waste oil and lubricants etc.	Hazardous and Other Wastes (Management, and Trans boundary Movement) Rules, 2016	HSPCB
13.	Management of waste resulting from construction, re-modeling, repair and demolition of any civil	Construction and Demolition Waste Management Rules, 2016	HSPCB

S. No	Clearance/Permission	Act/ Rules/ Notifications	Remarks
	structure		
14.	Noise Pollution (Regulation and Control) Rules, 2000 amendment in 2010 and 2017	Compliance with Ambient Noise Standards in accordance to land use of the area	HSPCB
15.	Management (Collection, Handling, Storage and disposal) of solid waste	Solid Waste Management Rules, 2016	HSPCB

TABLE 15.37: ROLES AND RESPONSIBILITIES –PREPARATION AND IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND ENVIRONMENTAL MONITORING PLAN (EMOP)

S. No.	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
Location and Design Phase				
1	Displacement and private property acquisition, impact of environmentally sensitive areas.	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
2	Loss of trees and water bodies		DPR and design consultant	PIU
3	Visual intrusion	Capital and operating cost and vibration impact of underground line in trade off with visual intrusion. To design aesthetic structures of viaduct and stations on elevated sections.	DPR and design consultant	PIU
4	Archaeological monuments	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
Pre-construction Phase				
5	Displacement and private property acquisition.	Implement R&R Plan	PIU	PIU
6	Loss of trees and water bodies	Implement compensatory afforestation	Forest Department	Forest Department
7	Site measures	Prepare Safety, Health and Environment (SH&E) Manual and secure approval.	Contractor	PIU
8	Water supply; sewage and solid waste disposal	Requirement for construction to be planned so as to avoid use of ground water.	Contractor	PIU
9	Environmental Management and Monitoring	Implement institutional requirements for implementation of EMP and EMoP.	Contractor	PIU
Construction Phase				
10	Soil erosion, fugitive dust generation, muck disposal and C&D waste management	Implement suitable construction methods and as per SH&E Manual	Contractor	PIU

S. No.	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
11	Air and noise Pollution	Vehicles and machinery are to be maintained to emission standards; machinery noise muffles etc and personal protective gear to workers.	Contractor	PIU
12	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures	Contractor	PIU
13	Water pollution	Implement measures such as precipitation tanks on site	Contractor	PIU
14	Soil pollution	Implement measures to prevent ingress of toxic / heavy metals	Contractor	PIU
15	Labour camp: water supply; sewage and solid waste disposal; health	Implement measures as per SH&E Manual	Contractor	PIU
16	Facilities on site and workplace safety		Contractor	PIU
17	Incident Management	Prepare Incident Management Plan with reporting formats.	Contractor	PIU
18	Environmental Monitoring	Prepare Environmental Monitoring Plan.		
19	Availability of institutional capacity	Implement training and establish environment unit.	Contractor	PIU
Operation Phase				
20	Noise Pollution	Implement and maintain noise barriers on viaduct	PIU	PIU
21	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures.	PIU	PIU
22	Water supply, sanitation, sewage and solid waste disposal at stations and depots	Implement prescribed measures including rain water harvesting at stations and depots; green belt and water recycling at depots.	PIU	PIU
23	Sewage and effluent disposal	Implement STP and ETP at depots.	PIU	PIU
24	Incident Management	Implement Incident Management Plan.	PIU	PIU
25	Environmental Monitoring	Implement Environmental Monitoring Plan.	PIU	PIU

The range of documentation required to be generated and maintained as part of EHS before and during construction and during operation is as follows:

- Controlled documents of mandatory environmental Approvals and clearances along with record extensions thereof
- Controlled documents of approved SH&E Manual, EMP and EMoP with revisions thereof and time schedule of such revisions if any
- Controlled documents of formats of site inspection checklists with revisions thereof and time schedule of such revisions if any
- Reports of site inspections, monitoring data, reports of internal or external audit, observations of PIU and local statutory agency if any like Pollution Control Board, local municipal authority, Forest Department etc. and subsequent remedial action taken by Contractor if any
- Records of coordination meetings of PIU/GC and Contractor with subsequent remedial action taken by Contractor if any
- Records of incident reporting and remedial action taken by Contractor if any and follow-up of such incidents

15.6. SUMMARY OF COST

Estimated cost of implementation of EMP, EMoP and Training for the proposed metro project is about **Rs 1197.01 Lakh**. Summary of cost estimate is given in the **TABLE 15.38**.

TABLE 15.38: SUMMARY OF COST ESTIMATE

S No	Item	Amount (Rs in Lakh)
1	Compensatory Afforestation	70.34
2	Noise Barrier	147.42
3	Rainwater Harvesting (Depot & Viaduct)	614.3
4	Treatment Plant for Depot	50
5	Environmental Monitoring	
	Construction Phase	72
	Operation Phase	10
6	Training and Extension	4.95
7	Environment Division	228
Total		1197.01

* GC: General Consultant as Project Management Consultant

15.7. SOCIAL IMPACT ASSESSMENT

The loss of private assets resulting in loss of income and displacement has made social impact assessment an important input into the project design while initiating and implementing developmental interventions. An understanding of the issues

related to social, economic and cultural factors of the affected people is critical in the formulation of an appropriate rehabilitation plan. As per requirement of Detailed Project Report (DPR) preliminary social impact assessment (SIA) was carried out.

15.7.1. Objectives of SIA

The specific objectives of the SIA are as follows:

- Identify PAPs by type and extent of loss;
- Identify the possible adverse effects of the project on the people and the area;
- Suggest culturally and economically appropriate measures for mitigation of adverse effects of the project;
- Provision of institutional mechanism for implementation of RAP;
- Provision for grievance redress mechanism;
- A time frame for implementation of RAP;
- Provision of budget for each activity of RAP, and
- Monitoring and Evaluation (M&E) of implementation of RAP.

15.7.2. Approach & Methodology for preparation of SIA

The present SIA study is for the requirement of DPR and has been prepared in accordance with the guidelines of Government of Haryana and Government of India. The study aims at collecting baseline data for socio-economic information and identifies the affected population by residence, business base and their locality. The study is primarily based on field data generated by the Social Development Experts of RITES during social survey and secondary data where necessary. The study was conducted in three phases.

15.7.2.1. Phase – I: Pre Survey Activities

Based on review of alignment drawings key stakeholders were identified. Team comprising of social safeguard professionals of RITES undertook reconnaissance of proposed corridor to verify the issues identified through review of alignment drawings and also provide the basis for field research preparation and helped in developing and testing survey questionnaires and checklists. Both the review and rapid reconnaissance survey helped in finalizing the study tools and techniques.

15.7.2.2. Phase II: Survey Activities

Before the actual household socio-economic survey, all the structures (i.e. residential, commercial and common properties) that were likely to be affected by the project were identified and were enumerated considering the ROW and

alignment drawings. After enumeration of the structures likely to be affected in the project area, socio-economic survey of households was carried out. The household social survey was carried out by trained field investigators with the help of a pre-tested "Household Questionnaire". The detailed socio-economic survey was conducted during November 2018. Qualitative survey comprising consultation at project level and interviews with various sections of people was conducted to elicit their expectations and suggestions, which will support and provide additional information collected through quantitative survey. Relevant state and national guidelines pertinent to land acquisition, rehabilitation and resettlement were reviewed.

15.7.2.3. Phase III: Post Survey Activities – Analysis and Reports

The information collected through household survey was coded, validated, analyzed and tabulated.

15.7.3. Social Impacts

The proposed project will have a number of positive and negative impacts. In general the project shall bring following positive impacts:

- Generate Employment opportunities and economic growth
- Mobility and safe travel
- Traffic decongestion
- Save fossil fuel
- Reduce air pollution

The anticipated negative impacts include:

- Loss of Land
- Loss of Residential Structures
- Loss of Commercial Structures
- Loss of Jobs/Works
- Loss of Livelihood
- Loss of Common Property Resources
- Loss of Public Utility structures

Impacts on PAFs/PAPs have been assessed and presented here.

15.7.4. Land Requirement and Acquisition

The total land required including government and private is 15.94 ha. The project shall require the acquisition of 11.44 ha of land permanently. Out of the total land, 4.73 ha is government land and 6.71 ha is private land. The project also requires 4.5 ha land for temporary use. The land identified for temporary use shall be returned to the owning agencies after the completion of the project construction.

15.7.5. Inventory of Affected Structures

Table 15.39 indicates impact of the proposed project on the different types of structures i.e. residential, commercial, residential cum commercial and other. Majority of affected structures are of commercial use. One residential structure is identified in proposed Udyog Vihar IV station which belongs to India Army. Another four guard rooms has been identified between Udyog Vihar Phase-V and Cyber City station. Those guard rooms belongs to the nearby private offices.

TABLE 15.39: STATION WISE TYPE OF AFFECTED STRUCTURES

Station	R	C	R+C	Other	Total
Between Sector-4 and Sector-5 Station	2	0	0	0	2
Udyog Vihar Phase -6	0	13	1	0	14
Sector-10	2	0	0	0	2
Sector-37	0	3	0	0	3
Basai Village	8	6	0	0	14
Sector-22	0	3	5	0	8
Between Sector-22 and Udyog Vihar Phase IV Station	0	6	0	1	7
Udyog Vihar Phase IV Station	0	0	0	3	3
Udyog Vihar Phase V and Cyber City Station	0	4	0	1	5
TOTAL	11	35	6	5	58

Source: RITES Field Survey, 2019

The magnitude of project impact on the structures, which is categorized as partially and fully affected structures, is presented here. On the basis of alignment drawing it was found during site visit that out of total 58 structures, about 18 structures shall be partially affected and remaining 40 structures shall be fully affected (**Table 15.40**).

TABLE 15.40: SUMMARY OF AFFECTED PROPERTIES/STRUCTURES

Station	Partially	Fully	Total
Between Sector-4 and Sector-5 Station	0	2	2
Udyog Vihar Phase -6	8	6	14
Sector-10	2	0	2
Sector-37	2	1	3
Basai Village	2	12	14
Sector-22	0	8	8
Between Sector-22 and Udyog Vihar Phase IV Station	3	4	7
Udyog Vihar Phase IV Station	0	3	3
Udyog Vihar Phase V and Cyber City Station	1	4	5
TOTAL	18	40	58

Source: RITES Field Survey, 2019

Among the total partially affected structures, two are residential, 15 are commercial, one is residential cum commercial structures. Similarly, out of the total fully affected structures 10 are residential, 20 are commercial structures. It is observed that majority of structures which are likely to be affected either partially or fully are commercial.

TABLE 15.41: PARTIALLY AND FULLY AFFECTED STRUCTURES BY TYPE OF STRUCTURES

Structures	R	C	R+C	Kiosk	Other	Total
Partially affected	2	15	1	0	0	18
Fully affected	10	20	5	0	5	40
Total	12	35	6	0	5	58

Source: RITES Field Survey, 2019

15.7.6. Impact on PAFs/PAPs

About 69 families shall be affected due to the proposed metro project in Gurgaon. Majority of families are likely to be affected in Udyog Vihar Phase-6 (26 PAFs) and Basai village (20 PAFs).

Station wise number of PAFs is presented in Table 15.42. *Exact number of affected and displaced families/persons will be found out during detailed Census/Baseline Socio-Economic Survey (BSES) after peg marking of alignment on the ground.*

TABLE 15.42: IMPACT ON PAFs

Station	PAFs
Between Sector-4 and Sector-5 Station	2
Udyog Vihar Phase -6	26
Sector-10	3
Sector-37	3
Basai Village	20
Sector-22	8
Between Sector-22 and Udyog Vihar Phase IV Station	7
TOTAL	69

Source: RITES Field Survey, 2018

Table 15.43 shows that out of total affected families, 31 PAFs shall be partially affected and whereas 38 families shall be fully affected. Out of the total partially affected families, three are residential and 28 are commercial. Similarly, out of the total fully affected families 11 are residential and 27 are commercial.

TABLE 15.43: STATION WISE FULLY AND PARTIALLY AFFECTED FAMILIES WITH TYPE OF LOSS

Station	Partially affected families			Fully Affected families			Total
	R	C	Total	R	C	Total	
Between Sector-4 and Sector-5 Station	0	0	0	2	0	2	2
Udyog Vihar Phase -6	0	20	20	0	6	6	26
Sector-10	3	0	3	0	0	0	3
Sector-37	0	2	2	0	1	1	3
Basai Village	0	2	2	9	9	18	20
Sector-22	0	0	0	0	8	8	8
Between Sector-22 and Udyog Vihar Phase IV Station	0	4	4	0	3	3	7
Total	3	28	31	11	27	38	69

Source: RITES Field Survey, 2019

Table 15.44 shows that out of the total families, 35 are title holders and 34 are non-titleholders. Among the non-title holders, 5 are squatters and 8 are encroachers.

TABLE 15.44: TITLE HOLDERS AND NON-TITLE HOLDERS AMONG AFFECTED FAMILIES

Station	Total PAFs				Total
	Title Holders	Non-title holders			
		Tenant	Squatter	Encroacher	
Between Sector-4 and Sector-5 Station	2	0	0	0	2
Udyog Vihar Phase -6	16	10	0	0	26
Sector-10	2	1	0	0	3
Sector-37	1	2	0	0	3
Basai Village	13	7	0	0	20
Sector-22	0	0	5	3	8
Between Sector-22 and Udyog Vihar Phase IV Station	1	1	0	5	7
Total	35	21	5	8	69

Source: RITES Field Survey, 2019

15.7.7. Socio-economic profile of Project Affected Families

Information on affected families was collected through interviews of sample PAFs at their homes or shops in November 2018.

Gender and Sex Ratio

The data on gender and sex ratio is very helpful indicator to know the participatory share of male and female in the society, which is also an important indicator for human development index. Among the surveyed population it is observed that 57.7% are male and remaining 42.3% are female. The sex ratio is 732 per 1000 males. The demographic characteristics of sample PAP is given in Table 15.45

TABLE 15.45: DEMOGRAPHIC CHARACTERISTICS OF SAMPLE PAPs

Characteristics	Number	Percent
Sex		
Male	41	57.7
Female	30	42.3
Sex ratio	732	
Age group		
0-17	13	18.31
18-34	32	45.07
35-59	20	28.17
60 & above	6	8.45
Marital status		
Married	38	53.52
Unmarried	33	46.48
Total	71	100.0

Age Group

The persons of surveyed families have been categorized into four age groups. The distribution of person's age in various group shows that 18.31% of the total persons belong to below 17 years. 45.07% belong to the age group of 18-34 years which is potentially productive group. About 28.17% belong to the age group of 35 to 59 years. About 8.45% of total persons belong to 60 years and above, who are dependent population. It is observed that majority of persons belong to 18 to 34 years age group.

Marital Status

The marital status of the surveyed family members is indicated under two categories – married and unmarried. It is observed that out of total surveyed people, majority of them (53.52%) are married, and about 46.48 % are unmarried.

Religious and Social Groups

Data on religious groups was collected in order to identify people with the specific religious belief among the surveyed families. The religious beliefs and social affiliation of the people are indicators that help understand cultural behavior of the groups. The social and cultural behavior will help understand the desires and preferences of PAPs, which is a prerequisite to rehabilitate the affected people and their families. **Table 15.46** shows that two religions are practiced in the study area

viz., Hindu and Muslim. The study result shows that about 81.25% of the surveyed families are Hindu followed by Muslims (18.75%). Majority of families are Hindu in this corridor.

TABLE 15.46: SOCIAL CHARACTERISTICS OF SAMPLE PAFs

Characteristics	Number	Percent
Religious groups		
Hindu	13	81.25
Muslim	3	18.75
Caste groups		
SC	1	6.25
OBC	4	25
General	11	68.75
Family pattern		
Joint	13	81.25
Nuclear	3	18.75
Family size		
Small (2-4)	9	56.25
Medium (5-7)	7	43.75
Large (Above 7)	0	0
N	16	
Education (PAPs)		
Illiterate	13	18.31
Primary (1-5)	3	4.23
High School (6-10)	16	22.54
Higher Secondary (11-12)	12	16.90
Graduate and above (13-17)	27	38.03
Total	71	

The social affiliation of the group differentiates them for benefits under government schemes. In general, the families belonging to Scheduled Castes (SCs) and Scheduled Tribes (STs) under the provisions of Constitution of India get preferential treatment in the government benefits because the group includes the people who are traditionally vulnerable. Except general category, all other groups need attention and to be addressed for their backward socio-economic conditions. The survey results show that two-third of surveyed families belong to general caste followed by Other Backward Classes (25%). About 6.25% of PAFs belong to Scheduled Castes. Both Scheduled Castes and Other backward class families are found in the corridor.

Family Pattern and Family Size

Family pattern and family size indicate the fabric of sentimental attachment among the family members. It is observed from the **Table 15.46** that majority of surveyed families are joint (81.25%) followed by nuclear (18.75%). It is also observed that majority of surveyed families belong to joint family in the corridor.

Family size has been classified into three categories i.e. small (2-4), medium (5-7) and

large (7 & above). **Table 15.46** shows that majority of families (56.25%) are small in size followed by 43.75% families are medium in nature. Higher proportion of small size families have been found in the corridor.

Educational Attainment

Education is a tool for vertical mobility in the society. It provides an opportunity to participate in the process of growth and development. However, it also creates differences among people and introduces a new kind of inequality between those who have it and those who do not. In all the cases, education is a basic need and the best indicator of socio-economic development of a region. The analysis indicates that out of the total surveyed people, about one-fifth are illiterate. So far as educational attainment is concerned 4.23% are educated up to primary class, High school (22.54%), and 16.90 % studied up to higher secondary school and 38.03 % have studied up to graduate and above.

Household Main Occupation

Occupational pattern of the surveyed persons is recorded to assess their skill so that income generation plan can be prepared accordingly for alternative income generating scheme. Secondly, occupational pattern helps in identifying dominating economic activity in the area. The survey results in **Table 15.47** shows that majority of surveyed families are employed in business and shop keeping activities. Out of the total surveyed PAFs, about 50% of them are involved in business and shop keeping, 18.75% and 12.5% are employed in private and government services respectively. 18.75% surveyed population have other source of income. It is observed that majority of PAFs are involved in business/shop keeping activities.

TABLE 15.47: CORRIDOR WISE OCCUPATIONAL CHARACTERISTICS OF SAMPLE PAFs

Characteristics	Number	Percent
Household main occupation		
Business/Shop	8	50
Private Job	3	18.75
Govt. Job	2	12.5
Others	3	18.75
Household annual income		
Rs. <70000	0	0
Rs. 70001 -150000	1	6.25
Rs. 150001 -350000	7	43.75
Rs. >350000	8	50
Average annual income (Rs)	34187.5	
Monthly per capita income (Rs)	1032	
Annual household expenditure		
Rs. <70000	0	0
Rs. 70001 -150000	3	18.75
Rs. 150001 -350000	8	50
Rs. >350000	5	31.25

Characteristics	Number	Percent
Average annual expenditure (Rs)	25625	
Monthly per capita expenditure (Rs)	774	
Earning members in family		
1 Member	11	68.75
2 Members	3	18.75
Above 2 Members	2	12.5
Dependent members in family		
< 2 members	2	12.5
2-3 Members	9	56.25
> 3 Members	5	31.25

Table 15.47 Shows that majority of families have annual income more than 350000. The average income of a family is Rs.34187/- per annum. Monthly per capita income is Rs.1032/-. Average family expenditure is Rs.25625/- per annum. Majority of the surveyed population have one earning member in the family and dependents are two to three persons.

Commercial/ Self Employment Activities

Out of the total surveyed families, there are 6 commercial units and 10 are residential units. About 16.67% of commercial units are hotel and 33.33% population is engaged in repair and workshop activity. Majority of the surveyed population (50%) have enterprises as a source of income. The employment pattern indicates the number of people involved in the commercial activities. About 33.33% of the surveyed commercial establishments are operated by owners without any manpower support, 66.67% have employed 5 and above people in their work. The proposed metro project shall have cumulative impacts on both the affected commercial establishments as well as their employed people.

TABLE 15.48: PROJECT AFFECTED TYPE OF COMMERCIAL ACTIVITY

Characteristics	Number	Percent
Type of PAFs		
Commercial	6	37.5
Residential	10	62.5
Type of commercial activity		
Hotel	1	16.67
Repair & Workshop	2	33.33
Other enterprise [#]	3	50.00
Commercial establishment		
Owner /Operator	2	33.33
Employed more than 5 pers.	4	66.67
Total	6	100

* Other shops mainly includes bakery, mobile, grocery, cloth, stationery shop

[#]Other enterprise includes saloon, tailoring, sweet making

Vulnerable Groups

Vulnerable group is defined as indigenous people, ethnic minorities, the poorest, women, the aged, the disabled and other socially/economically vulnerable groups who would be adversely affected from a project.

As regards vulnerability among surveyed PAFs, 12 families belong to vulnerable category. Of the total vulnerable families, about 83.33 % would be under BPL if they lose their livelihood due to the proposed project. About 8.33% PAFs are female headed households and 8.33% are of Scheduled Castes. It is observed that 75% of surveyed families are under vulnerable category (**Table 15.49**).

TABLE 15.49: VULNERABILITY OF PAFs

PAFs	Number	Percent
Vulnerabilities		
Total PAFs	16	100.00
Vulnerable	12	75.00
Vulnerabilities of PAFs		
HH becoming BPL due to loss of livelihood / assets	10	83.33
Scheduled Caste	1	8.33
Scheduled Tribe	0	0.00
Female Headed Household	1	8.33
Total	12	100.00

Awareness and opinion about the project

During socio-economic survey, some questions were asked to surveyed families regarding their awareness about the project, source of information and opinion about the proposed metro rail project. The findings of the survey with regards to awareness, and opinion about the proposed project have been presented in **Table 15.50**.

TABLE 15.50: AWARENESS AND OPINION OF PAFs ON PROPOSED METRO

Opinion of PAFs	Number	Percent
Project awareness		
Yes	12	75
No	4	25
Opinion on project		
Positive	4	25
Negative	12	75
Can't say	0	0
Positive opinion of PAFs		
Easy travelling	1	6.25
Loss of House	8	50.00
Loss of Shop	5	31.25
No Pollution	1	6.25
Reduced Traffic	1	6.25
Total	16	100.00

Preferred Location and R&R Options

Table 15.51 shows that about 100% of surveyed families preferred to be located within the area if they are displaced due to the proposed metro rail project. Majority of families preferred constructed houses and shops in resettlement site. 6.25% families preferred land for land and 12.50% preferred cash assistance. Income from business activity, close to market, daily jobs, school and hospital are considered as main factors while providing alternate place to displaced families.

TABLE 15.51: PREFERRED LOCATION AND R&R OPTIONS

Preferred Location	Number	Percent
Within the area	16	100.00
R & R Option		
Land for land lost	1	6.25
Cash assistance	2	12.50
House in resettlement site	7	43.75
Shop in resettlement site	6	37.50
Don't know	0	0.00
Factors to be considered while providing alternate place		
Access to family/friends	0	0.00
Income from business activity	1	6.25
Daily job	0	0.00
Close to market	14	87.50
Close to school and hospital	1	6.25
Other	0	0.00
Total	16	100.0

15.7.8. Public Consultation and Participation

Background

Aiming at promotion of public understanding of the project and understanding of issues of resettlement likely displaced persons were consulted through local public consultations. This participatory process helped in reducing the public resistance to change and enabled the participation of the local people in the decision making process.

Objectives of Public Consultation

The basic objective is as follows:

- Disseminate information to the people about the project in terms of its activities and scope of work; and understand the views and perceptions of the people affected and local communities with reference to acquisition of land or loss of property and its due compensation.
- Generate ideas regarding resettlement options;

- Identify and assess major economic and social information and characteristics of the project area to enable effective social and resettlement planning and its implementation.
- Resolve issues related to impacts on community property and their relocation.
- Establish an understanding for identification of overall developmental goals and benefits of the project.

Approach and Method of Consultation

Public consultation was conducted at Basai Chowk. The consultation process involved various sections of affected persons such as title holders, tenants, women, shop keepers, and other inhabitants. During public consultations, issues related to land acquisition, compensation, income restoration, employment generation, information flow, grievance redressal, safety, health and education facilities for children of PAFs etc. were discussed. The response received has been consolidated in **Table 15.52**.

The Resettlement Action Plan (RAP) addresses all issues raised during public consultation and recommends institutional strengthening measures as well.

Summary of Public Consultation

Place: Basai Chowk

Date: 09/11/2018

No of Participants: 10

TABLE 15.52: SUMMARY OF PUBLIC PARTICIPATION

S. No.	Issues Raised/ Discussed	Suggestion by Stakeholders
1.	Loss of Houses	There are 11 houses including one plot located in the proposed Basai Village Metro Station. All the houses are G+1 and G+0 type provides with electricity, sewage, water connection. All the houses are well constructed and invested. All the house owners have filed case against HUDA (Haryana Urban Development Authority) against the land acquisition for the Gurgaon Metro Rail Project. Presently a stay has been put up from the court in favor of the householders.
2.	Conflict with HUDA	The HUDA authority has claimed that the houses are illegally constructed although the titleholders have the necessary legal documents which already been produced in the civil court, Gurgaon
3.	Compensation	The title holders do not want to allow the HUDA to acquire the private land for the proposed Metro Project but if they get provided with proper compensation considering the present land value, then they can reconsider for the land acquisition.

S. No.	Issues Raised/ Discussed	Suggestion by Stakeholders
4.	R & R Plan	The householders said that they are looking forward to the court judgment with regard to the land acquisition. Therefore, after court's judgment they will proceed.
5.	Benefit of Metro Project	The proposed Metro project would be beneficial to people but their houses shall not be acquired. The government shall restructure the alignment and shift the proposed station to some other empty land. So that the residential area could be saved

Key Findings of Consultation

The consultant briefed the participants about the objectives of the meeting regarding various social issues related to the project i.e., land acquisition, loss of livelihood etc. The participants were invited to give their valuable suggestions on the above issues and were assured for suitable incorporation of such suggestions in the project within the technical limitations and scope of the project.

The issues raised during the public consultation can be broadly classified under traffic reduction, increased connectivity, reduction in pollution and problems related to land acquisition and displacement. In Basai Chowk most of the respondents reported that they would not allow HUDA (Haryana Urban Development Authority) to acquire the private land for the proposed Gurgaon Metro Project. The issue of compensation was raised by the participants. As reported by participants, metro train will surely augment infrastructure and other facilities, so participants strongly suggested that the affected families/people should get adequate compensation considering the latest land value in order to re-instate the life of people. In the similar vein, the issue of livelihood has been raised in Basai Chowk. Further, a few participants of public consultation highly appreciate the upcoming metro project as it will increase connectivity, reduce the traffic load and reduce existing level of pollution.

15.7.9. Resettlement Policy, Framework and Entitlement Matrix

Compensation for resettlement and rehabilitation shall be considered as per Government of Haryana (GoH) and Government of India policies and guidelines for land acquisition, rehabilitation and resettlement. The Project Resettlement Policy is aimed at filling-in any gaps in what local laws and regulations cannot provide in order to help and ensure that PAPs are able to rehabilitate themselves to at least their pre-project condition.

The Entitlement Matrix

An Entitlement Matrix has been developed in compliance with RTFCTLARR Act 2013. The entitlement matrix summarizes the types of losses and corresponding nature and scope of entitlements. PAPs who are squatters and not legal titleholder of land and buildings shall also be eligible for R&R if enumerated during the census survey. Therefore, the date of completion of census survey shall be the Cut-off Date. It is on this date that all impacted persons will be identified and the nature of the impact disclosed. PAPs who settle in the affected areas after the cut-off date will not be eligible for compensation and/or other assistance. They, however, will be given sufficient advance notice, requested to vacate premises and dismantle affected structures prior to project implementation. Their dismantled structures will not be confiscated and they will not pay any fine or suffer any sanction. The entitlement matrix presents the entitlements of the affected and displaced people in the following order. The Entitlement matrix is given in **Table 15.53**.

- a) Entitlement for titleholders consisting of
 - (i) loss of private land;
 - (ii) Loss of private residential structure;
 - (iii) Loss of private commercial structures;
 - (iv) Impact to tenants(residential/commercial/residential cum commercial)
- b) Entitlement to Non-Titleholders consisting of
 - (i) Impact to squatters;
 - (ii) Impact to encrochers
 - (iii) Impact to Kiosks
- c) Loss of Employment to workers/employees
- d) Assistance to affected and displaced vulnerable people
- e) Common infrastructure and Common Property Resources(CPRs)

TABLE 15.53: ENTITLEMENT MATRIX

S. No	Type of Loss	Unit of Entitlement	R&R Entitlement Framework
1	Loss of land(agricultural/homestead/commercial or otherwise	Titleholder family	a) Land will be acquired on payment of compensation as per RTFCTLARR Act 2013. (i) Market value as per the Indian Stamp Act,1899 for the registration of sale deed or agreement to sell, in the area where land is situated; or Average sale price of similar type of land situated in the nearest vicinity area, ascertained from the highest 50% of sale deeds of the proceeding 3 years; or Consented amount paid for PPPs or private

S. No	Type of Loss	Unit of Entitlement	R&R Entitlement Framework
			companies. (ii) Plus 100% solatium and 12% interest from the date of notification to award. (iii) The multiplier factor will be applied as per the Act. b) Where jobs are created through the project, after providing suitable training and skills development in the required field, make provision of employment at a rate not lower than minimum wages; or Onetime payment of Rs.5, 00,000/- per affected household or annuity policy that shall pay Rs.2000/- per month for 20 years with appropriate indexation to Consumer Price Index for Agricultural Labourers (CPIAL). c) One time subsistence allowance of Rs.36,000/- per affected family who require to relocate due to project. d) Shifting assistance of Rs.50,000/- per affected family who requires to relocate due to the project. e) One time Resettlement Allowance of Rs.50,000/- for affected family.
2	Loss of Residential Structure	Titleholder family	<i>In addition to Compensation for land and Assistances listed above under S.No.1</i> a) Cash compensation at scheduled rates for structure without depreciation with 100% solatium. b) Right to salvage affected materials. c) One time assistance of Rs.25,000 to all those who lose a cattle shed. d) An alternative house as per Indira Awas Yojana (IAY) specifications in rural areas and constructed house/flat of minimum 50 sq.m in urban areas or cash in lieu of house if opted, for those who do not have any homestead land. The cash in lieu of house will be Rs.70,000/-(in line with IAY standards) in rural areas and 1,50,000/- in case of urban areas.

S. No	Type of Loss	Unit of Entitlement	R&R Entitlement Framework
			Note: Stamp duty and registration charges will be born in case of new houses or sites.
3	Loss of Commercial Structure	Titleholder family	In addition to Compensation for land and Assistances listed above under S.No.1 a) Cash compensation at scheduled rates for structure without depreciation with 100% solatium. b) Right to salvage affected materials. c) One time assistance of Rs.25,000 for loss of trade/self employment for the business owner.
4	Tensants (residential/commercial)	Tenant/lease holder	Residential: a) Rental allowance at Rs.3,000/- per month in rural areas and Rs.4,000/- per month in urban areas for six months. b) One time financial assistance of Rs.50,000 for shifting.
			Commercial:
			a) Rental allowance at Rs.4,000/- per month in rural areas and Rs.6,000/- per month in urban areas for six months. b) One time shifting assistance of Rs.50,000. c) Commercial tenant will receive one time financial assistance of Rs.25,000 (minimum) for loss of trade/self employment.
5	Squatters(homestead purpose)	Family	Residential: a) Compensation at scheduled rates without depreciation for structure. b) Right to salvage the affected materials. c) One time subsistence allowance of Rs.3,000 per month for one year from the date of award. d) One time shifting assistance of Rs.50,000.
	Squatters(commercial purpose)	Family	Commercial: a) Compensation at scheduled rates without depreciation for structure. b) Right to salvage the affected materials. c) Commercial squatter will receive one time financial assistance of Rs.25,000 for loss of

S. No	Type of Loss	Unit of Entitlement	R&R Entitlement Framework
			trade/self employment. e) One time shifting assistance of Rs.50,000.
6	Mobile and ambulatory vendors	Vendor	Ambulatory vendors licensed for fixed locations will be considered as kiosks and each affected vendor will get a) One time subsistence allowance of Rs.3,000 per month for six months from the date of award.
7	Loss of Employment	Workers/employees	b) One time subsistence allowance of Rs.3,000 per month for one year from the date of award.
8	Vulnerable family	Family	One adult member of the affected family whose livelihood is affected will be entitled for skill development. Training for skill development. This assistance includes cost of training and financial assistance for travel/conveyance and food.
9	Common infrastructure and common Property Resources	Community	a) Community properties will be replaced in consultation with the community. b) Civic infrastructure would be replaced in consultation with the affected community and the District/Urban/Rural administration
10	Any Unforeseen Impact	Affected community / persons	Any unforeseen impact would be mitigated/enhanced as per the RTFCTLARR Act 2013.

15.7.10. Institutional Framework

The Government of Haryana (GoH) will be the executing agency of the proposed Gurgaon metro rail project. A Special Purpose Vehicle (SPV) shall be set up by the GoH for implementation of the proposed metro rail project. The SPV will be headed by the Chairman cum Managing Director (CMD) will be the in charge of the overall project activities and will facilitate land acquisition, capacity building and implementation of RAP. The PIU headed by the Project Director (PD) is responsible for the overall execution of the project and planning and implementation of resettlement and rehabilitation component of the project. The PIU will coordinate with all implementing agencies and monitoring the progress of the project. Implementing Agency will set up a Social Management Unit (SMU) which shall look after land acquisition, resettlement and rehabilitation activities. The SMU shall ensure that all land acquisition issues are handled according to the Land Acquisition

and Rehabilitation & Resettlement policy/guidelines. It will also monitor that all the procedural and legal issues involved in land acquisition are fulfilled. The SMU will assist the IA for getting all the necessary clearances and implementation of the resettlement activities prior to start of any civil work. A Resettlement and Rehabilitation Officer (RRO) with background of social science may be appointed in this SMU to supervise and monitor overall activities of RAP and he/she will report day to day progress to SDO. RRO will also work closely with the District Collector to expedite the payment of compensation for land acquisition and assistance to APs. The RRO will form Local Resettlement Committees (LRC) in each project affected areas consisting of local representatives and other stakeholders including APs, women to assist in the implementation of RAP activities within the project area. Some of the specific functions of the SMU in regards to resettlement management will include the following:

- Overall responsibility of planning, implementation and monitoring of land acquisition, resettlement and rehabilitation activities in the project;
- Ensure availability of budget for R&R activities;
- Liaison lined agencies support for land acquisition and implementation of land acquisition and resettlement;
- Coordinating with line Departments.

NGO will be appointed by IA to extend implementation support to IA in the form of assisting affected families/persons during relocation and preparation of Income Restoration Plan (IRP). The NGO will help educating PAPs on proper utilization of compensation and rehabilitation grant and help them in getting financial assistance.

During implementation phase of RAP, IA will appoint a consultant (R&R) through General Engineering Consultancy (GEC) to assist IA in implementation of resettlement plan. The consultant will carry out due diligence in the implementation of resettlement and rehabilitation programmes through periodic monitoring. The consultant will be responsible for (i)preparation of database of affected structures, families, persons, (ii)verification of database through field survey,(iii)improve monitoring system,(iv)capacity building of implementation staffs ,(v)regular follow up implementation activities and other relevant activities.

Efficient grievance redressal mechanism will be developed to assist the PAPs resolve their queries and complaints. Grievances of PAPs will be first brought to the attention of field level staffs of IA. Grievances not redressed by the staffs (field level) will be brought to the Grievance Redressal Committee (GRC). The proposed GRC will have representatives from PAPs, women representative, Project Director (PIU), SDO, SMU of IA, NGO representative, representative of local body, and Land Acquisition Officer (LAO). The main responsibilities of the GRC are to: (i) provide support to PAPs on problems arising from land/property acquisition; (ii) record PAPs grievances, categorize, and prioritize grievances and resolve them; (iii) immediately inform the

SMU of serious cases; and (iv) report to PAPs on developments regarding their grievances and decisions of the GRC.

15.7.11. Work Schedule

The R&R activities of the proposed project are divided into three broad categories based on the stages of work and process of implementation. In the project preparation stage, identification of required land for acquisition, census & socio-economic survey, public consultation, preparation and review/approval of draft RAP, disclosure of RAP, establishment of GRC and preparation of resettlement site shall be carried out. Activities like notification of land acquisition, valuation of structure, payment by competent authority, shifting of PAPs shall be taken up during RAP implementation. During monitoring and evaluation stage internal monitoring will be carried out by IA and mid and end term evaluation will be carried out by an independent evaluation agency.

15.7.12. Monitoring and Evaluation of RAP

RAP implementation will be monitored both internally and externally. IA will be responsible for internal monitoring through their field level officers of Social Management Unit and will prepare quarterly reports on the progress of RAP implementation. An Independent Evaluation Consultant may be hired by IA for mid and end term evaluation of RAP implementation.

Internal Monitoring

The internal monitoring for RAP implementation will be carried out by IA. The main objectives of internal monitoring are to:

- measure and report progress against the RAP schedule;
- verify that agreed entitlements are delivered in full to affected people;
- identify any problems, issues or cases of hardship resulting from the resettlement process, and to develop appropriate corrective actions, or where problems are systemic refer them to the management team;
- monitor the effectiveness of the grievance system
- Periodically measure the satisfaction of project affected people.

Internal monitoring will focus on measuring progress against the schedule of actions defined in the RAP. Activities to be undertaken by the IA will include:

- Liaison with the Land Acquisition team, construction contractor and project affected communities to review and report progress against the RAP;
- Verification of land acquisition and compensation entitlements are being delivered in accordance with the RAP;

- Verification of agreed measures to restore or enhance living standards are being implemented;
- Verification of agreed measures to restore or enhance livelihood are being implemented;
- Identification of any problems, issues, or cases of hardship resulting from resettlement process;
- Through household interviews, assess project affected peoples' satisfaction with resettlement outcomes;
- Collection of records of grievances, follow up that appropriate corrective actions have been undertaken and that outcomes are satisfactory;

Monitoring is a continuous process and will be carried out by field level officers of Social Management Unit on regular basis to keep track of the R&R progress. For this purpose, the indicators suggested have been given in **Table 15.54**.

TABLE 15.54: INDICATORS FOR MONITORING OF RAP PROGRESS

MONITORING ISSUES	MONITORING INDICATORS
Physical	Extent of land acquired Number of structures dismantled Number of land users and private structure owners paid compensation Number of families affected Number of families purchasing land and extent of land purchased Number of PAPs receiving assistance/compensation Number of PAPs provided transport facilities/ shifting allowance Extent of government land identified for house sites
Financial	Amount of compensation paid for land/structure Cash grant for shifting oustees Amount paid for training and capacity building of staffs
Social	Area and type of house and facility at resettlement site PAPs knowledge about their entitlements Communal harmony Morbidity & mortality rate Taken care of vulnerable population Women concern
Economic	Entitlement of PAPs-land/cash Number of business re-established Utilization of compensation House sites/business sites purchased Successful implementation of Income Restoration Schemes
Grievance	Number of community level meeting Number of GRC meetings Number of cases disposed by IA to the satisfaction of PAPs Number of grievances referred and addressed by GRC Cases of LA referred to court, pending and settled

Independent Evaluation

As mentioned earlier, an Independent Evaluation Agency (IEA) will be hired by IA for mid and end term evaluation. The external evaluation will be carried out to achieve the following:

- Verify results of internal monitoring,
- Assess whether resettlement objectives have been met, specifically, whether livelihoods and living standards have been restored or enhanced,
- Assess resettlement efficiency, effectiveness, impact and sustainability, drawing lessons as a guide to future resettlement policy making and planning, and
- Ascertain whether the resettlement entitlements were appropriate to meeting the objectives, and whether the objectives were suited to affected persons' conditions,
- This comparison of living standards will be in relation to the baseline information available in the BSES. If some baseline information is not available then such information should be collected on recall basis during the evaluation.

Reporting Requirement

IA will be responsible for supervision and implementation of the RAP. IA will prepare quarterly progress reports on resettlement activities. The Independent Evaluation Agency will submit draft and final reports of their assignment to IA and determine whether resettlement goals have been achieved, more importantly whether livelihoods and living standards have been restored/ enhanced and suggest suitable recommendations for improvement. Submission of the draft report would be carried out after completion of assignment and the final report should be submitted after receiving feedback from IA.

15.7.13. Cost Estimate of R&R

The R&R budget is indicative and costs will be updated and adjusted to the inflation rate as the project continues and during implementation. Cost of compensation for land acquisition and structures is not covered under R&R. The total cost for R&R implementation plan is **INR 290.08** lakh. The R&R Cost is given in **Table 15.55**.

TABLE 15.55: R&R COST FOR IMPLEMENTATION OF RAP

S. N	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.in lakh)
A	Compensation for loss of private land and structure has been presented in capital estimate of DPR				
Compensation for Titleholders					
	Residential PAFs				
B	Annuity or employment	no.	10	500000	5000000
C	Subsistence allowance	no	10	36000	360000
D	Transportation allowance	no	10	50000	500000
E	Resettlement Allowance	no	10	50000	500000
	Commercial PAFs				
F	Annuity or employment	no.	27	500000	13500000
G	Transportation allowance	no	27	50000	1350000
H	Loss of Small traders/self employment	no	27	25000	675000
Compensation for Non-Titleholders					
	Tenants				
I	Rental Allowance	no	21	4000	84000
J	Shifting Allowance	no	21	50000	1050000
K	Financial assistance for loss of trade	no	21	25000	525000
	Squatters				
L	Subsistence allowance	no	5	36000	180000
M	Shifting Allowance	no	5	50000	250000
N	Financial assistance for loss of trade	no	5	25000	125000
	Kiosks(Vendors)				
O	Subsistence allowance	no	0	18000	0
Training for Skill Development					
P	Training Assistance(LS)	no	20	15000	300000
Loss of Employment					
Q	Compensation for economic loss of employees	no	15	36000	540000
Compensation for Community Structures					
R	Religious structures(LS)	no	0	1500000	0
S	Public Toilets(LS)	no	0	1000000	0
Engagement of NGO					
T	NGO Cost (LS)	no	1	2500000	2500000
Monitoring & Evaluation					
U	Cost of Independent Evaluation Agency(LS)		1	1000000	1000000
	Total (B+C+D+E+F+G+H+I+J+K+L+M+N+O+P+Q+R+S+T+U)				2849000
	Miscellaneous items @ 2% of sub total				568780
	TOTAL				29007780

Chapter – 16

DISASTER MANAGEMENT & SECURITY MEASURES

16. DISASTER MANAGEMENT AND SECURITY MEASURES

16.1 DISASTER MANAGEMENT AND IMPERATIVES

Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation. Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results insubstantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.

World Health Organization (WHO), defines disaster as "Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area."

16.2 NEED FOR DISASTER MANAGEMENT

Disaster brings about sudden and immense misery to humanity and disruptions to normal human life in established social and economic patterns. It has the potential to cause large scale human suffering.

Metro systems will carry thousands of passengers daily, therefore the effect of any disaster spread over in operational area (station, tunnels, viaducts etc.) is likely to be considerable. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro.

16.3 TYPE OF DISASTERS IN METRO SYSTEM

Metro specific disasters can be classified into two broad categories as Man-made and Natural.

a.Man Made Disaster

- Terrorist attack
- Bomb threat/ Bomb blast
- Hostage Situations

- Release of Chemical or biological gas in trains, stations or tunnels
- Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
- Train accident and train collision/derailment of a passenger carrying train
- Sabotage
- Stampede

b. Natural Disaster

- Earthquakes
- Floods

16.4 OBJECTIVES OF DISASTER MANAGEMENT PLAN

The main objectives of Disaster Management Measures are as follows:

- Save life and alleviate the sufferings.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instill a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation as early as possible.
- Lay down the actions required to be taken by staff in the event of a disaster in Gurugram Metro rail in order to ensure prompt handling of crisis situation in a coordinated manner.
- To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

16.5 PREPAREDNESS OF STAFF FOR DISASTERS

- 16.5.1 Being a technologically complex system with a new set of staff, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the actions required to be taken up while handling emergencies. They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their well being seeking their cooperation. Since learning can only be perfected by 'doing' the following Mock Drills are considered essential:

i. Fire Drill - This shall include

- Making announcements
- Protecting the area
- Summoning assistance
- Using fire fighting equipments locally available
- Passenger evacuation in case of need

ii. Rescue of a disabled train

- Identifying causes, isolating fault.
- Announcement to passengers
- Passenger evacuation
- Coupling / Uncoupling of trains for clearing a failed train by an assisting train.
- Driving from an intermediate cab with Cab to Cab telephone communication from front cab.

iii. Detrainment of passenger between stations

- Blocking adjacent line
- Announcement to passengers.
- Use of emergency doors.
- Guiding passengers to next station.

iv. Passenger evacuation from station

- Announcement to passengers.
- Closing of booking offices.
- Opening of AFC gates/ Emergency exits
- Changing the direction of escalators.
- Crowd control with assistance of security staff and Police/Metro Police.
- Working of TVS system.
- Working of fire suppression and detection system

v. Drill for use of rescue & relief train

- The following items need to be noted
- Time taken by the staff to report for duty from the time of first information.
- Departure time of rescue and relief train.
- Testing of all vital systems like generators, control panel.etc.
- Demonstrating a few key functions

- vi. Hot line telephone communication with state disaster management authority.

16.5.2 Authorities Coordination in Case of Disaster, Command & Control at the National, State & District Level

Authority coordination is essential for disasters of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. Following provisions have been considered for Gurugram MRTS:

i. National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:

- i. With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (The Disaster Management Act, 2005), an authority to be known as the National Disaster Management Authority.
- ii. The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:
 - The Prime Minister of India, who shall be the Chairperson of the National Authority, Ex officio;
 - Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.
- iii. The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice-Chairperson of the National Authority.
- iv. The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

ii. State Disaster Management Authority

Establishment of State Disaster Management Authority:-

- i. Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.
- ii. A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the

rules otherwise provide, the State Authority shall consist of the following members, namely:

- The Chief Minister of the State, who shall be Chairperson, ex officio;
- Other members, not exceeding eight, to be nominated by Chairperson of State Authority;
- The Chairperson of State Executive Committee, ex officio.

iii. The Chairperson of State Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice- Chairperson of the State Authority.

iv. The Chairperson of the State Executive Committee shall be Chief Executive Officer of the State Authority, the Chief Minister shall be the Chairperson of the Authority established under this section.

v. The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

iii. **Command & Control at the National, State & District Level**

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:

- i. National Crisis Management Committee (NCMC) under chairmanship of Cabinet Secretary
- ii. Crisis Management Group (CMG) under chairmanship of Union Home Secretary.
- iii. State Level Committee under the chairmanship of Chief Secretary.
- iv. District Level Committee under the Chairmanship of District Collector.

All agencies of Government at National, State and district levels will function in accordance with guidelines and directions given by these committees.

iv. **Plans by Different Authorities at District Level and their Implementation**

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:

- i. Prepare a disaster management plan setting out following, namely:-
 - Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;

- Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
 - The response plans and procedures, in the event of, any threatening disaster situation or disaster;
- ii. Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;
 - iii. Regularly review and update the plan; and
 - iv. Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

16.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

An effective system needs to be provided which includes Fire Detection and Suppression System, Smoke Management, Environmental Control System (ECS), Track-way Exhaust System (TES), Lighting System, Station Power Supply System, DG Sets & UPS, Seepage system, Water Supply and Drainage System, Sewage System, Station Area Lights and other facilities which may be deemed necessary.

The above said provisions are suggestive and an exhaustive set of facilities have to be provided based on site conditions, location and other internal and external factors.

16.6.1 Measures in Case of Fire

Fire has been recognized as one of the most dreaded accidents on metros primarily because of large concentration of passengers at stations and in trains. Fire prevention and prompt response to any incident of fire or smoke emission is therefore the most important component of disaster management on Metros. Universally accepted measures for fire prevention include:

- Rigid observance of non smoking regulations
- Total ban on carriage of inflammable/ explosive substance within metro premises and in trains
- Non accumulation of garbage in the metro station premises and inside trains
- All staffs posted at stations must ensure instructions are rigidly enforced by regular checks.

A. Fire and Smoke

In the event of fire and / or smoke either in train , station premises, right of way including the tunnel or other metro premises, every Metro Rail official whether on duty or not shall,

- Report the occurrence to the nearest Station Controller (SC) or Chief Controller (OCC)
- Take all possible steps to extinguish fire
- Disconnect electric supply, if required
- Prevent the fire from spreading
- Seek assistance of Fire services.

B. Fire in a Train

The guidelines set out below are based on the content analysis of past accidents on other Metros and are in the nature of best practices. Since every fire incident is unique, the train operator is to exercise quick judgment based on:

- The nature of fire whether localized or widespread in passenger area.
- The extent of occupation of the train-number of passengers-if the number is manageable he will ask passengers of the affected coach to move away to other coaches.
- Proximity of the next station – passenger evacuation and handling of emergency is much easier at station than in between stations. Train Operator (TO) has to exercise his judgment about those extreme cases where the train has to be stopped forthwith to save life by prompt evacuation or taken to the next station expeditiously.

C. Fire in Train at the Station Platform

The Train Operator shall open all train doors on the platform side and ask passengers to vacate the train. He will inform OCC and Station Controller and take assistance from station staff as required.

D. Fire Suppression System

A wet Fire Main System covers the station area as well as the entire length of the tunnels. In addition there are automatic sprinklers, inert gas based suppression systems and portable fire extinguishers at various locations. Immediately on receipt of information about a train with fire incident held up between stations – Auxiliary System Controller (ASC) will

- Identify the location of fire (front/rear of the train)
- Identify affected ventilation zone/s
- Other trains held up needing increased ventilation
- Help OCC to decide the correct direction of passenger evacuation.
- Identify the appropriate TVS Master mode and operate TVS system.
- Inform TO through TC the direction of evacuation.

Before starting evacuation, ASC/ Traction Power Controller (TPC) shall check for the adequacy of Lighting and correct Operation of ECS and lights can be switched on from Station control room by BMS controller/ nominated E&M staff.

E. Fire at Metro Station Premises

The fire can be at the following locations:

- In areas, where the passengers enter for purchasing tickets or leave the station after performing their train journey including lifts, staircases and escalators.
- Concourse
- Auxiliary electrical substations.

In case of fire in areas where passengers enter/leave the station premises, the endeavor of station staff should be to cordon off the area so that it is not approachable for intending Metro users or by Metro passengers leaving the station area.

16.6.2 Measures in Case of Collision of Trains

In the event of a train collision involving Metro trains, any employee witnessing, discovering or being involved in a train collision shall inform the Operations Control Center (OCC) and provide the following information-

- Callers name and identification,
- Reason for the call,
- Train identification,
- Location of the collision (Line identification , track (UP/DN), OHE mast no., nearest station if not at station),
- Need for medical assistance,
- Presence of smoke or fire

If the employee making the first report is a Train Operator (TO), Traffic Controller (TC) shall instruct the Train Operator to secure the train, inform the passengers about the incident, check if any passenger or employee needs medical attention. The TO will inform TC accordingly. If the other TO has not communicated with OCC, TC will ask TO to collect similar information about the second train and report.

A. Train Operator (TO) shall

- Look for presence of smoke or fire. Furnish details of visible damage, if any coaches are derailed or
- If the other track is obstructed.
- The OCC /TC shall instruct Train Operators of trains in approach of the collision site, in both directions, to stop their trains at stations and report their positions.

B. Duties of Train Operator:

- In the event of collision taking place involving his train, the train operator shall inform OCC by giving as many details as possible.
- In case of adjacent track is infringed, he will first protect the adjacent track to avoid multiple accidents as per prescribed procedure.
- He will inform passengers about the incident advising them about rescue and relief arrangements being made.
- He shall quickly assess the situation particularly in respect of passenger's injury and again inform OCC with as much details as available seeking medical and other assistance as required.
- He will render first aid to passengers and check for injury and damage to the train (both his train and other train).
- Shall seek OCC's permission for passenger evacuation.
- Shall await further instructions from OCC.

C. Duties of Station Controller:

- The Station Controller on receipt of information about collision at his station shall inform OCC.
- Arrange for immediate medical assistance as required.
- Inform Metro rail police/Local police.
- Mobilize the staff for evacuation of passengers and rendering of first aid to the injured and their hospitalization as required.

- Inform passenger awaiting at the station of the likely delays.
- Station controller will evacuate passengers as per instructions of OCC.

D. Duties of Traffic Controller:

- On receiving information about train collision the Traffic Controller shall block all movement on both the tracks to protect the site of accident.
- Inform HMRTC Disaster Management Team members.
- And other designated HMRTC departments and Personnel.
- Mobilize medical assistance as required.
- Inform the train depot to be in readiness to move rescue and relief train.
- Instruct Station Superintendent to depute staff for evacuation of passengers and providing medical aid to the injured.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Arrange for Public Address announcements to be made to passengers in trains and at stations.
- Initiate operating procedure to relieve train congestion at collision site by: a) Single track operation (Single Line Working), b) Turning trains on both sides of collision site (Short Loop Operation) etc.
- The OCC Chief Controller shall inform the Disaster Management Team, ED/OP, GM/OP and all controllers in OCC, the Police/Metro Police and Security Controller to secure the accident scene and Station Superintendent/Station Controllers on the affected line. Chief Controller shall also inform emergency services. All controllers in OCC shall inform their respective officers, maintenance/emergency team and others as applicable.

E. Medical Assistance

The TO/SC requesting medical assistance to OCC shall provide an estimate of the likely number of people requiring medical assistance and also indicate the most convenient access point for medical personnel to enter. (The names and addresses of person requiring/receiving medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/at OCC).

16.6.3 Measures in Case of Train Derailment

A. Duties of Train Operator:

- i. The TO becoming aware that his train has derailed shall stop the train immediately if not, already stopped and secure the train.
- ii. Inform passengers of the problem and action being taken.
- iii. Inform OCC providing following information:
 - Train Operator identification
 - Location (line identification, Track (UP/DN), & Mast No.)
 - Train description (Train no. & train set no.)
 - Adjacent track obstructed or clear.
 - Passenger injury or presence of smoke or fire.
 - Seek instruction for passenger evacuation.

B. Duties of Traffic Controller:

- TC shall instruct TOs of trains approaching the derailment site on both tracks to stop their trains and report their positions.
- TC shall immediately notify DMT and all concerned Metro departments, Police/Metro Police and Security Controller to secure the accident site and Station Superintendents on the affected line for informing waiting passengers at stations about the likely delay. OCC/TC will also arrange to inform passengers aboard trains held up.
- Mobilize medical assistance as required.
- Inform the depot to be in readiness to move the rescue and relief train.
- Instruct Station Managers to depute staff for evacuation of passengers and providing medical aid to the injured in case of derailment between stations.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Arrange for Public Address announcements to be made to passengers in trains and on stations.
- Request assistance of Police / Metro Police / Security/ Watch & Ward for crowd control at critical stations.
- Initiate operating procedure to relieve train congestion at derailment site by:
 - Single track operation (Single Line Working),
 - Turning trains on both sides of derailment site (Short Loop Operation) etc.

C. Medical Assistance:

The employee requesting medical assistance to OCC shall provide an estimate of likely number of people requiring medical assistance and will also indicate the most convenient access point for medical personnel to enter. (The names and addresses of passengers requiring medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/in OCC).

16.6.4 Measures in Case of Terrorist Actions

Increase in terrorist actions against public transport worldwide, indicates that public transport systems are becoming more vulnerable and potential targets for terrorist. It is clear that preventing terrorist activities is the primary responsibility of security agencies and state police.

However, concern for passenger well being and their security and adverse effects of such mishaps on the public image of transport systems itself, requires best possible level of preparedness for prevention of such threats within Metro premises. Key components of such preparatory and preventive action include:

- Encouraging and guiding passengers to be cautious themselves.
- An awareness program – appealing users to be on the alert and report any suspect package.
- Well thought out crisis communication to prevent misinformation, confusion, panic and shock.
- Clear procedures and systems of communications need to be established for emergencies and regularly tested, in order to ensure a working communication during crisis situation.
- Frequent mock drills to test effectiveness of passenger evacuation systems including the collaboration and response of passengers.
- Training all frontline staff to prevent dangerous situations and handle incidents.
- Once they have happened act with courage, promptitude and alertness, reassuring passengers and providing regular information for their guidance.
- Terrorist attack may take place anywhere in the metro rail's jurisdictions, however when it takes place, on the right of way particularly underground section, at metro station and in running trains it may have serious impact in terms of human distress and restoration of normal operation. On receipt of information of any terrorist act on Metro Trains, stations or on the Right of Way, OCC will take prompt action to get the entire metro network cleared of all passengers.

A. Terrorist attack at Station

Duties of Station Superintendent/Station Controller:

- Shall visit the affected spot, assess the extent of impact on human life and also how it may affect train services.
- Shall inform the OCC about details of incident.
- Sound the hooter and get the station premises vacated of all the passenger
- Depute staff to announce at 5 minute interval, through the station PA system what has happened and what the passengers are expected to do without getting panic.
- Mobilize resources to render first aid and evacuate the injured.
- In case any person is seen moving in a suspicious manner, he may be detained for interrogation with the help of security staff.
- Passengers found near the affected area may also be asked about their first hand knowledge of the occurrence and their statement with name and addresses recorded.
- Inform Police/Metro Police and depute station security staff to protect and cordon the site to preserve the clues and leave the site undisturbed for police investigation.

Duties of Traffic Controller/Chief Controller:

Immediately on receipt of the information about terrorist attack, Chief Controller shall:

- Inform Police/Metro Police and security personnel and ask them to rush to the spot of occurrence.
- Mobilize Medical Assistance and/ or Fire Services to reach the spot.
- Inform the DMT and other HMRTC departments and personnel.
- Hold trains at stations. Train movement shall only be resumed after confirming that the running of train through the affected station is safe, till the position becomes clear regular announcement to be made to passengers in train and at station of the likely delay and evacuation procedures started. The entire Metro network shall remain closed till rescue and search operations have been completed. Revenue operations shall only be started after ensuring that the system is fully safe and secure.

B. Terrorist Attack in Train:

Of all the cases of terrorist attack, those within a train will have most disastrous consequences and very prompt action will be necessary to restrict the damage to men

and material. Such a situation may include:

- A Bomb on the track which detonates under a train.
- Detonation of Bomb / igniting of inflammable material inside a train.
- Release of chemical / biological gases in a train.
- Criminal interference with train running equipments which causes fire in the coaches while on run.
- Other terrorist activities incapacitating the train on run.

C. Bomb Blast on Track:

There may be derailment of the train with large scale damage to the train and fixed structures as well as injury to the passengers in the train. In case of derailment, the train will immediately come to a stop. The Train Operator shall immediately inform Traffic Controller about the occurrence and ask for immediate assistance as required. TO shall seek permission for evacuation of passengers. In case the situation does not permit detrainment from one end, it may be arranged from both ends. The injured passengers should be evacuated as soon as the Medical Team arrives on the spot.

D. Bomb Blast inside the Train:

The Train operator shall:

- Inform Traffic Controller
- Inspect the impact of explosion and if the train is in a position to move, he will try to take the train to the next station at reduced speed.
- In case he is not able to take the train to the next station, Shall stop the train and inform the Traffic Controller about the incident.
- Shall seek assistance of fire services and medical services as required, take the permission of the TC to detrain the passengers.
- Shall make an on the spot assessment of the situation including the injury/death of passengers and inform the Traffic Controller for immediate appropriate action.
- The TO shall make announcement to the passengers through the train PA system about the situation and ask them to remain calm indicating that action has already been taken to arrange for detrainment of passengers.
- The TO will arrange evacuation of the passenger when authorized by OCC.
- This will help in reaching prompt assistance to the injured and disabled passengers on arrival of the Security and Medical Team.
- Train Operator will thereafter arrange to detrain the injured passengers with the help of security and medical staff.

E. Release of Chemical Poisonous or biological gases in tunnels, trains or at stations

Whenever other terrorist activities described above produce loud noise, explosion, fire and smoke, release of lethal or harmful gases works silently and can only be generally inferred from-

- Unusual smell
- Passengers or employees complaining of Breathing problems- including choking/fainting, Severe eye/Skin irritation and Vomiting etc.

Receiving any such complaint the Train Operator or Station Controller/ Station Manager will take serious note of it and immediately inform OCC to take prompt action to handle the emergency as case of suspected release of poisonous gases. If gas release is detected in a train, TO will inform OCC and expeditiously bring the train to the next station, open train doors and request all passengers to detrain. He will personally check with station staff, security and Police/Metro Police that the train has been completely vacated.

To prevent further spreading of gas in platform area and to help Police and Medical teams to investigate and identify the gas he will close the train doors. In the event of gas release in station premises, the station should be fully vacated and kept closed unless certified free of contamination by medical authorities.

Whereas, release of gases on the Right of Way in Rail corridors may not have serious impact, with gas spreading into atmosphere. In tunnel sections it will be necessary to

- Locate the presence of gas in specific ventilation zones.
- Activate appropriate TVS modes to dilute the gas.
- Degasify the tunnel portion or the entire tunnel, depending upon the severity of the case informing civil authorities of the likely discharge of gas in certain areas which may require to be protected.
- Pending this, the affected portion or the entire tunnel will have to be vacated of all passengers and staff.

Normal operation should only be resumed after running of a trial train with Police, Medical and metro authorities confirming that the section has been made free of contamination.

16.6.5 Measures in Case of Natural Calamities

On being informed about an earthquake in the city of Gurugram or experiencing the same, OCC Traction Power Controller (TPC) will switch off Traction power Supply in a manner which does not shut down station supplies informing the Traffic Controller who will instruct the TOs to stop their trains and report their position.

In the event of a significant earthquake, TO experiencing the impact or being informed by passengers or OCC will bring his train to a stop and inform OCC the location of the train.

- If at station, he will not move the train, inform OCC and advice passengers to remain inside the train.
- After receiving OCC instructions that the earthquake has subsided, the trains waiting at stations will detrain passengers.
- For the trains held up between stations, TOs to visually check the track. If the track is unaffected and there are no visible obstruction after informing OCC/TC, train can be moved at walking speed up to the next station where passengers shall be detrained.
- Train Operator (TO) will keep passengers informed of the problem and request them to maintain calm.

In case of any doubt, OCC will arrange for passenger evacuation on the right of way as per procedure. Normal operation of revenue trains shall only be resumed after the track and structures department issuing of a certificate of fitness for normal operations which will be issued after detailed physical inspection. OCC and Station Superintendent/Station Controllers will continuously inform passengers of the situation and likely time for commencement of train services.

16.7 SECURITY MEASURES, ESSENTIALS OF SECURITY MANAGEMENT, SECURITY SYSTEM DESIGN PARAMETER.

16.7.1 Security Measures & Essentials of Security Management

Metro Rail System has emerged as the most reliable mode of urban transportation system in India. The inherent characteristics of metro system make it an ideal target for terrorists and miscreants. Metro systems are typically open and dynamic systems which carry thousands of commuters. Moreover, high cost of infrastructure, its economic impacts to the society, being the life line of city with high news value pose greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally and differs from safety which addresses problems caused accidentally. Security problems or threats are

caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and terror threat.

The public transportation system is increasingly becoming important for urban areas to prosper in the face of challenges such as reduction in congestion and pollution. Therefore, security system for public transportation like metro rail plays an important role in helping the system to become the preferred mode choice for commuters. Therefore, provision of an excellent and reliable security system is a prerequisite for metro system for increasing its market share. Metro railway administration must ensure that security model keep pace with the rapid expansion of the metro and changing security scenario.

16.7.2 Security System Design Parameter

Security means protection of human, intellectual assets and infrastructure either from criminal interference, destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. Three important pillars of security are as follows:

- The Human factor;
- Procedures; and
- Technology

Staff interaction with passengers create a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective, staff has to be qualified, trained, well equipped and motivated. The staff members should be skillful, trained, drilled and experienced. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed, communicated and tested in advance. There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems differ i.e., detection of the plan before an attack, deny the access for carrying out an attack and mitigation measures after an attack.

16.7.3 Different Phases of Security

There are three different phases associated with the security system in metro. These phases are as under:

i. Prevention

These are the measures which can prevent a security breach from taking place. These can be identified by conducting risk assessment and gathering intelligence. Prevention begins with the daily operational security problems. Care has to be given in controlling unused, damaged properties which could otherwise prove to be a breeding ground for more serious crimes.

ii. Preparedness

Plans have to be prepared to respond to incidents and to mitigate the impacts. Staff have to be accordingly trained to carry out the exercises. The results of the risk assessment will give basis for such plans.

iii. Recovery

Urban transport system should have laid down procedures/instructions for quick recovery of normal service after an incident. Financial health is important for the recovery operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should also include an evaluation process for the lessons learnt.

16.7.4 Responsibilities and Partnerships

The responsibility of the Security lies with the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the State Government to ensure secured travel in Gurugram Metro.

16.8 SECURITY SYSTEMS RECOMMENDED FOR GURUGRAM METRO

For providing an efficient security system in metro station areas the following provisions are suggested:

- i. CCTV coverage of all metro stations with provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations.
- ii. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowded stations i.e at interchange may also be required.
- iii. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per

AFC array). The number can increase in view of the footfall at over crowded stations.

- iv. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station.
- v. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of DMRC.
- vi. Bomb Blanket at least one per station and depot.
- vii. Wireless sets (Static and Handheld) as per requirement of security agency.
- viii. Dragon light at least one per metro station.
- ix. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
- x. Dog Squads (Sniffer Dog), at least one dog for 4 metro stations. Dog Kennels alongwith provision for dog handlers and MI room will also be provided by metro train depot administration including land at suitable places line wise.
- xi. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration.
- xii. Bullet proof jackets and helmets for Quick Response Team (QRTs) and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 metro stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.
- xiii. Furniture to security agency for each security room and checking point at every entry point at stations. Scale is one office table with three chairs for security room & office and one steel top table with two chairs for checking point.
- xiv. Ladies frisking booth - 1 per security check point (AFC) Wooden Ramp - 1 per DFMD for security check points.
- xv. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.
- xvi. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.
- xvii. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.
- xviii. Iron grill at station entrance staircases, proper segregation of paid and unpaid areas by providing appropriate design grills etc.
- xix. Proper design of emergency staircase and fireman entry to prevent unauthorized entry.

Chapter – 17

DETAILED PROJECT COST ESTIMATES

17. DETAILED PROJECT COST ESTIMATES

17.1 CAPITAL COST ESTIMATE

17.1.1 Coverage

Cost estimate for Gurgaon Metro corridor has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. at Sept' 2021 price level.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) Route km length of alignment, (ii) Number of units of that item and (iii) Item being an independent entity. All items related with alignment, construction, permanent way, Traction, Signaling & Telecommunication, whether in main lines or in maintenance depot, have been estimated at rate per Route km/km basis.

Cost of station structures, other electrical services at these stations have been assessed in terms of each station as a unit. Similarly, for items like Rolling stock costs have been estimated in terms of number of units required for each item. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed based on each item, taken as an independent entity. Automatic Fare Collection (AFC) installations at all stations has been considered through PPP.

Basic cost is exclusive of taxes and duties. i.e. GST and Custom duty. Taxes and duties mainly comprising of latest prevalent GST & Custom duty are worked out for each corridor. Current rates of Taxes and circular of MoHUA, GOI for Minimum Local Content (MLC) have been taken into consideration.

17.1.2 Land Requirements

- a) Finalization of alignment, location of stations, entry / exits etc. has been done with the objective of keeping land requirement to the bare minimum. For this purpose, alignment, stations and depots have been planned in the Govt. land to the extent possible. One Stabling Depot has been planned at Private land at Sector-101. The summary of land requirement is given in **Table 17.1**.

TABLE 17.1: LAND & STRUCTURES REQUIREMENT (IN SQM)

Ownership	Purpose	Permanent Land (Sqm)	Temporary Land (Sqm)	Structures (Floor Area) (Sqm)
Central Govt.	Alignment / Stations, ancillary buildings & Misc.	1047	0	118
	Sub-Total	1047	0	118
State Govt.	Alignment / Stations, ancillary buildings & Misc.	41919	0	1221
	TSS	3000	0	0
	Construction Yards	0	45000	0
	Sub-Total	44919	45000	1221
Private	Alignment / Stations, ancillary buildings & Misc.	10291	0	1767
	Stabling Depot	55000	0	0
	Sub-Total	65291	0	1767
TOTAL		111257	45000	3106

- b) Rate of Central Govt. land required on permanent basis has been taken from Circle rates (2021-22). No solatium has been applied to the basic land cost.
- c) State Govt. land has been considered free of cost.
- d) Rate of Private land is based upon Circle rates (2021-22). 100% solatium has been applied to the basic land cost. No administrative cost is added towards land acquisition activities, as it is understood that this activity shall be carried out by State Govt. from its own resources.

The total cost of Land works out to be **Rs. 208.52 Crore**. The detail of land cost is given in **Table 17.9** to **Table 17.11**.

17.1.3 Items other than Land:

The rates of items other than land has been finalized on the basis of benchmarking exercise undertaken by MoHUA for similar works. No escalation has been considered on the benchmarked rates. The rates of cost components at Sept'2021 price level are given in **Table 17.2**.

TABLE 17.2: RATES OF ITEMS OTHER THAN LAND

Item No.	Item	Unit	Rates (Rs. In Crore)
2.0	Alignment and Formation		
2.1	Elevated section (Viaduct) including in station portion - Main Corridor	R. Km.	37.00
2.2	Elevated Section (Special Span -34m+45m+34m = 113m)	Each	15.58

Item No.	Item	Unit	Rates (Rs. In Crore)
2.3	Elevated Section (Special Span -34m+60m+34m = 128m)	Each	17.65
2.4	Elevated Section (Special Span - 34m+45m+75m+45m+34m = 233m)	Each	32.12
3.0	Station Buildings		
3.1	Elevated Station Buildings		
a	Elevated station (Civil including finishes) excluding Viaduct in Station portion	Each	26.00
b	Elevated station (E&M including lift & escalator)	Each	8
4.0	Maintenance Depot		
a	Civil works (Stabling Depot)	LS	55.00
b	EM works + Machinery & Plant + General Works	LS	25.00
5.0	P-Way		
5.1	Ballastless track for elevated section	Route Km.	6.60
5.2	Ballasted track for Depot	Track Km.	3.90
6.0	Traction & power supply (750V DC Third Rail)		
6.1	Elevated section including SCADA	R. Km.	11.00
6.2	For Depot	Track Km.	3.00
7.0	Signaling and Telecom		
7.1	Signaling – Main Corridor	R. Km.	4.40
7.2	Telecommunication - Station	Per Station	4.50
8.0	Environment and R & R incl. Hutments etc.		
a	Environmental Cost	As per details given in Chapter 15	
b	R & R		
9.0	Misc. Utilities		
a	Civil works	R. Km.	3.00
b	Electrical Works	R. Km.	3.00
10.0	Capital Expenditure on Security		
a	Civil works	Per Station	0.30
b	EM works	Per Station	0.07
11.0	Capital Expenditure on Inter modal integration including Footpath for pedestrians	Per Station	3.00
12.0	Rolling Stock	Each	8.00

17.2 INNOVATIONS PROPOSE TO REDUCE THE COST

Double U-girder viaduct has been proposed for the construction which is presently being used in most of the Metro system.

17.3 COSTING OF ENTIRE PROJECT

17.3.1 Corridor-wise Capital Cost Estimate

Detailed capital cost estimate for Corridor is given in **Table 17.3**.

TABLE 17.3: CAPITAL COST ESTIMATE

Total Length = 28.50 Km,

Main corridor (Elev) = 26.65 Km, Spur to Dwarka Expressway (Elev) = 1.85 Km,

Total Stations = 27, On Main Corridor (Elev) = 26 No's, On Spur (Elev) - 01 No.

September' 2021, Price Level (Rs. In Crores)

S. No.	Item	Unit	Rate	Qty.	Amount
1.0	Land				
a	Central Govt. Land -Permanent (for Alignment, Depot, stations, without Solatium)	Ha	LS	0.10	2.30
b	Central Govt. Land -Temporary	Ha	LS	0.00	0.00
c	Central Govt. Structures- Permanent	Ha	LS	0.01	0.10
d	State Govt. Land -Permanent (for Alignment, TSS, Stations, without Solatium)	Ha	LS	4.49	0.00
f	State Govt. Land -Temporary	Ha	LS	4.50	0.00
g	State Govt. Structures -Permanent	Ha	LS	0.12	0.98
h	Private Land -Permanent (for Alignment, Depot, Stations, including Solatium)	Ha	LS	6.53	203.65
j	Private Structure - Permanent including Solatium	Ha	LS	0.18	1.49
	Sub Total (1)				208.52
2.0	Alignment and Formation				
2.1	Elevated section (Viaduct) including in station portion (Two-tracks) - Main Corridor	R. Km.	37.00	25.16	931.05
2.2	Elevated section (Viaduct) including in station portion (Single track) - Main Corridor (Shyam Chowk to Moulisari Avenue)	R. Km.	20.00	1.18	23.60
2.3	Elevated section (Viaduct) including in station portion (Single track) - Main Corridor (Shyam Chowk to Vodafone Belvedere)	R. Km.	20.00	0.36	7.10
2.4	Elevated section (Viaduct) including in station portion (Two-tracks) - Spur to Dwarka Expressway	R. Km.	37.00	1.85	68.45
2.5	Elevated Section (Special Span - 34m+45m+34m = 113m)	Each	15.58	2.00	31.16

S. No.	Item	Unit	Rate	Qty.	Amount
2.6	Elevated Section (Special Span - 34m+60m+34m = 128m)	Each	17.65	2.00	35.29
2.7	Elevated Section (Special Span - 34m+45m+75m+45m+34m = 233m)	Each	32.12	1.00	32.12
2.8	Entry to Depot	R. Km.	37.00	0.60	22.20
	Sub Total (2)				1150.97
3.0	Station Buildings				
3.1	Elevated Station including finishes (Type - I: 130mx20m)				
a	Elevated station (Civil including finishes) excluding Viaduct in Station portion	Each	26.00	26.00	676.00
b	Elevated station (E&M including lift & escalator)	Each	8.00	26.00	208.00
3.2	Elevated Station including finishes (Type - II: 130mx28m - Single Platform and Single level at Cyber City)				
a	Elevated station (Civil including finishes) excluding Viaduct in Station portion	Each	26.00	1.00	26.00
b	Elevated station (E&M including lift & escalator)	Each	8.00	1.00	8.00
	Sub Total (3)				918.00
4.0	Maintenance Depot				
a	Civil works (Stabling Depot)	LS			55.00
b	EM works + Machinery & Plant + General Works	LS			25.00
	Sub Total (4)				80.00
5.0	P-Way				
5.1	Ballastless track for elevated section (two tracks)	Route Km.	6.60	25.30	166.98
5.2	Ballastless Track for Spur to Dwarka Expressway (two Tracks)	Route Km.	6.60	1.85	12.21
5.3	Ballastless track for elevated section (Single track)	Track Km.	3.30	1.75	5.78
5.4	Ballastless track for entry to Depot	Route Km.	6.60	0.60	3.96
5.5	Ballasted track for Depot	Track Km.	3.90	6.00	23.40
	Sub Total (5)				212.33
6.0	Traction & power supply (750V DC Third Rail)				
6.1	Elevated section including SCADA (Two Tracks)	R. Km.	11.00	25.30	278.30
6.2	Elevated section including SCADA for Spur to Dwarka Expressway (Two Tracks)	R. Km.	11.00	1.85	20.35
6.3	Elevated section including SCADA (Single Track)	Track Km.	5.50	1.75	9.63
6.4	For entry to Depot	R. Km.	11.00	0.60	6.60
6.5	For Depot	Track Km.	3.00	6.00	18.00
6.6	RSS/TSS	Each	25.00	2.00	50.00
	Sub Total (6)				382.88
7.0	Signaling and Telecom.				
7.1	Signaling - Main Corridor	R. Km.	4.40	28.50	125.40

S. No.	Item	Unit	Rate	Qty.	Amount
7.2	Signaling - Depot	Track Km.	3.20	6.00	19.20
7.3	Signaling - On Board Equipment	Per Train	1.70	53.00	90.10
7.4	Signaling - Upgradation on existing Rapid Metro	R. Km.	3.00	10.00	30.00
7.5	Telecommunication - Station	Per Station	4.50	27.00	121.50
7.6	Telecommunication - Depot	Per Depot	3.50	2.00	7.00
7.7	Automatic fare collection	Per station	through PPP		
	Sub Total (7)				393.20
8.0	Environment and R & R incl. Hutments etc.				
a	Environmental Cost	As per details given in Chapter 15			11.97
b	R & R				2.90
	Sub Total (8)				14.87
9.0	Miscellaneous Utilities				
a	Civil works	R. Km.	3.00	28.50	85.50
b	Electrical Works	R. Km.	3.00	28.50	85.50
	Sub Total (9)				171.00
10.0	Capital Expenditure on Security				
a	Civil works	Per Station	0.30	27.00	8.02
b	EM works	Per Station	0.07	27.00	1.91
	Sub Total (10)				9.92
11.0	Capital Expenditure on Inter modal integration including Footpath for pedestrians	Per Station	3.00	27.00	81.00
12.0	Rolling Stock	Each	8.00	81.00	648.00
13.0	Total of all items except Land and R&R				4059.26
14.0	General Charges including Design charges, incl. Metro Bhawan (Civil+EM works) @ 5% on all items except land and R&R				202.96
15.0	Total of all items including G. Charges except Land and R&R				4262.23
16.0	Contingencies @ 3 % on all items except land and R&R				127.87
17.0	Gross Total including Contingencies (excluding Land and R&R Cost)				4390.09
18.0	Gross Total including Contingencies (including Land and R&R Cost)				4601.51
19.0	Central GST & Basic Customs duty				311.25
20.0	State GST				276.45
21.0	Total Cost including Taxes & Duties				5189.21

TABLE 17.4: COST COMPONENT UNDER PPP

September' 2021, Price Level (Rs. In Crores)

S. No.	Item	Unit	Rate	Qty.	Amount
1.0	Automatic fare collection	Per station	3.50	27.00	94.50
2.0	General Charges including Design charges@ 5%				4.73
3.0	Total of all items including G. Charges				99.23
4.0	Contingencies @ 3 % on all items including GC				2.98
5.0	Total including Contingencies & GC				102.20
6.0	Central GST & Basic Customs duty				10.98
7.0	State GST				8.06
8.0	Total Cost including Taxes & Duties				121.24

17.3.2 Taxes and Duties

Taxes and duties are worked out separately. Current rates of GST (i.e. 12% on Metro projects) have been taken into consideration and have been applied as per prevalent practice. Components of Taxes & duties considered for calculation are shown in **TABLE 17.5**. Custom Duty has been calculated on various components duly considering the circular dated 14.10.2020 of MoHUA, GOI on Minimum Local Content (MLC) (**Annexure-1**) Taxes & duties for Corridor have been worked out in **Table 17.6**.

TABLE 17.5: TAXES AND DUTIES COMPONENTS

S.NO.	TAX COMPONENT		%
1	BASIC CUSTOMS DUTY	=	5.1500%
2	CGST CUSTOMS DUTY	=	9.4635%
3	SGST CUSTOMS DUTY	=	9.4635%
4	TOTAL CUSTOMS DUTY	=	24.0770%
5	GENERAL IGST	=	12.0000%
6	GENERAL CGST	=	6.0000%
7	GENERAL SGST	=	6.0000%

TABLE 17.6: TAXES AND DUTIES

(Rs. In Crores)

S. No.	Description	Total cost without Taxes & duties	Taxes and duties							
			Basic Customs Duty	IGST (CGST portion)	IGST (SGST portion)	Total Customs Duty	CGST	SGST	Total GST (CGST & SGST)	Total Taxes & Duties
1	Alignment & Formation									
	Elevated	1150.97	0.00	0.00	0.00	0.00	69.06	69.06	138.12	138.12
2	Station Buildings									
	Elevated station - civil works	702.00	0.00	0.00	0.00	0.00	42.12	42.12	84.24	84.24
	Elevated station-EM works	216.00	2.22	4.09	4.09	10.40	10.37	10.37	20.74	31.14
3	Depot									
	Civil works	55.00	0.57	1.04	1.04	2.65	2.64	2.64	5.28	7.93
	EM and M&P works	25.00	0.26	0.47	0.47	1.20	1.20	1.20	2.40	3.60
4	P-Way	212.33	2.19	4.02	4.02	10.22	10.19	10.19	20.38	30.61
5	Traction & power supply									
	Traction and power supply	382.88	9.86	18.12	18.12	46.09	11.49	11.49	22.97	69.06
6	S and T Works									
	S & T	246.90	6.36	11.68	11.68	29.72	7.41	7.41	14.81	44.54
	AFC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Environmental Works	11.97	0.00	0.00	0.00	0.00	0.72	0.72	1.44	1.44

S. No.	Description	Total cost without Taxes & duties	Taxes and duties							
			Basic Customs Duty	IGST (CGST portion)	IGST (SGST portion)	Total Customs Duty	CGST	SGST	Total GST (CGST & SGST)	Total Taxes & Duties
8	Miscellaneous Utilities									
	Civil works	85.50	0.00	0.00	0.00	0.00	5.13	5.13	10.26	10.26
	EM works	85.50	0.00	0.00	0.00	0.00	5.13	5.13	10.26	10.26
9	Security									
	Civil works	8.02	0.00	0.00	0.00	0.00	0.48	0.48	0.96	0.96
	EM works	1.91	0.00	0.00	0.00	0.00	0.11	0.11	0.23	0.23
10	Intermodal Integration	81.00	0.00	0.00	0.00	0.00	4.86	4.86	9.72	9.72
11	Rolling stock	648.00	13.35	24.53	24.53	62.41	23.33	23.33	46.66	109.06
12	Rent on Temporary Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	General Charges	202.96	0.00	0.00	0.00	0.00	18.27	18.27	36.53	36.53
14	Total	4115.93	34.80	63.95	63.95	162.70	212.50	212.50	425.00	587.70
Rate of Taxes & Duties on Total cost without taxes & duties										14.28%
Total Central GST & Basic Customs duty										311.25
Total State GST										276.45
Total Taxes & Duties										587.70

17.4 SUMMARY OF CAPITAL COST

17.4.1 Summary of Capital Cost

The abstract of capital cost estimate is given in **TABLE 17.7**.

TABLE 17.7: ABSTRACT OF COST ESTIMATE

September'21 Price Level (Rs. In Crores)

S. No.	Item	Amount
1	Land	208.52
2	Alignment and Formation	1150.97
3	Station Buildings	918.00
4	Depot	80.00
5	P-Way for main line & depot	212.33
6	Traction & power supply	382.88
7	Signaling and Telecom	393.20
8a	Environment	11.97
8b	R & R incl. Hutments etc.	2.90
9	Misc. Utilities	171.00
10	Capital Expenditure on Security	9.92
11	Capital Expenditure on Inter modal integration	81.00
12	Rolling Stock	648.00
13	Total of all items except Land and R&R	4059.26
14	General Charges including Design charges @ 5% on all items except land and R&R	202.96
15	Total of all items including G. Charges except land and R&R	4262.23
16	Contingencies @ 3 %on all items except land and R&R	127.87
Gross Total including Contingencies (excluding Land and R&R Cost)		4390.09
Gross Total including Contingencies (including Land and R&R Cost)		4601.51
Central GST & Basic Customs duty		311.25
State GST		276.45
Total Cost including Taxes & Duties		5189.21

17.5 ESTIMATIONS OF OPERATIONS AND MAINTENANCE COST

The Operation and Maintenance cost for Gurugram Metro Corridor is worked under three major heads:

- Staff cost
- Maintenance cost which includes expenditure towards upkeep and maintenance of the system and consumables and
- Energy cost

17.5.1 Staff Cost

The O&M staff is assumed to be provided @ 35 persons per kilometer and the annual cost this account is estimated considering average staff salary of Rs. 8.47 Lakhs per annum in the year 2019. The escalation factor used for staff costs is 9% per

annum to provide for growth in salaries. The staff cost is estimated to be Rs. 130.06 Cr in the inception year i.e. 2026. No escalation has been considered till the start of construction period i.e. 2022.

17.5.2 Maintenance Expenses

Maintenance expenses are taken @ Rs. 1.82 Crores/km in the year 2019. Maintenance cost for Gurugram Metro corridor would be Rs. 66.20 Crores for in the inception year i.e. 2026 considering escalation @ 5% p.a. for every year of operation. No escalation has been considered till the start of construction period.

17.5.3 Energy Charges

The energy consumption to meet the traction and non-traction power requirement is based on traffic demand for different horizon years. The cost of electricity is a significant part of O&M charges, constituting about 20-30% of total annual working cost. The traction power tariff is taken @ Rs. 6.25 per kVAh and fixed charge is taken as Rs. 160/kVA/month in the year 2019, which is escalated @ 5% every year of operation. Annual energy consumption charges have been estimated as Rs. 54.91 Crores in year 2026, Rs. 93.20 Crores in 2031 and Rs. 181.11 Crores in 2041.

17.5.4 Additional Investment

To cater to increased traffic demand, additional investment will have to be made for purchase of additional coaches. The additional investment works out to **Rs. 994.70 Crores for purchase of 102 additional coaches in the year 2031** and **Rs. 641.93 Crores** for 54 additional coaches in year 2041.

These additional investment costs for Rolling Stock have been worked out considering an escalation factor of 2% per annum. No escalation has been considered till the start of the construction period i.e. year 2021.

17.5.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipments due to wear and tear. With the nature of equipment proposed to be provided for the corridor, it is expected that about 25% of the equipment comprising Electrical, Rolling stock and 50% of Signalling & Telecom would require replacement/rehabilitation after 20 years.

The replacement cost for the Gurugram corridor works out to be **Rs. 1910.29 Crores** in year 2045. The replacement cost has been worked out considering an escalation

factor of 5% per annum. No escalation has been considered till the start of construction period i.e. year 2021.

The year wise total Operation and Maintenance cost for the corridors of Gurugram MRTS is indicated in **Table 17.8**.

TABLE 17.8: O&M COST FOR GURUGRAM METRO CORRIDOR

Year	Staff Cost Esc @9%	Maintenance Expenses Esc @5%	Energy Charges Esc @5%	Total O&M cost (Cr.)	Addition/ Replacement Cost (Cr.)	
2026	130.06	66.20	54.91	251.17		
2027	141.77	69.51	61.46	272.74		
2028	154.53	72.99	68.53	296.05		
2029	168.44	76.64	76.14	321.22		
2030	183.60	80.47	84.33	348.40		
2031	200.12	84.49	93.20	377.81	994.70	Addition of 102 coaches
2032	218.13	88.71	99.76	406.60		
2033	237.76	93.15	106.77	437.68		
2034	259.16	97.81	114.17	471.14		
2035	282.48	102.70	122.06	507.24		
2036	307.90	107.84	130.47	546.21		
2037	335.61	113.23	139.39	588.23		
2038	365.81	118.89	148.87	633.57		
2039	398.73	124.83	158.99	682.55		
2040	434.62	131.07	169.70	735.39		
2041	473.74	137.62	181.11	792.47	641.93	Addition of 54 coaches
2042	516.38	144.50	193.24	854.12		
2043	562.85	151.73	206.12	920.70		
2044	613.51	159.32	219.86	992.69		
2045	668.73	167.29	234.41	1070.43	1910.29	Replacement of 25% of Elec. & 50% S&T assets
2046	728.92	175.65	249.87	1,154.44		
2047	794.52	184.43	266.30	1,245.25		
2048	866.03	193.65	283.71	1,343.39		
2049	943.97	203.33	302.24	1,449.54		
2050	1028.93	213.50	321.93	1564.36		
2051	1121.53	224.18	342.82	1688.53		
2052	1222.47	235.39	364.95	1822.81		
2053	1332.49	247.16	388.45	1968.10		
2054	1452.41	259.52	413.39	2125.32		
2055	1583.13	272.50	439.91	2,295.54		
2056	1725.61	286.13	467.95	2479.69		

TABLE 17.9: LAND COST FOR VAIDUCT/RUNNING SECTION

S. No.	Location	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (sqm)	Rate (Rs.)	Amount (Rs.)
1	Near Hero Honda Chowk	RS-01	79	39468	78,936.00	62,35,944	Private	Viaduct	G+0	79	8600	679400
2	Near Pace Hotel Hero Honda Road	RS-02	110	0		-	Govt. (State)	Viaduct	Nil	0		
3	Near Pace Hotel, Hero Honda Road	RS-03	166	39468	78,936.00	1,31,03,376	Private	Viaduct	G+3 (Hotel Pace) Partly affected	280	8600	2408000
									Balaji G+0 and Tin Shed	90	5000	450000
4	Near Vikas Nagar Chowk	RS-04	888	0		-	Govt. (State)	Viaduct	Ciara Industry and 4nos G+1 Partially affected	212	8600	1823200
5	Before Basai Chowk	RS-05	109	35880	71,760.00	78,21,840	Private	Viaduct	Ciara Industry and 4nos G+1 Partially affected Tin Shed	212 15	8600 5000	1823200 75000
6	Before Basai Chowk	RS-06	15	35880	1,760.00	10,76,400	Private	Viaduct	Nil	0		
7	Basai Village	RS-07	79	35880	1,760.00	56,69,040	Private	Viaduct	Nil	0		
8	Basai Village	RS-08	112	0		-	Govt. (State)	Viaduct	Shyam Intl (G+3)	84	8600	722400
9	Basai Village	RS-09	28	35880	71,760.00	20,09,280	Private	Viaduct	Nil	0		
10	After Basai Village station	RS-10	545	0		-	Govt. (State)	Viaduct	Nil	0		
11	After Basai Village station	RS-11	257	35880	71,760.00	1,84,42,320	Private	Viaduct	House (G+0)	15	8600	129000
12	After Basai Village on Neki Ram Marg	RS-12	208	41860	83,720.00	1,74,13,760	Private	Viaduct	Nil	0		
13	After Sector -7 station	RS-13	6	41860	83,720.00	5,02,320	Private	Viaduct	2G+1 Corner affected	10	8600	86000
14	After Sector -7 station	RS-14	6	41860	83,720.00	5,02,320	Private	Viaduct	No 949/4 & 950/4, G+0, Partly affected	440	8600	3784000
15	Sector 4-7 chowk	RS-15	423	41860	83,720.00	3,54,13,560	Private	Viaduct	Nil	0		

S. No.	Location	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (sqm)	Rate (Rs.)	Amount (Rs.)
16	Near Sant Baba Prakash Puri Chowk	RS-17	51	0		-	Govt. (State)	Viaduct	Nil	0		
17	Near Carterpuri Chowk	RS-18	5	0		-	Govt. (State)	Viaduct	Corner of discovery wines G+0	5	5000	25000
18	Rezang La chowk	RS-19	54	0		-	Govt. (State)	Viaduct	Kishan Mandi Shed	40		0
19	After Sector 22 station	RS-20	432	0		-	Govt. (State)	Viaduct	Guard Room	8	8600	68800
20	After Udyog Vihar Ph- V Station	RS-21	51	43056	86,112.00	43,91,712	Private	Viaduct	Nil	0		
21	After Udyog Vihar Ph- V Station	RS-22	134	0		-	Govt. (State)	Viaduct	G+0 Bldg	121	8600	1040600
22	After Udyog Vihar Ph- V Station	RS-23	500	0		-	Govt. (State)	Viaduct	Nil	0		0
23	Before NH -8 Crossing	RS-24	293	0		-	Govt. (State)	Viaduct	Nil	0		0
24	After crossing NH-8 (RHS Track)	RS-25	474	0		-	Govt. (State)	Viaduct	Nil	0		0
25	After crossing NH-8 (RHS Track)	RS-26	284	0		-	Govt. (State)	Viaduct	G+0 Bldg	121	8600	1040600
26	Before cyber city station	RS-27	221	47362	94,723.20	2,09,33,827	Private	Viaduct	Nil	0		
27	Before cyber city station	RS-28	137			-	Govt. (State)	Viaduct	Nil	0		
28	Before cyber city station	RS-29	888			-	Govt. (State)	Viaduct	Nil	0		
29	After cyber city station	RS-30	872			-	Govt. (State)	Viaduct	Nil	0		
30	After cyber city station	RS-31	2119			-	Govt. (State)	Viaduct	Nil	0		
31	After Shankar chowk	RS-32	144			-	Govt. (State)	Viaduct	Nil	0		

S. No.	Location	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (sqm)	Rate (Rs.)	Amount (Rs.)
32	DLF Cyber City after NH-8 Crossing (LHS Track)	RS-33	431	0		-	Govt. (State)	Viaduct	3 Nos (G+1)	172	8600	1479200
33	After Basai Village station	RS-34	756	16744	33,488.00	2,53,16,928	Private	Viaduct	Nil	0		
34	After Basai Village station	RS-35	645	16744	33,488.00	2,15,99,760	Private	Viaduct	Nil	0		
35	After Basai Village station	RS-36	583	16744	33,488.00	1,95,23,504	Private	Viaduct	Nil	0		
36	Dhobi Ghat Before Railway Track	RS-37	200	16744	33,488.00	66,97,600	Private	Viaduct	Nil	0		
37	After Railway Track to Sector 101 station	RS-38	826	0		-	Govt. (State)	Viaduct	Nil	0		
38	Near Sector-101	Depot Entry	4529	13156	26,312	11,91,67,048	Private	Depot entry				
				Total Amount in Cr.		32.58						1.38

TABLE 17.10: LAND COST FOR STATIONS

S. No.	Station	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (Sqm)	Rate (Rs.)	Amount (Rs.)
1	Huda City Centre	ST-01	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-01A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
2	Sector -45	ST-02	201	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-02A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-02B	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
3	Cyber Park	ST-03	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-03A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
4	Sector -46	ST-04	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-04A	181	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		

S. No.	Station	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (Sqm)	Rate (Rs.)	Amount (Rs.)
		ST-04B	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
5	Subhash Chowk	ST-05	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-05A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-05B	4780	-		-	Govt (State)	Parking				
6	Sector -48	ST-06	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-06A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
7	Sector 72A (Future)	ST-07	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-07A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
8	Hero Honda Chowk	ST-08	199	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-08A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
9	Udyog Vihar Phase-6 Station	ST-09	64	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-09A	99	39468	78,936	78,14,664	Private	Station Building	2 Tin Shed	47	5000	235000
									1 G+2	81	8600	696600
									1 G+0	30	8600	258000
		ST-09B	637	-		-	Govt (State)	Station Building	Nil	0		
ST-09C	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0				
10	Sector 10 station	ST-10	902	-		-	Govt (State)	Station Building	1 G+0	344	8600	2958400
		ST-10A	364	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-10B	200	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
11	Sector 37 Station	ST-11	449	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-11A	113	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-11B	256	50232	1,00,464	2,57,18,784	Private	Entry/Exit, Lift etc	Nil	0		
		ST-11C	3865	-		-	Govt (State)	Parking	1 (G+0)	466	8600	4007600
Tin shed	255								5000	1275000		
12	Basai Village	ST-12	186	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-12A	186	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-12B	45	-		-	Govt (State)	Station Building	Nil	0		
		ST-12C	61	-		-	Govt (State)	Station Building	Nil	0		
		ST-12D	143	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-12E	237	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
13	Sector 09	ST-13A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-13A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		

S. No.	Station	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (Sqm)	Rate (Rs.)	Amount (Rs.)
14	Sector 07	ST-14	180	41860		75,34,800	Govt. (Central)	Entry/Exit, Lift etc	Nil	0		
		ST-14A	206	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-14 B	499	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
15	Sector 04	ST-15	488	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-15 A	181	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
16	Sector 05	ST-16	389	161460	3,22,920	12,56,15,880	Private	Entry/Exit, Lift etc	Shops (G+0)	107	8600	920200
		ST-16 A	182	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-16 B	370	41860		1,54,88,200	Rly Govt. (Central)	Entry/Exit, Lift etc	Toilet (G+0)	118	8600	1014800
		ST-16 C	3970	-		-	Govt (State)	Parking	Nil	0		
17	Ashok Vihar	ST-17	141	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-17A	214	53820	1,07,640	2,30,34,960	Private	Entry/Exit, Lift etc	Bldg (G+0)2	46	8600	395600
		ST-17B	216	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
18	Sector-3	ST-18	240	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-18A	359	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
19	BAJGHERA ROAD	ST-19	323	41860	83,720	2,70,41,560	Private	Entry/Exit, Lift etc	G+0,	7	8600	60200
		ST-19A	288	41860	83,720	2,41,11,360	Private	Entry/Exit, Lift etc	Nil	0		
20	Palam Vihar Extension	ST-20	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-20A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
21	Palam Vihar	ST-21	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-21A	361	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-21B	4500	-		-	Govt (State)	Parking	Nil	0		
22	Sector 23 A	ST-22	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-22A	361	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
23	Sector 22	ST-23	361	41,860	83,720	3,02,22,920	Private	Entry/Exit, Lift etc	Nil	0		
		ST-23A	361	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
24	Udyog Vihar Phase-IV	ST-24	199	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		

S. No.	Station	Plot No.	Area (Sqm)	Rate (Rs.)	Rate including 100% Solatium on Private land	Amount (Rs.)	Ownership (Govt./ Pvt.)	Purpose	Properties Affected	Floor Area (Sqm)	Rate (Rs.)	Amount (Rs.)
		ST-24A	355	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
25	Udyog Vihar Phase-V	ST-25	335	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-25A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
26	Cyber City station	ST-26	2400	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
27	Dwarka Expressway station	ST-26	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
		ST-26A	198	-		-	Govt (State)	Entry/Exit, Lift etc	Nil	0		
				Total Amount in Cr.		28.66						1.18

TABLE 17.11: LAND COST FOR DEPOT

S. No.	Plot No.	Location	Land Ownership	Area (Sqm)	Cost per Sqm (Rs.)	Rate including 100% Solatium on Private land (Rs.)	Amount in Cr
1	Depot-1	Sector -101	Private	55000	13156	26312	144.72

Annexure-1

33245/2021/O/O US(MRTS-I) No. K-14011/08/2017/MRTS-Coord
Government of India
Ministry of Housing and Urban Affairs
(MRTS-Coord Desk)

311-B, Nirman Bhawan, New Delhi,
Dated the 14th October, 2020.

To

Managing Directors of All Metro Rail Corporations
(As per standard list)

Subject: Revision of Minimum Local Content (MLC) of various metro rail components under MII-PPP Order, 2017 of DPIIT

I am directed to refer to the above cited subject and to say that the existing Minimum Local Content (MLC) of various metro rail components issued vide this Ministry's letter of even number dated 13.07. 2018 was reviewed in the last meeting of Managing Directors of various Metro Rail Corporations held on 08.10.2020. The revised minimum local content to be adopted by Metro Rail Companies in the procurement of various components shall be as under:

S. No	Metro Rail Components	Existing % of MLC	Revised % of MLC
1	Rolling Stock	40% which could be increased to 50% from FY-2019	60%
2	Telecom	40% which could be increased to 50% from FY-2020	50%
3	Signaling	30% which could be increased to 40% from FY-2020 and 50% from FY-2023	50%
4	Civil Works (Elevated & Underground)	80%	90% (for Elevated) 80% (for Underground)
5	Electrical and Mechanical	50%	60%

2. The above Minimum Local Content would be for Class-I local supplier under MII-PPP Order of DPIIT. For Class-II local supplier, the Minimum Local Content should be kept at 20% for all components as mentioned in extant MII-PPP Order of DPIIT.

3. This is for information and necessary action.

Yours faithfully,

Rachna

(Rachna Kumar)
Under Secretary to the Govt. of India
Telefax: 2306 2935

Chapter – 18

TRANSIT ORIENTED DEVELOPMENT PLAN

18. TRANSIT ORIENTED DEVELOPMENT PLAN

18.1. NATIONAL TRANSIT ORIENTED DEVELOPMENT (TOD POLICY)

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. TOD integrates land use and transport planning and aims to develop planned sustainable urban growth centers, having walkable and livable communes with high density mixed land-use. Citizens have access to open green and public spaces and at the same time transit facilities are efficiently utilized.

TOD focuses on creation of high density mixed land use development in the influence zone of transit stations, i.e. within the walking distance of (500-800 m) of transit station or along the corridor in case the station spacing is about 1 km. TOD advocates pedestrian trips to access various facilities such as shopping, entertainment and work.

TOD increases the accessibility of the transit stations by creating pedestrian and Non-Motorised Transport (NMT) friendly infrastructure that benefits large number of people, thereby increasing the ridership of the transit facility and improving the economic and financial viability of the system. Since the transit corridor has mixed land-use, where the transit stations are either origin (housing) or destination (work), the corridor experiencing peak hour traffic in both directions would optimize the use of the transit system.

18.2. OBJECTIVES OF TOD

The objectives of TOD include:

- To promote the use of public transport by developing high density zones in the influence area, which would increase the share of transit and walk trips.
- To provide all the basic needs of work/ job, shopping, public amenities, entertainment in the influence zone with mixed land-use development
- To establish a dense road network within the development area for safe and easy movement and connectivity of NMT and pedestrians between various uses as well as to transit stations.
- To achieve reduction in the private vehicle ownership, traffic and associated parking demand.

- To provide all kinds of recreational/entertainment/ open spaces, required for a good quality of life in the influence area.
- To prevent urban sprawl by accommodating the growing population in a compact area with access to the transit corridor, this would also consolidate investments and bring down the infrastructure cost for development.
- To reduce carbon footprints by shifting towards environmentally friendly travel options for the line haul as well as for access and egress trips.

18.3. TOD POLICY AND GUIDELINES IN HARYANA

The Council of Ministers in its meeting held on 17.08.2014 approved a policy document prescribing parameters for creating Transit Oriented Development (TOD) as a means of densification of the corridors along the MRTS Projects and also as a source of generating revenue for financing these MRTS projects. Subsequent to approval of the CMM, the TOD Policy for Haryana State was published vide notification no. CCP(NCR)/TOD/2014/1826 dated 05.09.2014. After incorporating some modifications, the revised TOD Policy document has been notified vide notification no. CCP(NCR)/TOD/2016/343, dated 09.02.2016.

The highlights of TOD Policy are presented in subsequent sections.

18.3.1. Definition of TOD

Transit Oriented Development is essentially any development, macro or micro that is focused around/along a transit node/corridor and facilitates complete ease of access to the transit facility, thereby inducing people to prefer to walk and use public transportation over personal modes of transport.

The primary goals of TOD are to:-

- Reduce/discourage private vehicle dependency and induce public transport use through design, policy measures and enforcement.
- Provide easy public transport access to maximum number of people within walking distance through densification and enhanced connectivity.

In order to ensure optimum utilization of scarce land resources and to provide opportunities for restructuring along MRTS corridors, TOD will be allowed. However, in the first phase, TOD will be allowed on the existing and proposed metro corridors. Identification of new corridors for MRTS shall be done by the Haryana Mass Rapid Transit Corporation (HMRTC). The State Government will approve new corridors on the recommendations of HMRTC and such corridors shall be considered as included in the Annexure to the policy.

18.3.2. Demarcation of TOD Zones

The TOD Zone shall be designated upto 800 metres depth on both sides from the boundaries of the Right of Way (ROW) of the road, on which MRTS corridor is proposed to be provided. This 800 meters proposed TOD Zone has been bifurcated as under, for the purpose of the developments proposed to be carried out:-

- Intense TOD Zone : The first 500 metres
- Transition TOD Zone : Between 500 to 800 metres

It is clarified that MRTS can be constructed either on the central verge of the ROW of the road or on any point/stretch of this road but for the purposes of TOD Zone, 800 metres will be calculated from the boundaries of the ROW of the acquired road irrespective of construction of MRTS on any point in the ROW.

18.3.3. Planning Parameters within TOD Zone

The permissible uses within the TOD Zone are detailed in **TABLE 18.1**. Mixed land use (residential and commercial only) and FAR 3.5/2.5 shall be permitted upto 30% residential component in licenced colonies in commercial zones and upto 30% commercial component in Residential/Industrial/ Institutional zones of Development Plans. Similarly IT/ITES projects approved in residential/industrial zones shall also be eligible under this TOD policy and such re-densification shall be permitted with maximum FAR of 3.5/3.0 with mixed land use upto 30% for commercial/ residential purposes. Charges would be levied as per the category of use and proposed usage of FAR.

The height restrictions shall be subject to the regulations of the Airport Authority of India and structural stability / fire safety compliances as per applicable laws.

TABLE 18.1: PLANNING PARAMETERS WITHIN TOD ZONE

	TOD Zone	Maximum Ground Coverage	FAR	Density (Persons per Acre)
Multi-storeyed group housing	Intense	40%	3.5	600 (+ 10%)
	Transition	40%	2.5	430 (+ 10%)
Integrated commercial /office spaces/ mixed land use	Intense	40%	3.5	-
	Transition	40%	2.5	-
IT/ITes	Intense	40%	3.5	-
	Transition	40%	3.0	-

18.4. VALUE CAPTURE FINANCE (VCF)

18.4.1. Value Capture - Overview

Value capture is based on the principle that private land and other structures in the influence area benefit from public investments in infrastructure and policy decisions of Governments considering change of land use or Floor Space Index. Appropriate value capture tools can be adopted to capture a part of the appreciation in value of land and buildings to be used in project investment. As this additional value is generated by actions other than land owner's direct investment, value capture is distinct from user charges or fees that agencies collect for provision of services.

As per the Value Capture Finance Policy Framework issued by MoHUA, the main types of Value Capture Finance (VCF) methods are given below.

- i. **Land Value Tax:** It is considered the most ideal Value Capture tool which apart from capturing any value increment, helps stabilize property prices, discourage speculative investments.
- ii. **Fees for changing land use (agriculture to non-agriculture):** Land revenue codes provide for procedures to obtain permission for conversion of land use from agricultural to non-agricultural use.
- iii. **Betterment Levy:** One time upfront charge on the land value gain caused by public infrastructure investment. This occurs in two forms - revenue source for improvement schemes and for specific projects.
- iv. **Development Charges (Impact Fees):** These are area based and link the development charge to the market value of land by carrying out periodic revisions.
- v. **Transfer of Development Rights (TDR):** It is used for trading development rights. Many states have enabling laws for using TDRs for developing open spaces, promoting affordable housing etc.
- vi. **Premium on additional FSI/FAR:** It is widely used in many states to allow for additional development rights beyond the permissible limits in the State Town Planning Laws and Regulations.
- vii. **Vacant Land Tax:** It is applicable on those landowners who have not yet initiated construction on their lands

- viii. **Tax Increment Financing:** Tax Increment Financing (TIF) tools are especially useful to finance new investments in existing habitations. In TIF, the incremental revenues from future increases in property tax or a surcharge on the existing property tax rate is ring-fenced for a defined period to finance some new investment in the designated area.
- ix. **Land Acquisition and Development:** Acquiring and developing land could be adopted as a useful Value Capture method to mobilize resources.
- x. **Land Pooling System:** It is a form of land procurement where all land parcels in an area are pooled, converted into a layout, infrastructure developed, and a share of the land, in proportion to original ownership, returned as reconstituted parcels.

The Government of Haryana has the following practices:

- i. Tax on conversion of Land – As per Section 3(1) - HDRUA Act
- ii. Betterment Levy - As per Section 93 - HUDA Act
- iii. Development Charge/Impact Fees – No specific provision, however, a development charge is collected in controlled area (Haryana Municipal Act section 302D(1))
- iv. TDR and incentive FSI – No specific provision
- v. Premium on Relaxation of Rules or Additional FSI – No specific provision
- vi. Charge for regularization of Unauthorised Development – No specific provision
- vii. Vacant Land Tax – No specific provision
- viii. Town Planning Scheme – No specific provision

18.4.2. Value Capture Finance in Gurgaon

From the above mentioned value capture tools, premium on additional FAR is the most widely used source for generating non fare box revenue. Apart from this, additional surcharge on stamp duty is also commonly used source. They have been used in many metros like Nagpur Metro, Thane Metro, Lucknow Metro and Metros in other UP cities. Thus for Gurgaon Metro, following sources of Value Capture Finance have been taken:

- i. Premium on sale of additional FAR
- ii. Additional Surcharge on Stamp Duty

The total revenue generated from each of the tools have been given in subsequent sections.

a. Premium on sale of additional FAR

- As per Haryana Building Code, 2016, maximum permitted FAR is 1.75 and as per TOD policy of Haryana, maximum 3.5 FAR has been permitted in TOD Zone. Therefore, an additional FAR of 1.75 can be sold by the authority to generate additional revenue. It has been assumed that an additional FAR of 1.75 will be consumed in 30 years after the operation of metro starts. The receipt of sale of FAR will be distributed equally @3.3% per year.
- Sale of FAR will be done in the belt of 500 m (intense zone) on either side of the Metro corridor as laid down in TOD policy.
- Sale of FAR has been assumed in 50% of the length of the corridor
- Only 25% of the occupants in this influence zone will opt for purchase of FAR.
- Out of the total influence zone area calculated as above, 20% is excluded for roads
- Rate of land for sale of additional FAR has been assumed as Rs. 4,800/ sq. m (6% of circle rate i.e. 80,000/ sqm) considering that the assumed rate will be attractive for purchasing FAR
- From the above, total FAR available for sale = 0.5 (50% of the length of corridor) x 1000 (width of influence belt) x length of corridor x 0.8 (20% deduction for road area) x 0.25 (only 25% occupants purchasing FAR) x 1.75 (additional FAR).

It is proposed that 35% of yearly projected revenue collection from sale of additional FAR will accrue to Gurgaon Metro (in same lines with Lucknow Metro). Remaining 65% may be used as allied investments in expanding utility capacity to densify areas around the metro stations.

Based on the above assumptions and method, total revenue inflow from sale of additional FAR along the metro corridors has been given in **TABLE 18.2**.

TABLE 18.2: REVENUE ASSESSMENT FROM PREMIUM ON ADDITIONAL FAR

Items	2025	2031	2041	2051
Premium on sale of Additional FAR (Rs. in Cr)	111	149	243	396
Metro Share @35% (Rs. in Cr)	39	52	85	139

b. Additional Surcharge on Stamp Duty

The stamp duty charged upon transactions of developed properties are charged at varying rates for different jurisdiction areas. Stamp duty charges are collected on various kinds of deed registrations and registration charges thereon. In Gurgaon, 6% stamp duty is levied on property transactions. Major portion of these charges invariably come from Sale deed, Conveyance deed and Lease deed. Apart from the stamp duty charges, registration charges are also charged from these heads which vary based on value of property/document/deed to be registered and range between minimum Rs. 100/- to maximum Rs. 50,000/- per deed.

The annual collection of stamp duty in Gurgaon city for the past five years from 2013-14 to 2017-18 has been collected from Registrar Office (**TABLE 18.3**).

TABLE 18.3: STAMP DUTY COLLECTION IN GURGAON CITY

S. No.	Year	Stamp Duty Collection (INR Cr)
1	2013-14	815.35
2	2014-15	892.45
3	2015-16	1116.22
4	2016-17	1167.35
5	2017-18	1644.33

Based on the past growth trends of stamp duty collection, the average growth rate comes out to be 20% which is on very higher side because the figures of 2017-18 are very high as compared to 2016-17. Considering that the stamp duty collection will increase in coming years but at low pace, it has been assumed that expected stamp duty collection in Gurgaon may be expected to grow at a Y-o-Y growth rate of 5%.

Levying additional surcharge on stamp duty has been an important source of non fare box revenue for metro projects. It has been implemented in Nagpur metro and also proposed in Thane metro. In similar lines, 0.5% additional surcharge on stamp duty may be levied in Gurgaon and 35% share of the collected revenue may be accrued to Gurgaon Metro. The estimated revenue to Gurgaon Metro from 0.5% additional surcharge on stamp duty is presented in **TABLE 18.4**.

TABLE 18.4: REVENUE FROM ADDITIONAL SURCHARGE ON STAMP DUTY

S. No.	Year	Stamp Duty Collection at Y-o-Y 5% CAGR (INR Cr)	Revenue from additional 0.5% Surcharge on Stamp Duty (INR Cr)	35% Share to Metro (INR Cr)
1	2013	815		
2	2014	892		
3	2015	1116		
4	2016	1167		

S. No.	Year	Stamp Duty Collection at Y-o-Y 5% CAGR (INR Cr)	Revenue from additional 0.5% Surcharge on Stamp Duty (INR Cr)	35% Share to Metro (INR Cr)
5	2017	1644		
6	2018	1727		
7	2019	1813		
8	2020	1904		
9	2021	1999		
10	2022	2099		
11	2023	2204		
12	2024	2314		
13	2025	2429	202	71
14	2026	2551	213	74
15	2027	2678	223	78
16	2028	2812	234	82
17	2029	2953	246	86
18	2030	3101	258	90
19	2031	3256	271	95
20	2032	3418	285	100
21	2033	3589	299	105
22	2034	3769	314	110
23	2035	3957	330	115
24	2036	4155	346	121
25	2037	4363	364	127
26	2038	4581	382	134
27	2039	4810	401	140
28	2040	5051	421	147
29	2041	5303	442	155
30	2042	5568	464	162
31	2043	5847	487	171
32	2044	6139	512	179
33	2045	6446	537	188
34	2046	6768	564	197
35	2047	7107	592	207
36	2048	7462	622	218
37	2049	7835	653	229
38	2050	8227	686	240
39	2051	8638	720	252
40	2052	9070	756	265
41	2053	9524	794	278
42	2054	10000	833	292
		Total	13451	4708

The total revenue share to Gurgaon Metro from all the above value capture finance tools in different years is given in **TABLE 18.5**.

TABLE 18.5: TOTAL REVENUE SHARE TO GURGAON METRO FROM TOD (VCF)

S. No.	Year	Revenue (INR Cr)		
		Premium on Additional FAR (Share to Metro)	Additional 0.5% Surcharge on Stamp Duty (Share to Metro)	Total
1	2025	39	71	110
2	2026	41	74	115
3	2027	43	78	121
4	2028	45	82	127
5	2029	47	86	134
6	2030	50	90	140
7	2031	52	95	147
8	2032	55	100	155
9	2033	58	105	162
10	2034	60	110	170
11	2035	63	115	179
12	2036	67	121	188
13	2037	70	127	197
14	2038	73	134	207
15	2039	77	140	217
16	2040	81	147	228
17	2041	85	155	240
18	2042	89	162	252
19	2043	94	171	264
20	2044	98	179	278
21	2045	103	188	291
22	2046	109	197	306
23	2047	114	207	321
24	2048	120	218	337
25	2049	126	229	354
26	2050	132	240	372
27	2051	139	252	391
28	2052	146	265	410
29	2053	153	278	431
30	2054	160	292	452
	Total	2589	4708	7297

Chapter – 19

FINANCIAL ANALYSIS AND NON FARE BOX REVENUE ASSESSMENT

19. FINANCIAL ANALYSIS & NON FARE BOX REVENUE ASSESSMENT

19.1 INPUT FOR THE ANALYSIS

The financial analysis has been carried out for the proposed Metro corridor. Project cost includes various associated costs in terms of:

- Capital cost of project
- Operation and Maintenance Costs
- Replacement and capital cost for capacity augmentation

Capital cost of project includes design, civil works, electrical works of traction & power supply, signal and telecommunication, rolling stock and maintenance depot. O&M cost is based on costs of functioning of Delhi, Bangalore and Chennai Metro.

19.1.1 Capital Cost

The cost of land is estimated at **Rs. 208.52 Crore** including Rs. 205.14 Crores for private land and Rs. 3.38 Crores for government land. The cost of R&R is estimated to be **Rs 2.90 Crore**. The total cost of project including land and R&R cost but excluding taxes and duties is estimated at **Rs. 4601.51 Crore**. The Central GST, Basic Customs Duty and State GST amounts to **Rs. 587.70 Crore**. The capital cost components at Sept'2021 prices are given in **Table 19.1**.

TABLE 19.1: CAPITAL COSTS

Cost Component	Amount (Rs. in Crore)
Construction Cost excluding GC, Contingencies, Land and R&R	4059.26
Land Cost	208.52
R & R incl. Hutments	2.90
General Charges and Contingencies	330.83
Construction Cost including land and R&R, GC and contingencies	4601.51
Taxes	587.70
Central GST & Basic Customs Duty	311.25
State GST	276.45
Total Cost including Taxes & Duties	5189.21

19.1.2 Completion Cost

Considering the length Gurgaon Metro, it is expected that the construction will take 4 years, so the operation can start by Year 2026. The phasing of expenditure of 4 years is considered in the ratio 10:30:35:25. For financial analysis both Govt and private land costs have been considered and acquisition of land will require payouts in initial years, land acquisition would be completed in two years with cost phasing of 50:50. It is proposed to start land acquisition and construction work in Year 2022 and commission the system by Year 2026.

With escalation factor of 5% p.a. (on all costs excluding land and R&R), the Completion Cost of the project including taxes & duties but without land and R&R, IDC and Front End Fee is estimated to be **Rs. 5419.18 Crore** and with taxes & duties it is estimated at **Rs. 5758.46 Crore**.

The details of completion cost under different scenarios are as per **Table 19.2**.

TABLE 19.2: DETAILS OF COMPLETION COSTS (Rs in Crore)

Particulars	Completion Cost
Cost without taxes & duties, w/o Land and R&R and w/o contingencies	4762.50
Cost of Contingencies	127.87
Cost of Central and State Taxes	656.68
Cost of Land and R&R	211.42
Cost excl. Land and R&R & w/o Contingencies but with Central & State Taxes	5419.18
Cost with Central & State taxes, Contingencies and Land and R&R	5758.46

The details of escalation in basic cost of project from 2022 price levels to 2025 price levels is shown in **Table 19.3** below.

TABLE 19.3: COMPLETED COST OF PROJECT

Year wise escalation in basic cost for Gurgaon Metro Rail Project										
FY	Cost at Sept 2021 levels				Escl. Factor ¹	Completion Cost with escalation				Progress
	Const. Cost	Central Taxes	State Taxes	Total		Const. Cost	Central Taxes	State Taxes	Total	
2022	426.22	31.13	27.64	484.99	1.0248	436.78	31.90	28.33	497.00	10%
2023	1278.67	93.38	82.93	1454.98	1.0760	1375.85	100.47	89.24	1565.56	30%
2024	1491.78	108.94	96.76	1697.47	1.1300	1685.64	123.09	109.33	1918.07	35%
2025	1065.56	77.81	69.11	1212.48	1.1865	1264.23	92.32	82.00	1438.55	25%
Total	4262.23	311.25	276.45	4849.93		4762.50	347.78	308.90	5419.18	

¹Escalation factor from Sept 2021 onwards is calculated as $(1+5\%)^{\wedge(\text{April (year)} - \text{Sept 2021})}$ (in years). For example, escalation factor applicable for FY 2022 is $(1+5\%)^{\wedge(\text{April 2022} - \text{Sept 2021})} = 1.05^{\wedge(6/12)} = 1.05^{\wedge 0.50} = 1.02$

19.1.3 Operation & Maintenance Costs Estimates

➤ Basis of O&M Cost Estimates

The O&M Cost has three major components which include:

- Manpower Cost
- Energy Cost
- Maintenance Cost

The O&M staff has been considered at 35 persons per route km. The average salary of the staff is assumed to be 8.47 lakhs per annum for the year 2019. The escalation factor used for staff cost is taken at 9% per annum to provide for growth in salaries.

The maintenance expenses for the Gurgaon Metro have been considered at Rs. 1.82 Cr/km in the year 2019. The escalation factor used for maintenance expense is taken as 5% per annum

The energy cost has been calculated as per the train operation plan (explained in detail in Chapter 8).

Several measures have been proposed for the Gurgaon Metro which will help in reduction of O&M cost. These include:

- Use of energy efficient LED lights in place of conventional lights.
- Installation of solar panels on the rooftops of all elevated stations and the sheds of the depot. The solar energy harnessing is proposed with RESCO model as adopted in various metro projects. Fixed tariff as per the power purchase agreement shall be applicable for a period of 20-25 years. This shall result in savings in energy cost due to use of solar energy.
- Preventive maintenance schedule as given in Maintenance depot chapter shall be followed so as to reduce the number of breakdowns. This will ensure the smooth operation of the trains.
- CBTC (Communication Based Train Control) Signaling system has been proposed which will enable the trains to operate with high frequency and improve the operational capability of the system.
- Outsourcing of various activities like ticketing, crowd control, housekeeping etc.

➤ O&M Cost Estimates

Based on above principles, O&M Cost for this corridor has been worked out and shown in **Table 19.4**. The total O&M cost in the year 2026 is estimated at **Rs. 251.17 Crore**. The total O&M cost in the year 2031 is estimated at **Rs. 377.81 Crore**. The Table also gives the requirement of Additional and Replacements costs as well.

To cater to increased traffic demand, additional Rolling Stock would be required. Additional investment of **Rs. 994.70 Crore** in the Year 2031, **Rs. 641.93 Crore** in Year 2041 has been estimated. The replacement cost for Electrical and S&T Assets of the corridors is estimated to be **Rs. 1910.29 Crore** in the year 2045.

TABLE 19.4: OPERATION AND MAINTENANCE COSTS WITH ESCALATION

Year	Staff Cost Escl @9%	Maintenance Expenses Escl @5%	Energy Charges Escl @5%	Total O&M Cost	Addition/ Replacement Cost (Cr.)
2026	130.1	66.2	54.9	251.17	
2027	141.8	69.5	61.5	272.74	
2028	154.5	73.0	68.5	296.05	
2029	168.4	76.6	76.1	321.22	
2030	183.6	80.5	84.3	348.40	
2031	200.1	84.5	93.2	377.81	994.70 (Addition of 102 coaches)
2032	218.1	88.7	99.8	406.60	
2033	237.8	93.2	106.8	437.68	
2034	259.2	97.8	114.2	471.14	
2035	282.5	102.7	122.1	507.24	
2036	307.9	107.8	130.5	546.21	
2037	335.6	113.2	139.4	588.23	
2038	365.8	118.9	148.9	633.57	
2039	398.7	124.8	159.0	682.55	
2040	434.6	131.1	169.7	735.39	
2041	473.7	137.6	181.1	792.47	641.93 (Addition of 54 coaches)
2042	516.4	144.5	193.2	854.12	
2043	562.9	151.7	206.1	920.70	
2044	613.5	159.3	219.9	992.69	
2045	668.7	167.3	234.4	1070.43	1910.29 Replacement of 25% of Elec. & 50% S&T assets
2046	728.9	175.7	249.9	1154.44	
2047	794.5	184.4	266.3	1245.25	
2048	866.0	193.7	283.7	1343.39	
2049	944.0	203.3	302.2	1449.54	
2050	1028.9	213.5	321.9	1564.36	
2051	1121.5	224.2	342.9	1688.63	
2052	1222.5	235.4	365.3	1823.12	

Year	Staff Cost Escl @9%	Maintenance Expenses Escl @5%	Energy Charges Escl @5%	Total O&M Cost	Addition/ Replacement Cost (Cr.)
2053	1332.5	247.2	389.1	1968.72	
2054	1452.4	259.5	414.4	2126.37	
2055	1583.2	272.5	441.4	2297.07	

19.2 MEANS OF FINANCE

The Revenue for this corridor of Gurgaon metro will mainly consists of fare box collection and revenue from other non-fare box sources such as property development, advertisement, parking, taxes etc. Estimation of revenue from fare box and non-fare box source has been made.

19.2.1 Fare Box Revenue

➤ Projected Traffic Demand

The ridership on this proposed corridor of Gurgaon metro system has been estimated at 4.17 Lakh passenger trips per day in the year 2026. The ridership figures for key horizon years are given in **Table 19.5**.

TABLE 19.5: EXPECTED METRO RIDERSHIP IN HORIZON YEARS

Year	Passenger Trips per day (Lakh)
2026	4.17
2031	7.26
2041	8.81
2051	10.70

➤ Trip Length Distribution

The trip length distribution has been taken on the basis of the available details on land use, corridor composition and existing traffic characteristics in the catchment areas of various sections of the corridor. The trip length distribution is given in **TABLE 19.6**.

TABLE 19.6: TRIP LENGTH DISTRIBUTION

Trip Length (Km)	Year 2026	Year 2031	Year 2041
0-2	9.63%	9.41%	9.03%
2-5	19.72%	21.08%	21.13%
5-12	43.39%	45.68%	46.69%
12-21	24.02%	21.11%	20.61%
21-36	3.24%	2.72%	2.53%
Total	100%	100%	100%

➤ Fare Structure

Table 19.7 gives the fare structure proposed for this corridor of Gurgaon Metro and is based on the fare structure of DMRC. Assuming fare revision of 5% every 2 years starting from year 2020, fare structure for Gurgaon Metro for horizon years has been worked out.

TABLE 19.7: FARE STRUCTURE FOR DELHI METRO 2019-2020

DISTANCE SLAB (KM)	FARE IN RS.
0-2	10
2-5	20
5-12	30
12-21	40
21-36	50

19.2.2 Non Fare Revenue

Non-fare sources of revenue incorporated in financial analysis are as follows:

- Advertisement a) in stations, b) inside and outside trains
- Rental from Kiosks inside the stations
- Film shooting Charges
- Telecom cable & Tower license fee
- Semi-naming Rights of Stations

The assumptions of unit rates and rates of increase are tabulated in **TABLE 19.8**.

TABLE 19.8: RATES FOR NON FARE BOX REVENUES

Type of Revenue	Unit Rate (Rs)	Rate of Increase (%)
Advertising panels inside and outside stations	2,500 per sqm per month	5% every year
Train wrap (Outside for 30% of Train Racks)	30 lakh per train wrap per month	5% every year
Advertisement inside train coach	25000 per coach per month	5% every year
Kiosk rentals	2000 per sqm per month	5% every year
Film shooting charges	Rs. 4 Lakh/ hour for inside Train/Station assumed for 8 hrs and once in 4 months i.e. 24 hrs in a year	5% every year
Telecom Cable & Tower license fee	2500 per Km per month for entire track length, 75000 per Km per month for underground section Telecom Tower License fees @Rs. 15000 per month for elevated stations	10% every 2 years
Semi-naming Rights of Stations	15 Lakh per station per month Assuming 50% stations given for semi-naming rights in 2025, 60% in 2031 and 70% in 2041	5% every year

Advertising in stations is proposed at following locations with areas as mentioned in **TABLE 19.9**.

TABLE 19.9: ADVERTISING AREA

S. No.	Place of Advertisement	Area of Advertising (in Sqm)
1	Elevated Stations Advt. (27 Stations)	9,746

Based on above parameters, revenue estimation from non-fare box sources has been made. The summary of non-fare revenue under the heads of advertisement receipts, rentals from kiosks, Film Shooting, Telecom Cable & Tower (License fees), and semi-naming rights is presented in **TABLE 19.10**.

TABLE 19.10: NON FARE BOX REVENUE

Revenue Stream	Total Revenues (in Rs. Crore)		
	2026	2031	2041
Advertisement Receipts	129	206	397
Rentals from Kiosks	5	6	9
Film Shooting Charges	1	2	3
Telecom Cable & Tower (License fees)	5	6	9
Semi naming Rights of Stations	36	52	100
Total	175	271	518

19.2.3 Revenue from TOD

The total revenue from TOD as estimated in previous chapter is given in **TABLE 19.11**.

TABLE 19.11: TOTAL REVENUE FROM TOD (VCF)

	Total Revenue (in Rs. Crore)		
	2026	2031	2041
Total Revenue from TOD	115	147	240

The year wise revenue from non-fare box sources including TOD up to 2054-55 is presented in **Table 19.12**.

TABLE 19.12: TOTAL REVENUE FROM TOD & NON FARE BOX SOURCES

Year	Total Revenue (Rs. In Crore)		
	Revenue from TOD (VCF)	Revenue from Non-Fare Box Sources	Total
2026	115	175	290
2027	121	184	305
2028	127	193	320
2029	134	203	336
2030	140	213	353
2031	147	271	418
2032	155	285	440

Year	Total Revenue (Rs. In Crore)		
	Revenue from TOD (VCF)	Revenue from Non-Fare Box Sources	Total
2033	162	299	462
2034	170	314	484
2035	179	330	508
2036	188	346	534
2037	197	364	561
2038	207	382	589
2039	217	401	618
2040	228	421	649
2041	240	518	758
2042	252	544	795
2043	264	571	836
2044	278	600	877
2045	291	630	921
2046	306	661	967
2047	321	694	1015
2048	337	729	1067
2049	354	765	1120
2050	372	804	1176
2051	391	844	1235
2052	410	886	1297
2053	431	930	1361
2054	452	977	1429
2055	475	1026	1501

19.2.4 Total Revenue

The total annual revenue through the fare box and other sources for both the corridors is given in **Table 19.13**.

TABLE 19.13: TOTAL REVENUE COLLECTION (Rs. In Crore)

Source of Revenue	2026	2031	2041	2051
Fare Box Revenue	514	969	1504	2323
Non-Fare Box Revenue	290	418	758	1235
Total Revenue	804	1387	2262	3558

19.3 OPERATIONAL VIABILITY/FIRR

The FIRR for the project with capital costs including all taxes and revenues from fare box and non-fare box sources works out to be **13.03 %** for the base case and its detailed calculations are presented in **Table 19.16**.

FIRR under various scenarios has been computed and shown below in **Table 19.14**.

TABLE 19.14: COST AND RIDERSHIP SENSITIVITY

Scenario	FIRR
FIRR with Farebox, Advt. revenue and TOD revenue (" base case ")	13.03%
FIRR with Farebox, Advt. revenue but w/o TOD revenue	11.08%
FIRR with only Farebox	6.28%

19.4 SENSITIVITY ANALYSIS

The FIRR of the project is sensitive to revenues, and capital costs. The sensitivity of the project with respect to these factors is given in **Table 19.15**. It can be seen that the project is more sensitive to ridership variations than to variations in costs.

TABLE 19.15: COST AND RIDERSHIP SENSITIVITY

Parameter	+5%	+10%	-5%	-10%
Capital Cost	12.56%	12.12%	13.54%	14.08%
Ridership	13.57%	14.09%	12.47%	11.89%

TABLE 19.16: GURGAON METRO FIRR WITH ALL TAXES (RS. IN CRORE)

Year	Completion Cost	Taxes and Duties	Additional Investment	Fare Box Revenue	Other income	Gross Revenue	O&M Cost	Net Cash Flows
2022	555	60	0	0	0	0	0	-615
2023	1520	190	0	0	0	0	0	-1710
2024	1730	232	0	0	0	0	0	-1963
2025	1296	174	0	0	0	0	0	-1471
2026	0	0	0	514	290	804	251	553
2027	0	0	0	572	305	877	273	604
2028	0	0	0	664	320	984	296	688
2029	0	0	0	740	336	1076	321	754
2030	0	0	0	870	353	1223	348	874
2031	0	0	995	969	418	1387	378	15
2032	0	0	0	1038	440	1478	407	1071
2033	0	0	0	1058	462	1520	438	1082
2034	0	0	0	1127	484	1611	471	1140
2035	0	0	0	1149	508	1657	507	1150
2036	0	0	0	1235	534	1769	546	1223
2037	0	0	0	1259	561	1820	588	1232
2038	0	0	0	1357	589	1946	634	1312
2039	0	0	0	1384	618	2002	683	1319
2040	0	0	0	1475	649	2124	735	1389
2041	0	0	642	1504	758	2262	792	828
2042	0	0	0	1599	795	2394	854	1539
2043	0	0	0	1630	836	2466	921	1545

Year	Completion Cost	Taxes and Duties	Additional Investment	Fare Box Revenue	Other income	Gross Revenue	O&M Cost	Net Cash Flows
2044	0	0	0	1759	877	2636	993	1643
2045	0	0	1910	1793	921	2714	1070	-267
2046	0	0	0	1922	967	2889	1154	1734
2047	0	0	0	1959	1015	2974	1245	1729
2048	0	0	0	2086	1067	3153	1343	1810
2049	0	0	0	2127	1120	3247	1450	1797
2050	0	0	0	2278	1176	3454	1564	1890
2051	0	0	0	2323	1235	3558	1689	1869
2052	0	0	0	2483	1297	3780	1823	1956
2053	0	0	0	2531	1361	3892	1969	1923
2054	0	0	0	2728	1429	4157	2126	2031
2055	0	0	0	2782	1501	4282	2297	1985
Project IRR								13.03%

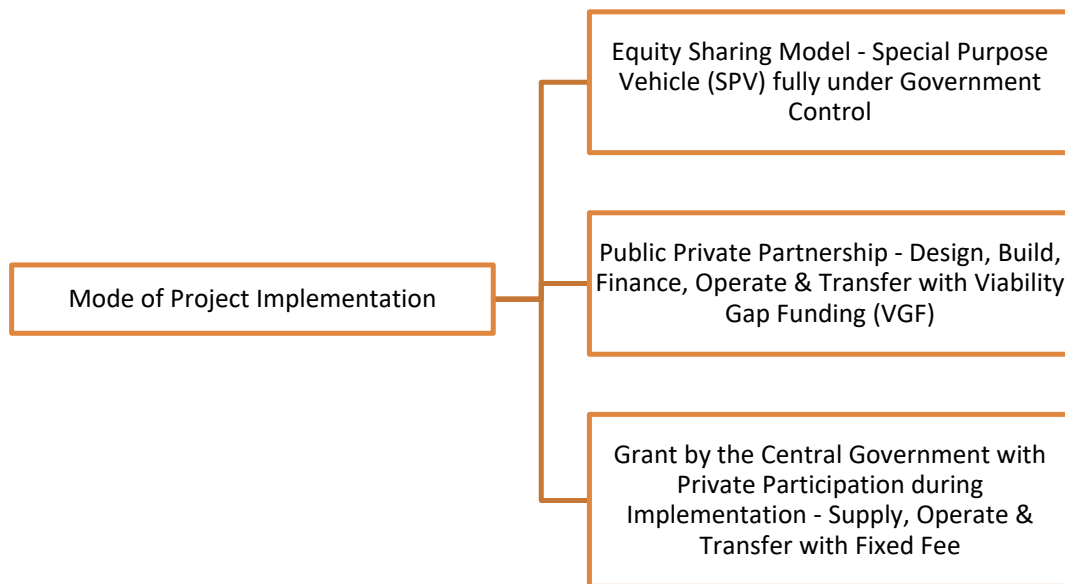
19.5 ALTERNATE MEANS OF FINANCING

The financing option for metro implementation depends upon selection of the dedicated agency created to implement the project. As per Metro Rail Policy '2017, the prominent models are:

- Equity Sharing Model (Special Purpose Vehicle fully under Government Control)
- Built, Operate & Transfer (BOT) or Public Private Partnership (PPP)
- Grant by the Central Government

Figure 19.1 presents the implementation models graphically.

FIGURE 19.1: MODEL OF IMPLEMENTATION OF MRTS PROJECTS



19.5.1 Equity Sharing Model (SPV Model)

Under this model, a Special Purpose Vehicle (SPV) is set up as a joint venture between Central Government and State Government for the implementation of the project and for its subsequent Operation & Maintenance. Under this arrangement Government of India and State Government make equal equity contribution and run SPV as a commercial enterprise. As per the prevalent practice, Central Government contribute 20% of the project cost as their equity contribution. An equal amount can be contributed by State Government aggregating the total equity to 40%. Remaining 60% is arranged as soft loan as ODA from bilateral/multilateral funding agencies. Delhi Metro Rail Corporation,

Bangalore Metro Rail Corporation, Chennai Metro Rail Corporation & Kolkata Metro Rail Corporation are some of the examples of success of such a SPV.

19.5.2 Public Private Partnership

As per Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail.

The fundamental principle underlying Public Private Partnerships (PPP's) as a development option for any infrastructure project is to combine the strengths of the private sector with those of the public sector in order to overcome challenges faced during construction & operation and to achieve better outcomes. The private sector can be expected to contribute to efficiency gains in the development of land, construction, operations and maintenance through the use of technology, better management and construction practices. In addition, the private sector should be expected to bring economies of scale from large projects and by involving a larger number of private partners.

However, the success of PPP will depend critically on designing PPP structures that make an appropriate allocation of risks, responsibilities, rewards and penalties, and create the incentives for value creation. Indeed, this risk allocation is the defining feature of the PPP strategy. The golden principle is that risks should be allocated to the entity best equipped to manage each risk. The expectation is that such an allocation of risks will not only produce the best possible program and project outcomes but also optimize costs. This should lead to good quality outcomes at optimum prices.

19.5.3 Grant by Central Government

Under this option Central Government would fund 10% of the project completion cost excluding private investment Land, R&R and state taxes. Remaining costs to be borne by state with Private sector participation.

These models have been explored for implementation of this corridor of Gurgaon Metro.

19.5.4 Case Studies of Private Sector Participation in MRTS in Indian Cities

Metro systems being planned in the cities of India have majorly adopted equity sharing model. Some of the cities have gone for private sector participation also. **Exhibits 19.1 to 19.4** give the examples of PPP in construction and operation of MRT system

Some of the metro companies have involved private sector in O&M also. **Exhibits 19.5 to 19.7** give the examples of PPP in some of the O&M activities.

The involvement of private sector in O&M activities in case of Gurgaon Metro can be finalized at the time of operation.

EXHIBIT 19.1: DELHI AIRPORT LINE UNDER PPP MODEL

DMRC has implemented a High Speed Airport Link from New Delhi Railway Station to IGI Airport and further extension to Sector-21, Dwarka covering a distance of 22.7 KM with private sector participation. The project with an estimated cost of Rs. 3869 Crore has been implemented under a unique model of PPP where in the DMRC has undertaken the civil works with the funds being contributed by GoI, GNCTD, Delhi International Airport Limited and DDA (54%) and the cost of systems and Rolling Stock (46%) is being met by the private operator who will operate the system for 30 years, after which the system will revert back to DMRC. The approved funding pattern of the line is depicted in **Figure 19-3**. There have been some issues with the concessionaire and DMRC is now operating the system.

FIGURE 19.2 APPROVED FUNDING PATTERN OF DELHI AIRPORT LINE

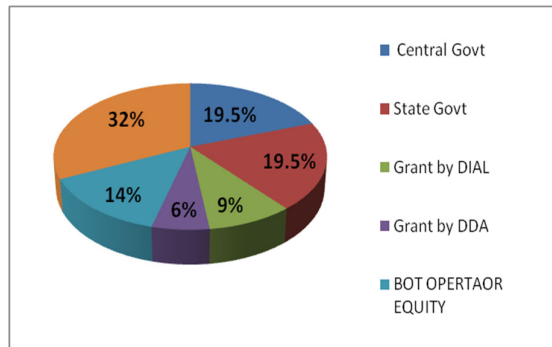


EXHIBIT 19.2: HYDERABAD METRO UNDER PPP MODEL

Hyderabad Metro is the first PPP Metro Rail Project that has been sanctioned by Government of India. GoAP has undertaken the Hyderabad Metro Rail Project under Viability Gap Funding (VGF) scheme of GoI. The MRTS network include three high density traffic corridors with total length of about 71 km. The Project is being executed by L&T on design, build, and finance, operate and transfer (DBFOT) basis. GoAP will spend another ₹ 1,980 Crore towards land acquisition, R&R package, shifting of utilities and GoI will support the project with grant of ₹ 1,458 Crore as VGF. **Figure 19-4** gives the funding plan of Hyderabad metro.

FIGURE 19.3 FUNDING PATTERN OF HYDERABAD METRO

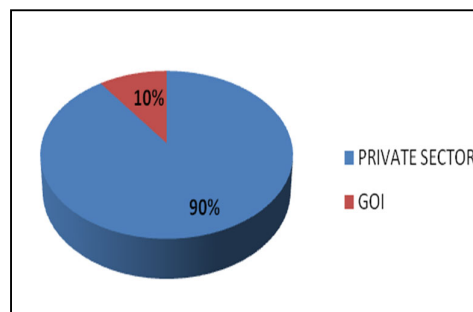


EXHIBIT 19.3: GURGAON METRO UNDER PPP MODEL

Gurgaon's Rapid Metro project is India's first fully privately financed metro. With the project cost of Rs 1100 Crore, it has a network of 5.1 km connecting Cyber City, NH-8 & Sikanderpur Station (DMRC) in Phase I. The planned route for Rapid Metro acts as a feeder to the MRC's Jahangirpuri-Central Secretariat-HUDA City Centre (Yellow Line). A special purpose vehicle (SPV), Rapid Metro Rail Gurgaon Limited (RMGL) was formed to construct, operate and maintain the metro.

EXHIBIT 19.4: MUMBAI METRO LINE 1 & 2 UNDER PPP MODEL

In contrast to the SPV model adopted for construction of metro rail system in the city of Delhi, Bangalore, Chennai & Kolkata, the Maharashtra government has opted Build Own, Operate & Transfer (BOOT) model in the city of Mumbai.

So far, 2 lines covering a distance of 44 KMs (Line 1 of 11.07 KMs from Versova – Andheri - Ghatkopar with a total cost of Rs. 2356 Crore and Line 2 of 32 KMs from Charkop – Bandra – Mankurd with an estimated cost of Rs. 8250 Crore) have been awarded to private operator for construction and operation by giving Viability Gap Funding by GoI & Maharashtra State Government to the extent of Rs. 650 Crore and Rs. 1532 Crore for Line 1 & Line 2 respectively.

*Mumbai Metro One Private Limited is a Joint Venture Company formed by Reliance Energy Limited, a Reliance ADA Group Company, Veolia Transport, France and Mumbai Metropolitan Region Development Authority (MMRDA) incorporated under the Companies Act, 1956 to implement this project. **Figure 19-5** gives the funding pattern of Mumbai Metro Line 1. Line 1 is now operational. There are some issues with the concessionaire and the implementation mechanism for Line 2 is being revisited.*

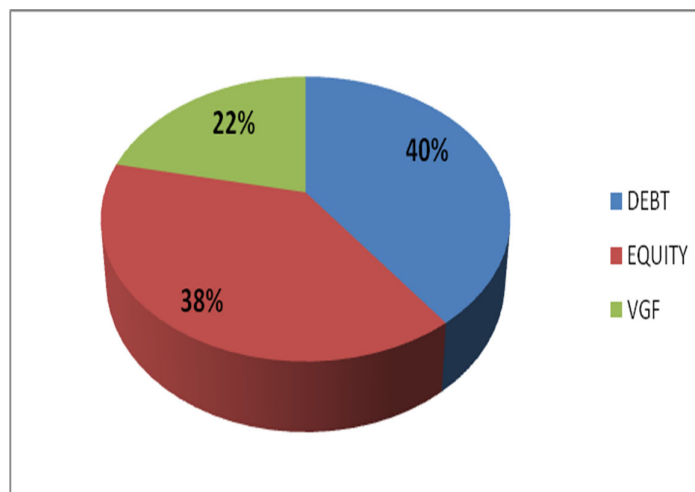
FIGURE 19.4 FUNDING PATTERN OF MUMBAI METRO LINE 1

EXHIBIT 19.5: PPP IN O&M ACTIVITIES IN BANGALORE METRO

Bangalore Metro Rail Corporation Ltd (BMRL) has signed a memorandum of understanding (MoU) with the Embassy Group to build the Kadubeesanahalli Metro station. Embassy Group will pay Rs 100 Crore to BMRL in installments. The group is the first corporate to sign the agreement under the public-private partnership scheme.

The station, to be located just outside the Embassy Tech Village on the Outer Ring Road, will be on the recently approved 17-km North-South Metro corridor linking Silk Board Junction with Krishnarajapuram.

The construction will be done in accordance with the façade designs and specifications approved by BMRL. The period of concession and permission granted to Embassy Group will be for 30 years starting from the date of commencement of commercial operations and could be extended further on mutual terms. The agreement mandates that the group will maintain Kadubeesanahalli Metro station, including housekeeping and maintenance, along with all the equipment, according to specifications laid down by the corporation.

The partnership also means the group will be entitled to utilize the pre-determined spaces for advertisements. Embassy can also use the leasable retail space measuring approximately 3,000 sq. ft at the Metro station. Embassy will also have the advantage of leveraging the linear zone of 250 metres around the Kadubeesanahalli Metro station.

EXHIBIT 19.6: PPP IN O&M ACTIVITIES IN LUCKNOW METRO - AFC

LMRC has tied up with M/s HDFC Bank for Fare Collection System and Provision of Allied Banking Application for Phase I (21 stations of North South Corridor of the project). The Bank was offered two options for partnership

Option 1 – Annual royalty payable by bidder to LMRC (including provisions of TVMs and RCTMs)

Option 2 – Annual royalty payable by bidder to LMRC (excluding provisions of TVMs and RCTMs)

The Royalty Shall increase by 20% on completion of every 3 years on an compounding basis.

M/s HDFC Bank opted for Option 2 i.e. Annual Royalty payable by Bidder to LMRC (excluding provisions of TVMs and RCTMs). HDFC Bank pays Rs. 1000 as Annual Royalty under option 2 to LMRC. While opting for option 2, following cost is being incurred by HDFC Bank in discharging the obligation.

Annual Manpower Cost (including dress) – Rs. 101.17 Lakh

Annual Cash Management Charges – Rs. 53.4 Lakh

Annual Maintenance Charges – Rs. 3.00 Lakh

Total - Rs. 157.54 Lakh

The above cost will be increased by approx 9% annually considering the inflation and other cost.

EXHIBIT 19.7: PPP IN O&M ACTIVITIES IN KOCHI METRO - AFC

Kochi Metro Rail Limited (KMRL) has signed a public-private partnership (PPP) pact with Axis Bank for the automated fare collection (AFC) system. Under the agreement, investment for the entire funding required for the AFC system will be undertaken by Axis Bank, which will also maintain it for 10 years. The bank will pay a royalty of Rs 209 Crore over the next 10 years for the right to be KMRL's partner in this endeavour. In return, Axis Bank will get the right to issue co-branded cards, which will function as a smart card as well as a ticket, to the users of the metro. In addition to this, 0.2 per cent of Axis Bank's gross revenue, from the utilisation of this card outside KMRL's ecosystem in various mercantile outlets and internet transactions, will also accrue to KMRL over the next 10 years.

The AFC system is a critical core component of any metro system. It includes complex hardware and software installed at entry points of metro stations as well as buses and boats. It uses radio frequency identification devices (RFID) to collect fares from the users. In such a system, the metro ticket can be in the form of a co-branded card or an NFC-enabled smart phone or a 'patch' on a mobile device or any other surface with NFC stickers or QR code, or even as a paper-coupon. The smart card can be linked with any bank account of the user, in any bank.

KMRL is planning a 'click and collect' system whereby the commuter will be able to order goods and services using this card, which can be delivered at all metro stations. It is also planning to start a drive for including a variety of local and national goods and services that can be accessed using the KMRL-Axis Bank co-branded card. In addition to the co-branded card, the bank will also develop a mobile app, which can be used for ticketing as well as e-commerce. This initiative is unique in that it is for the first time that 'open-loop' smart cards are being introduced in the metro system.

19.5.5 Equity Sharing Model (SPV Model) for Gurgaon Metro

Under this model, a Special Purpose Vehicle (SPV) will be set up as a joint venture between Central Government and Government of Haryana for the implementation of the project and for its subsequent Operation & Maintenance. As per the prevalent practice, Central Government contribute 20% of the project cost excluding land and state taxes as its equity contribution. An equal amount will be contributed by State Government aggregating the total equity to 40%. In addition to equity, GoH will also fund the cost of land and state taxes. Remaining amount of 60% is to be taken as Term Loan from either Multilateral Agencies or Commercial Banks.

Since, metro projects are capital intensive and the terms of commercial banks are costlier, financing from multilateral agencies like JICA, WB or ADB is preferred as seen from numerous examples of funding of metro rail projects in India. The loan from these bilateral/ multilateral funding agencies as ODA loans

is being provided to GOI which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Since the loan will be in foreign currency (USD or JPY), fluctuation in exchange rate at the time of repayment is considered to be borne by the Central Government and State Government in proportion of their shareholding. Alternatively, the funding agencies can release the loan to the SPV for which a sovereign guarantee will be required from Central Government, the cost of which at applicable rates (1.2% on external borrowings as per GFR 2017) shall have to be borne by the SPV. Foreign exchange variation in such eventuality will be borne either by the SPV or GoH. In either case loan shall be repaid by SPV from the income streams of metro operations.

The funding pattern developed under this model (SPV) is placed in **Table 19.17**. Equity Cash Flows (considering soft loan from multilateral funding agencies and excluding cost towards hedging of exchange rate risk) is placed at Annexure 19.1.

TABLE 19.17: FUNDING PATTERN UNDER SPV WITH CENTRAL TAXES

Source of Funding	Amount (Rs in Crores)	% Of contribution
Equity by GoI	873.74	16.68%
Equity by GoH	873.74	16.68%
SD by GoH for Central Taxes	173.89	3.32%
SD by GoI for Central Taxes	173.89	3.32%
Contribution by Local Bodies	200.00	3.82%
Soft loan from multilateral agencies/Term Loan	2942.89	56.18%
Total	5238.14	100.00%
SD by GoH for Land and R&R	211.42	
SD by GoH for State Taxes	308.90	
Total Cost	5758.46	
SD by GoH for IDC and Front End Fee	66.10	
PPP Component (AFC for Stations)	135.47	
Total	5960.03	

19.5.6 Public Private Partnership – DBFOT with VGF for Gurgaon Metro

In this model, the private firm may be responsible for designing, building, operating and maintaining of the entire project. Government of Haryana will bear the cost towards land including R&R irrespective of the model of PPP. The metro rail being a social sector project not many private parties are available to bid for such a project. Besides quite expectedly the private operator may

demand assured rate of return in the range of 16% to 18% or a comfort of guaranteed ridership.

The operation period by a private entity is considered as 30 years, Debt: Equity ratio for all financing by private entity is considered as 70:30, with long term cost of debt as 12% p.a. The Private Partner will develop the infrastructure with its own funds and funds raised from lenders at its risk (that is, it will provide all or the majority of the financing). The Private Partner is also responsible for operating (supply and running of rolling stock) and managing the infrastructure life cycle (assuming life-cycle cost risks) for a specified number of years. To carry out these tasks, the Private Partner, will usually create an SPV.

The bid parameter in such projects is either Premium (as percentage of revenues) if the funds coming from users are sufficient to cover O&M expenses and long-term maintenance with a surplus that can then be used as a source to repay the financing of the construction of the asset, and where no Bidder is offering a Premium, bidding parameter is the Grant required (as per VGF scheme of Government of India). The Grant/ Premium is computed for a target pre-tax equity IRR of private entity as 18%. Based on above, the funding pattern without additional income from PD is provided in **Table 19.18**. Equity Cash Flows to Concessionaire is provided in Annexure 19.2.

TABLE 19.18: FUNDING PATTERN UNDER PPP – BOT WITH VGF

Particulars	Amount	% of Contribution
	(Rs in Cr)	
VGF by Gol	845.21	13.44%
VGF by GoH	845.21	13.44%
Equity by Concessionaire	1156.99	18.40%
Concessionaire's Debt @ 12% p.a.	2699.64	42.94%
IDC (to be borne by Concessionaire)	740.47	11.78%
Total	6287.52	100%
Land and R&R by GoH	211.42	
PPP component (AFC installations) by private party	135.47	
Total	6634.41	

19.5.7 Grant by the Central Government – Supply of System and O&M by Private Participation

Under this model, Government of Haryana will bear the cost towards land including R&R and state taxes. Central Government shall provide a grant of 10% and post-construction of civil assets by State Government the Private

Partner installs the system (signaling and telecommunication assets), procures rolling stock and operates and maintains all these assets. The State Government collects all the revenue and pays the Private Partner a monthly/annual payment for operations and maintenance of the system. The remuneration given could comprise of a fixed fee and a variable component, which would depend on the quality of service provided and the fixed fee is computed for a target pre-tax equity IRR of private entity as 18% which will be financed through the revenue generated in the project. For our analysis, a fixed fee escalated at long-term WPI i.e. 4% p.a. is considered. Equity Cash Flows to Private Partner is provided in Annexure 19.3. Based on above, the funding pattern is provided in **Table 19.19**.

TABLE 19.19: FUNDING PATTERN UNDER FIXED FEE MODEL

Particulars	Amount (Rs in Cr)	% of Contribution
Capital Contribution by GoI	523.81	10%
Capital Contribution by GoH	3308.27	63%
Equity by Concessionaire	421.82	8%
Concessionaire's Debt @ 12% p.a.	984.24	19%
Total	5238.15	100%
Land and R&R by GoH	211.42	
State Taxes by GoH	308.90	
IDC (to be borne by Concessionaire)	269.96	
PPP component (AFC installations)	135.47	
Total	6163.90	

The total fund contribution of GoI & GoH for the Gurgaon Metro corridor under analysis as per above alternatives excluding land and state taxes is tabulated in **Table 19.20**.

TABLE 19.20: COMPARISON OF THREE IMPLEMENTATION MODELS (Rs. Crore)

Particulars	SPV	VGF	Fixed Fee
Contribution by GoI	1047.63	845.21	523.81
Contribution by GoH	1047.63	845.21	3308.27
Sub-Total	2095.26	1690.42	3832.08
Land and R&R by GoH	211.42	211.42	211.42
State Taxes by GoH	308.90	0.00	308.90
IDC by GoH	66.10	0.00	0.00
Total	2681.67	1901.84	4352.40
Present Value @8% of Net Cash Flow to Public Entity	2815.81	65.70	3108.71

It can be seen from the above table that the return in terms of PV of Net cash flows to Government is highest in case of Fixed Fee model, however the contribution of Government under Fixed Fee model is much higher than that under SPV model, contribution of Governments under SPV model is more than that of VGF and less than that of Fixed Fee model. Although under the VGF model, the contribution of Government is lowest, the entire revenues for the Concession Period are accruing to the Private Partner with no return on Government's contribution. Accordingly, based on a balance between Capital contribution by Govt. and Return to the Government, the SPV model is most preferable and therefore it is proposed that the project may be implemented on SPV Model. As per new Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail.

Accordingly, under SPV model for implementation of Gurgaon Metro project following activities have been identified for private participation:

- i) Private participation in Automatic Fare System by completely outsourcing operation of Ticket Operating Machines (TOMs), Ticket Vending Machines (TVMs) and Card Recharge Machines including Smart Cards provisions and Merchant Acquirer functions.
- ii) Maintenance contracts with System suppliers for Rolling Stock and Signaling systems in place of in house maintenance.
- iii) Station Civil and E&M maintenance and parking management.
- iv) Exploring long term lease of Elevators at Metro Stations

The cost of the AFC Installations to be borne by a private partner is estimated at **Rs. 121.24 Crore** at September-2021 price level which translates to completion cost of **Rs. 135.47 Crore** in the year 2026.

ANNEXURE 19.1: EQUITY CASH FLOWS TO GOVERNMENT (EXCLUDING STATE TAXES) IN THE SPV MODEL

Period	Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment ²	Interest Repayment	Closing Balance	Equity CF
2022	615	6	0	0	0	2	0	0	0	-620
2023	1710		0	0	36	8	0	0	36	-1665
2024	1963		0	36	1660	20	0	0	1697	-283
2025	1471		0	1697	1246	31	0	0	2943	-194
2026			553	2943		35	0	0	2943	553
2027			604	2943		35	0	35	2943	569
2028			688	2943		35	0	35	2943	653
2029			754	2943		35	0	35	2943	719
2030			874	2943		35	0	35	2943	839
2031			1009	2943		35	0	35	2943	974
2032			1071	2943		34	147	34	2796	890
2033			1082	2796		33	147	33	2649	903
2034			1140	2649		31	147	31	2501	962
2035			1150	2501		29	147	29	2354	974
2036			1223	2354		27	147	27	2207	1048
2037			1232	2207		26	147	26	2060	1059
2038			1312	2060		24	147	24	1913	1141
2039			1319	1913		22	147	22	1766	1150
2040			1389	1766		20	147	20	1619	1221
2041			1470	1619		19	147	19	1471	1304
2042			1539	1471		17	147	17	1324	1376
2043			1545	1324		15	147	15	1177	1383

² ODA Loan is considered with financing terms are 10 years moratorium, 20 years repayment, 1.20% interest rate and 0.20% Front End Fee.

Period	Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment ²	Interest Repayment	Closing Balance	Equity CF
2044			1643	1177		13	147	13	1030	1483
2045			1644	1030		11	147	11	883	1485
2046			1734	883		10	147	10	736	1577
2047			1729	736		8	147	8	589	1574
2048			1810	589		6	147	6	441	1656
2049			1797	441		4	147	4	294	1646
2050			1890	294		3	147	3	147	1740
2051			1869	147		1	147	1	0	1721
2052			1956	0		0	0	0	0	1956
2053			1923	0		0	0	0	0	1923
2054			2031	0		0	0	0	0	2031
2055			1985	0		0	0	0	0	1985
Total	5758	6			2943	625	2943	530	50291	20.11%

ANNEXURE 19.2: EQUITY CASH FLOWS TO CONCESSIONAIRE IN DBFOT WITH VGF MODEL

Period	Capital Cost	Revenue	O&M Cost	Cash Flow before debt	Equity With drawn	Loan Opening Balance	With drawn	Interest	Principal Repay-ment	Interest Repay-ment	Closing Balance	Equity Cash Flow
2022	386	0	0	-386	386	0	0	0	0		0	-386
2023	1157	0	0	-1157	771	0	386	23	0		386	-794
2024	1350	0	0	-1350	0	386	1350	127	0		1735	-127
2025	964	0	0	-964	0	1735	964	266	0		2700	-266
2026	0	689	251	438	0	2700	0	324	0		2700	114
2027		756	273	483	0	2700	0	313	180	313	2520	-10
2028		857	296	561	0	2520	0	292	180	292	2340	89
2029		943	321	621	0	2340	0	270	180	270	2160	171
2030		1083	348	734	0	2160	0	248	180	248	1980	306
2031		1240	378	862	0	1980	0	227	180	227	1800	456
2032		1323	407	916	0	1800	0	205	180	205	1620	531
2033		1357	438	919	0	1620	0	184	180	184	1440	556
2034		1441	471	970	0	1440	0	162	180	162	1260	628
2035		1479	507	972	0	1260	0	140	180	140	1080	651
2036		1581	546	1035	0	1080	0	119	180	119	900	736
2037		1623	588	1035	0	900	0	97	180	97	720	758
2038		1739	634	1105	0	720	0	76	180	76	540	850
2039		1785	683	1102	0	540	0	54	180	54	360	868
2040		1896	735	1161	0	360	0	32	180	32	180	948
2041		2022	792	1230	0	180	0	11	180	11	0	1039
2042		2143	854	1288	0	0	0	0	0	0	0	1288
2043		2201	921	1280	0	0	0	0	0	0	0	1280
2044		2359	993	1366	0	0	0	0	0	0	0	1366
2045		2423	1070	1353	0	0	0	0	0	0	0	1353

Period	Capital Cost	Revenue	O&M Cost	Cash Flow before debt	Equity With drawn	Loan Opening Balance	With drawn	Interest	Principal Repay-ment	Interest Repay-ment	Closing Balance	Equity Cash Flow
2046		2583	1154	1428	0	0	0	0	0	0	0	1428
2047		2653	1245	1408	0	0	0	0	0	0	0	1408
2048		2815	1343	1472	0	0	0	0	0	0	0	1472
2049		2892	1450	1442	0	0	0	0	0	0	0	1442
2050		3082	1564	1518	0	0	0	0	0	0	0	1518
2051		3167	1689	1478	0	0	0	0	0	0	0	1478
2052		3369	1823	1545	0	0	0	0	0	0	0	1545
2053		3461	1969	1492	0	0	0	0	0	0	0	1492
2054		3705	2126	1579	0	0	0	0	0	0	0	1579
2055		3808	2297	1511	0	0	0	0	0	0	0	1511
Total	3857				1157		2700	3170	2700	2430		18.0%

ANNEXURE 19.3: EQUITY CASH FLOWS TO PRIVATE ENTITY IN FIXED FEE MODEL

Period	Capital Cost	Revenue (Fixed Fee)	O&M Cost	Cash Flow before debt	Equity With drawn	Loan Opening Balance	With drawn	Interest	Principal Repay ment	Interest Repay ment	Closing Balance	Equity Cash Flow
2022	141	0	0	-141	141	0	0	0	0		0	-141
2023	422	0	0	-422	281	0	141	8	0		141	-290
2024	492	0	0	-492	0	141	492	46	0		633	-46
2025	352	0	0	-352	0	633	352	97	0		984	-97
2026	0	554	251	303	0	984	0	118	0		984	185
2027		576	273	303	0	984	0	114	66	114	919	124
2028		599	296	303	0	919	0	106	66	106	853	131
2029		623	321	302	0	853	0	98	66	98	787	138
2030		648	348	300	0	787	0	91	66	91	722	144
2031		674	378	296	0	722	0	83	66	83	656	148
2032		701	407	294	0	656	0	75	66	75	591	154
2033		729	438	291	0	591	0	67	66	67	525	159
2034		758	471	287	0	525	0	59	66	59	459	162
2035		789	507	281	0	459	0	51	66	51	394	165
2036		820	546	274	0	394	0	43	66	43	328	165
2037		853	588	265	0	328	0	35	66	35	262	164
2038		887	634	253	0	262	0	28	66	28	197	160
2039		923	683	240	0	197	0	20	66	20	131	155
2040		959	735	224	0	131	0	12	66	12	66	147
2041		998	792	205	0	66	0	4	66	4	0	136
2042		1038	854	184	0	0	0	0	0	0	0	184
2043		1079	921	159	0	0	0	0	0	0	0	159
2044		1122	993	130	0	0	0	0	0	0	0	130
2045		1167	1070	97	0	0	0	0	0	0	0	97

Period	Capital Cost	Revenue (Fixed Fee)	O&M Cost	Cash Flow before debt	Equity With drawn	Loan Opening Balance	With drawn	Interest	Principal Repay ment	Interest Repay ment	Closing Balance	Equity Cash Flow
2046		1214	1154	60	0	0	0	0	0	0	0	60
2047		1263	1245	17	0	0	0	0	0	0	0	17
2048		1313	1343	-30	0	0	0	0	0	0	0	-30
2049		1366	1450	-84	0	0	0	0	0	0	0	-84
2050		1420	1564	-144	0	0	0	0	0	0	0	-144
2051		1477	1689	-212	0	0	0	0	0	0	0	-212
2052		1536	1823	-287	0	0	0	0	0	0	0	-287
2053		1598	1969	-371	0	0	0	0	0	0	0	-371
2054		1661	2126	-465	0	0	0	0	0	0	0	-465
2055		1728	2297	-569	0	0	0	0	0	0	0	-569
Total	1406				422		984	1156	984	886		18.0%

ANNEXURE 19.4: BREAK UP OF CAPITAL COST

S. No.	Item	Amount (Rs. in Cr.)
1	Alignment and Formation	1150.97
2	Station Buildings incl. Civil works, EM works, Finishes	918.00
3	Depot including civil, EM, Machinery & plants, general works	80.00
4	P-Way for main line, depot and depot connectivity	212.33
5	Traction & power supply	382.88
6	Signaling and Telecom	393.20
7	Environmental	11.97
8	Misc. Utilities	171.00
9	Capital Expenditure on Security	9.92
10	Capital Expenditure on Inter modal integration including Footpath for pedestrians	81.00
11	Rolling Stock	648.00
12	Total Cost at Sept-2021 price levels except Land, R&R, Contingencies, Central & State Taxes	4059.26
13	General Charges incl. Design charges (Civil+EM works) @ 5% on all items except Land & R&R	202.96
14	Contingencies @ 3 %	127.87
15	Total Cost at Sept-2021 price levels (except Land, R&R, Central & State Taxes, IDC and PPP cost)	4390.09
16	Escalation at 5% p.a	500.27
17	Total Cost with Escalation (excluding Taxes, Land, R&R and Contingencies)	4890.36
18	Central Taxes including basic customs duty	311.25
19	Escalation at 5 % p.a for Central Taxes	36.53
20	Total Cost including Central Taxes (excluding Land, R&R and State Taxes) at Sept 2021 price levels (17+18)	4701.34
21	Total Cost including Central Taxes (excluding Land, R&R and State Taxes) with escalation at 5% p.a. (19+20)	5238.15
22	Land Cost	208.52
23	R&R Cost	2.90
24	Total of Land and R&R Costs	211.42
25	State Taxes at Sept 2021 price levels	276.45
26	Escalation at 5 % p.a for State Taxes	32.45
27	Total Cost with Central and State Taxes including Land and R&R but excluding PPP component (AFC installations) at Sept 2021 Price Levels (20+24+25)	5189.21
28	Total Cost with Central and State Taxes with escalation @ 5% p.a including Land and R&R but excluding PPP component (AFC installations) (21+24+25+26)	5758.46
29	PPP component (AFC installations)	135.47
30	Interest during Construction	60.21
31	Front End Fee	5.89
32	Total Completion Cost incl. IDC, Front End Fee & PPP Component (AFC Installations) (28+29+30+31)	5960.03

Chapter – 20

ECONOMIC ANALYSIS

20. ECONOMIC ANALYSIS

20.1 APPROACH AND METHODOLOGY FOR ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV.

20.1.1 Evaluation Assumptions

Project horizon comprises of the construction and operation period of the rail based transit project. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR. The key assumptions used in the evaluation are listed in **Table 20.1**.

TABLE 20.1: KEY EVALUATION ASSUMPTIONS

Parameter	Assumption
Price Level	September '2021
Construction period	4 Years
First year of operation of MRTS	2026
Daily to annual factor	340

20.1.2 Development of Alternative Scenarios

The development of the two scenario starts with estimating the traffic and the modal share in these scenarios for the system. **Table 20.2** gives the estimated traffic and modal share in different horizon years for Metro. It can be seen that the total estimated demand in the year 2026 is about 33.36 Lakh which is

expected to rise to about 78.17 Lakh in the year 2051. In the year 2026, rail based transit system is expected to cater to about 5.34 Lakh trips per day which is expected to rise to about 8.98 lakh in the year 2051.

TABLE 20.2: ESTIMATED DEMAND AND MODAL SHARE IN 'WITH' AND 'WITHOUT' SCENARIO

Mode	Trips Without Mass Transport System				Trips with Mass Transport System			
	2026	2031	2041	2051	2026	2031	2041	2051
Bus	753287	1238074	1478406	1765391	656639	1061196	1263567	1542474
Car	307532	505447	603564	720726	261223	425980	506994	618511
2 Wheelers	1406472	2311624	2760351	3296184	1257755	2014982	2400260	2931888
Auto	868452	1427355	1704430	2035290	786121	1254245	1494365	1825883
HMRTC Metro (Gurugram)	-	-	-	-	374006	726098	881563	898833
Total	3335744	5482500	6546750	7817590	3335744	5482500	6546750	7817590

20.2 ESTIMATION OF ECONOMIC COST OF MRTS

The economic costs of the capital works and annual operation and maintenance costs have been calculated from the financial cost estimates by excluding:

- Price contingencies/price escalations
- Import duties and taxes
- Sunk costs
- Interest payment, principal payment and interest during construction period

The economic costs (**Table 20.3**) have been derived from financial costs using following shadow price factor for each component to take care of the distortions brought by above factors.

TABLE 20.3: FACTORS USED FOR CONVERTING PROJECT COSTS TO ECONOMIC COSTS

S. No	Item	Factor
1	Capital Cost	0.83
2	Operations & Maintenance Cost	0.87

Table 20.4 and **Table 20.5** give the capital and O&M costs of the system at September '2021 Price levels in financial and economic terms respectively.

TABLE 20.4: FINANCIAL COSTS OF MRTS - CAPITAL AND O&M

Cost Component	Metro (Rs. in Crore)
Capital Cost Including Land and R&R	4601.51
Taxes and Duties	587.70
O&M Costs	
• 2026	251.17
• 2031	377.81
• 2041	792.47
• 2051	1688.53

TABLE 20.5: ECONOMIC COSTS OF MRTS - CAPITAL AND O&M

Cost Component	Metro (Rs. in Crore)
Capital Cost Including Private land and R&R	4598.13
O&M Costs	
• 2026	179.41
• 2031	193.57
• 2041	204.60
• 2051	215.62

20.3 ECONOMIC BENEFITS OF MRTS

Gurugram Metro will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. The introduction of MRTS will result in reduction in number of buses, IPT, usage of private vehicles, air pollution and increase in the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general. The benefit stream includes:

- Savings in Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing modes in case MRTS project is not taken up.
- Savings in operating costs of different modes due to de-congestion including those that would continue to use the existing transport network even after the MRTS is introduced.
- Savings in time of commuters using the MRTS over the existing transport modes because of faster speed of MRTS.

- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.
- Savings on account of prevention of accidents and pollution with introduction of MRTS.
- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case MRTS is not introduced.

The Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area
- Improving the image of the city

Following factors have been used for converting project benefits to economic costs (Table 20.6).

TABLE 20.6: FACTORS USED FOR CONVERTING PROJECT BENEFITS IN TERMS OF ECONOMIC COSTS

S. No	Item	Factor
1	Savings in Capital & Operating Cost of Buses	0.83
2	Savings in Capital & Operating cost of Private Vehicles	0.83
3	Savings in Passenger Time	1.0
4	Savings in VOC	0.9
5	Savings in Accident Costs	0.9
6	Savings in Pollution Costs	1.0

20.3.1 Input Parameters

Inputs used for Economic analysis have been collected from primary and secondary data sources. Vehicle Operating cost (VOC) and Value of Travel Time (VOT) are the two important parameters of Economic Analysis.

Vehicle Operating Cost (VOC): VOC is a function of speed, road roughness, carriageway, width/capacity, rise and fall per unit. The VOC unit cost have been

taken from the “Manual on Economic Evaluation of Highway Projects in India, 2009” by the Indian Road Congress (IRC).

The VOC has been adjusted for Gurugram according to the traffic, road conditions, fuel cost in the city as recommended in the manual. **Table 20.7** gives the mode wise VOC to estimate benefits accruing to the society from the project.

TABLE 20.7: MODE WISE VOC FOR GURUGRAM

Mode	VOC* Rs /Km
Car	6.7
2w	2.0
Auto	3.3
Bus	27.8

**Source IRC SP 30 (2009) Values brought to 2019 level*

Value of Travel Time (VOT): VOT is another important parameter of Economic Analysis. It refers to the cost of time spent on transport. It includes costs of both work and non-work trips. The value of travel time for MRTS passengers has been taken as that of deluxe bus. **Table 20.8** gives the mode wise VOT to estimate benefits accruing to the society from the project.

TABLE 20.8: MODE WISE VOT FOR GURUGRAM MRTS

Mode	Value of Travel Time Passenger/ Hour
Car	100
2w	50
Auto/Taxi	50
Bus	50
Metro	50

**Source RITES Primary Survey 2018*

Other operational parameters required to assess the savings in VOC and VOT, accidents, pollution for the system in the year 2051 are presented in **Table 20.9**.

TABLE 20.9: MODE WISE OPERATIONAL PARAMETERS – METRO

Mode	Average Lead KM	Veh-KM/ Day	Average Speed (Km/Hr)*		Occupancy
			Without MRTS	With MRTS	
Bus	7.94	200	13	17	40
Car	11.54	30	18	24	2.2

Mode	Average Lead KM	Veh-KM/Day	Average Speed (Km/Hr)*		Occupancy
			Without MRTS	With MRTS	
2wh	8.42	20	18	24	1.1
Auto/Taxi	7.0	150	18	24	2.5

Source: RITES Primary Survey 2018, * Derived from Transport Demand model

Other benefits that will accrue to the society include reduction in emission, savings due to reduction in accidents. The input for the benefit estimation from these parameters include the emission factors by vehicle category as given by CPCB (Table 20.10), vehicle and accident statistics and cost of accidents (Table 20.11) in Gurugram.

TABLE 20.10: MODE WISE EMISSION FACTORS (Gram/Km)

Vehicle Type/ Pollutant	CO	HC	NOX	PM	CO2
2-wheeler	1.4	0.7	0.3	0.05	28.58
Auto	2.45	0.75	0.12	0.08	77.89
Cars (incl. cabs)	1.39	0.15	0.12	0.02	139.52
Bus (incl. BRT)	3.72	0.16	6.53	0.24	787.72
Treatment Cost (Rs. /ton)	1,00,000	1,00,000	1,00,000	1,00,000	500

Source: Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017

TABLE 20.11: COST OF ACCIDENTS

Type of Accident	Accident Cost (Rs.)	
	(2004 prices)*	(2019 prices)**
Cost of fatal accident	437342	909203
Cost of major accident	64256	133584
Cost of damage to Two wheelers	2286	4752
Cost of damage to Car	9763	20297
Cost of damage to buses in road accidents	32818	68226

Source: *Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017

**derived using escalation factor of 5%

20.3.2 Estimation of Project Benefits

Quantifiable benefits accrued to the society owing to implementation of the Metro project include:

- Travel Time Savings
 - Travel Time Savings due to higher speed of MRTS project as compared to 'Without' project scenario.
 - Congestion reduction due to modal shift leads to fewer vehicles on roads. This also contributes to time savings of passengers travelling on other modes.
- Savings in Vehicle Operating Cost
 - Absence of vehicles on road due to modal shift passengers on MRTS

- Smoother operations of passenger trips of other mode vehicles owing to reduced congestion on roads.
- Savings from Accident Reduction
 - Reduction in fatal and injury accidents due less no of vehicles on roads
 - Savings in damage cost to vehicles involved in accidents.
- Savings from Pollution Reduction
 - Absence of vehicles on road due to modal shift passengers on MRTS
 - Less pollution due to reduced congestion on roads.
- Savings in Road Infrastructure Maintenance
 - With less no of vehicles on roads, expenditure on road maintenance is expected to go down. In the absence of data, a lump-sum expenditure of Rs. 48 Cr/ year has been assumed.

Above socio-economic benefits have been converted in money cost. With input from above tables, the accrued project benefits for Gurugram Metro during the frame work period of 30 years have been summarized in **Table 20.12**.

TABLE 20.12: COMPARISONS OF SAVINGS FROM MRTS IN HORIZON YEAR – 2051

S.NO	BENEFITS	MRTS	
		Amount (crore)	% Share
1	Travel Time Savings	697.20	42.89%
2	Savings in Vehicle Operating Cost	741.60	45.62%
3	Savings from Accident, Pollution & Road maintenance Reduction	186.80	11.49%
	Total	1625.60	100%

It is clear from the table that benefits irrespective of the system benefits are mainly come from saving of travel time by MRTS and road passengers (42.89%), VOC savings (45.62%), and Environmental benefit from emission reduction, accident reduction and road maintenance cost (together 11.49%).

20.4 EIRR FOR 30 YEARS

For deriving the values of economic indicators (EIRR, ENPV), cost and benefit stream has been constructed in terms of money value. The Toolkit on Finance and Financial Analysis 2013 by MoHUA, suggests that ENPV to be calculated on social cost of capital or government security rate. Accordingly, ENPV have been calculated on both the rates.

Metro Rail Policy 2017 prescribes 14% as acceptable EIRR rate for metro project, same has been considered as the social cost of capital. The government security rate in December '2017 is 8%. Accordingly, ENPV has been calculated based on these rates. The summary of the ENPV and EIRR is presented in **Table 20.13**. The cost and benefit streams for Metro system is presented in **Table 20.15**.

TABLE 20.13: ECONOMIC RETURN PARAMETERS OF GURUGRAM METRO

S.NO	PARAMETER	Metro
1	EIRR	20.36%
2	ENPV - Social cost of capital @14% - Government Security Rate@ 8%	Rs. 1688 Crore Rs. 6413 Crore

20.5 OUTCOME ON ECONOMIC VIABILITY

The project has EIRR more than 14%, indicating that the benefits to the society are more than the social cost of capital of 14%. It also meets the acceptable norm of MoHUA. Thus, the project is economically viable and should be implemented.

20.5.1 Sensitivity Analysis

The sensitivity analysis has been carried out to see the impact of change in critical parameters in the range of 5% to 15% on EIRR and is presented in **Table 20.14**.

TABLE 20.14: SENSITIVITY ANALYSIS

S. No.	Factor	Range		
		5%	10%	15%
1	Cost overruns due to delay or other factors	19.63	18.96	18.34
2	Increase in Maintenance Cost	20.31	20.11	19.98
3	Reduction in Ridership	20.18	20.01	19.83
4	Reduction in benefits	19.94	19.51	19.08
5	Combination of reduction in benefits and increase in cost	19.23	18.17	17.18

TABLE 20.15: COST AND BENEFIT STREAM FOR METRO SYSTEM (IN CRORE)

PRICE LEVEL: September'2021

Year	Capital Cost	O&M Cost	Additional Cost + Replacement Cost	Total Cost	Saving in Capital Cost of Reduced Buses	Saving in Capital Cost of Reduced of other vehicles	VOC Saving of all vehicles	Savings due to Decongestion Effect	Savings in Passenger time	Savings due to Less pollution	Savings due to Less No. of accidents	Savings in Infrastructure Maintenance due to Less No. of accidents	Total Savings	Net Cash Flow (Rs. in Crore)
2022	381.64			381.6									0.0	-381.6
2023	1144.93			1144.9									0.0	-1144.9
2024	1335.76			1335.8									0.0	-1335.8
2025	954.11			954.1									0.0	-954.1
2026		156.1		156.1	42.1	641.8	185.3	133.7	303.76	53.5	5.7	48.6	1414.5	1258.4
2027		158.5		158.5	4.5	68.5	204.8	144.7	328.9	58.5	6.3	48.6	864.8	706.3
2028		161.0		161.0	4.5	68.5	226.4	156.7	356.0	64.0	7.0	48.6	931.7	770.7
2029		163.5		163.5	4.5	68.5	250.3	169.6	385.4	70.0	7.8	48.6	1004.7	841.2
2030		165.9		165.9	4.5	68.5	276.7	183.6	417.3	76.6	8.6	48.6	1084.4	918.4
2031		168.4	709.9	878.3	4.5	68.5	305.9	198.7	451.8	83.8	9.6	48.6	1171.3	293.0
2032		169.4		169.4	4.5	68.5	338.2	215.1	489.1	91.6	10.6	48.6	1266.2	1096.8
2033		170.3		170.3	4.5	68.5	344.7	218.9	497.7	93.3	10.8	48.6	1287.0	1116.6
2034		171.3		171.3	4.5	68.5	351.3	222.7	506.5	95.0	11.0	48.6	1308.1	1136.8
2035		172.2		172.2	4.5	68.5	358.0	226.6	515.4	96.7	11.2	48.6	1329.6	1157.4
2036		173.2		173.2	82.3	1258.7	364.8	230.6	524.5	98.5	11.4	48.6	2619.5	2446.3
2037		174.2		174.2	1.3	19.8	371.8	234.7	533.7	100.3	11.7	48.6	1321.9	1147.8
2038		175.1		175.1	1.3	19.8	378.9	238.8	543.2	102.2	11.9	48.6	1344.7	1169.5
2039		176.1		176.1	1.3	19.8	386.2	243.1	552.7	104.0	12.1	48.6	1367.8	1191.7
2040		177.0		177.0	1.3	19.8	393.6	247.3	562.5	105.9	12.3	48.6	1391.3	1214.3

Year	Capital Cost	O&M Cost	Additional Cost + Replacement Cost	Total Cost	Saving in Capital Cost of Reduced Buses	Saving in Capital Cost of Reduced of other vehicles	VOC Saving of all vehicles	Savings due to Decongestion Effect	Savings in Passenger time	Savings due to Less pollution	Savings due to Less No. of accidents	Savings in Infrastructure Maintenance due to Less No. of accidents	Total Savings	Net Cash Flow (Rs. in Crore)
2041		178.0	375.8	553.8	1.3	19.8	401.1	251.7	572.4	107.9	12.6	48.6	1415.3	861.5
2042		179.0		179.0	1.3	19.8	408.8	256.1	582.5	109.8	12.8	48.6	1439.7	1260.8
2043		179.9		179.9	1.3	19.8	411.6	261.3	594.2	111.4	12.9	48.6	1461.1	1281.2
2044		180.9		180.9	1.3	19.8	414.5	266.6	606.2	113.0	13.0	48.6	1482.9	1302.0
2045		181.8	515.3	697.2	1.3	19.8	417.3	272.0	618.4	114.5	13.1	48.6	1505.1	807.9
2046		182.8		182.8	94.0	1436.9	420.2	277.5	630.9	116.2	13.2	48.6	3037.4	2854.6
2047		183.8		183.8	0.8	12.5	423.2	283.1	643.6	117.8	13.2	48.6	1542.8	1359.0
2048		184.7		184.7	0.8	12.5	426.1	288.8	656.6	119.4	13.3	48.6	1566.1	1381.4
2049		185.7		185.7	0.8	12.5	429.1	294.6	669.9	121.1	13.4	48.6	1589.9	1404.3
2050		186.6		186.6	0.8	12.5	432.0	300.5	683.4	122.8	13.5	48.6	1614.2	1427.5
2051		187.6		187.6	0.8	12.5	435.0	306.6	697.2	124.6	13.6	48.6	1638.8	1451.2
2052		188.6		188.6	0.8	12.5	438.1	312.8	711.2	126.3	13.7	48.6	1663.9	1475.4
2053		189.5		189.5	0.8	12.5	441.1	319.1	725.6	128.1	13.8	48.6	1689.5	1500.0
2054		190.5		190.5	0.8	12.5	444.2	325.5	740.2	129.9	13.9	48.6	1715.5	1525.0
2055		191.5		191.5	0.8	12.5	447.3	332.1	755.1	131.7	13.9	48.6	1742.1	1550.5
2056		192.5		192.5	101.4	1549.0	450.4	338.8	770.4	133.6	14.0	48.6	3598.8	3406.2
													EIRR	20.36%
													NPV@14%	1,688
													NPV@8%	6,413

Chapter – 21

IMPLEMENTATION PLAN

21. IMPLEMENTATION PLAN

21.1 PROJECT IMPLEMENTATION PLAN

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as Revised DPR is approved by Government of Haryana and HMRTC. The possible dates for important milestones are given in **Table 21.1**.

TABLE 21.1: PROJECT IMPLEMENTATION SCHEDULE

S. No.	Tasks	Timelines
1	Final DPR	October, 2019
2	Revised Final DPR	October, 2021
3	State Government Approval of DPR	November, 2021
4	Appointment of Interim Consultant	January, 2022
5	Approval by GoI	March, 2022
6	Appointment of DDC for Civil Works	June, 2022
7	Packaging and Invitation of Bids	September, 2022
8	Appointment of General Consultants	October, 2022
9	Commencement of Civil Works	December, 2022
10	Commencement of Operation	April, 2026

21.2 IMPLEMENTATION STRUCTURE

Gurgaon metro project will be implemented on SPV model by Haryana Mass Rapid Transport Corporation (HMRTC). However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model. The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

21.3 LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE PROJECT

21.3.1 Institutional Arrangements

The Government of Haryana created a Special Purpose Vehicle (SPV) for implementing the Gurgaon Metro Rail Project. The SPV, “Haryana Mass Rapid Transport Corporation (HMRTC)” was incorporated on 24.03.2012 under the

Companies Act, 1956.

HMRTC shall be responsible for implementation of the proposed Metro rail corridor in Gurgaon.

Metro construction is a very specialized and multi-disciplinary job. It is therefore, impossible to have a single organizational set up which can be responsible for all aspects of metro implementation, namely investigation, planning, design, drawing up of specifications, preparation of tender documents, fixing of contractors, supervising the contractors' works, ensuring interface fusion between different contractors, ensuring quality and safety during constructions, planning and supervising integration system trials and getting the project commissioned in time.

It is suggested to have a two tier organization with well defined responsibilities for implementation of this project. At the apex will be the HMRTC with full mandate and total power with accountability. The second level will be project management team called the 'General Consultant', who will be engaged by the HMRTC on contract basis. They will be fully responsible for planning, designing and project management. In fact, they will be 'Engineers' for the HMRTC, who will be the 'Client'. The Detailed Design Consultants as required may be engaged by the General Consultants as their sub-consultants within their own contractual responsibilities.

21.3.2 High Power Committee

During the implementation of the project, several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Haryana may be set up. Other members of this Committee may be the Secretaries of concerned Departments of State Government and Heads of civic bodies who are connected in one way or the other with the implementation of the project.

21.4 ROLE, RESPONSIBILITY AND INVOLVEMENT OF CITY GOVERNMENT

21.4.1 Unified Metropolitan Transport Authority (UMTA)

The National Urban Transport Policy 2006 has recommended setting up of Unified Metropolitan Transport Authorities (UMTA's) in million plus cities. The policy document stipulates following on UMTA.

“The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. These structures were put in place well before the problems of urban transport began to surface in India and hence do not provide for the right coordination mechanisms to deal with urban transport. The central government will, therefore, recommend the setting up of Unified Metropolitan Transport Authorities (UMTA's) in all million cities to facilitate more coordinated planning and implementation of urban transport programs & projects and integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful.”

The Metro Rail Policy - 2017 makes it mandatory for the cities which are planning to have MRTS to address their mass transport requirements to have city level UMTA.

For integrated approach in planning and management of urban transport in the city, State Government shall constitute Unified Metropolitan Transport Authority (UMTA) as a statutory body. This Authority would implement various proposals as per CMP for the city, organize investments in urban transport infrastructure, establish effective coordination among various urban transport agencies, manage the Urban Transport Fund (UTF) etc. UMTA will have to play active role in the implementation of Gurgaon Metro Rail project, being a city government authority.

21.4.2 Steering Committee

Apart from a High Power Committee under the chairmanship of Chief Secretary, Haryana, a 'Steering Committee' may be set up under the chairmanship of Commissioner, Gurgaon. Other members of this Committee may be District Magistrate, Municipal Commissioner and other heads of civic bodies who will be connected in one way or the other with the implementation of the project.

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. The steering committee will work for expeditious resolution of these problems at local level. This Committee may meet regularly to sort out all problems brought before it by HMRTC.

21.4.3 Performance Monitoring During Construction and Implementation

The efficiency in standards during construction and implementation will be monitored in following manner:

1. Constant monitoring in the meeting of the Board of Directors of the company.
2. Monitoring by High Powered Committee (HPC) of the State Government: During implementation of the project, a High Powered Committee under the chairmanship of the Chief Secretary of the State Government will be set up by the State Government to take expeditious decisions on land acquisition matters, diversion of utilities, shifting of structures in the project alignment, rehabilitation of Project Affected Persons, multimodal integration and such other matters where the State Government has to facilitate quick action including various conditions of sanction of this project.
3. Audit of the projects accounts to be monitored in the Audit Committee of BoD.

21.5 REALISING THE GOAL OF AATMANIRBHAR BHARAT

a. Aatmanirbhar Bharat

In the recent times, India has demonstrated how it rises up to challenges and uncovers opportunities therein, as manifested in the re-purposing of various automobile sector industries to collaborate in the making of life-saving ventilators. Atmanirbhar Bharat (self-reliant India) is the vision of the Hon'ble Prime Minister of India of making India a self-reliant nation. The first mention of this came in the form of the 'Atmanirbhar Bharat Abhiyan' or 'Self-Reliant India Mission' during the announcement of the COVID-19 pandemic related special economic package equivalent to 10% of India's GDP in May, 2020 with the aim of making the country independent against the tough competition in the global supply chain and to help in empowering the general public who have been adversely affected by COVID.

Due to the long-lasting lockdown phases, India has come to a very crucial juncture. The Indian culture and tradition have always backed the concept of being Self-Reliant and at the same time not being self-centric but being self sufficient.

The Five pillars of Atmanirbhar Bharat focus on:

- Economy
- Infrastructure
- System
- Vibrant Demography and
- Demand

b. Gurgaon Metro Project - Realising The Goal of Aatmanirbhar Bharat

The project has following major components:

- i) Alignment and Formation
- ii) Station Buildings
- iii) Maintenance Depot
- iv) Traction and Power Supply
- v) Telecommunication
- vi) Utility Diversion, Security & Intermodal Integration
- vii) Rolling Stock

The goods and services or works for which sufficient local capacity and local competition exist, the procurement will be from the indigenous sources.

21.6 WAY FORWARD

On acceptance of the Comprehensive Detailed Project Report, following actions may be initiated for implementing the project:

- Approval of State Government (Cabinet Approval) to the Detailed Project Report
- Issue of notifications for the project, alignment and setting up of UMTA
- DPR to be forwarded to the Ministry of Housing and Urban Affairs, Niti Aayog and Finance Ministry with request for approving the Metro project and for financial participation through equity contribution to the SPV
- Approval from Government of India
- Appointment of Detailed Design Consultants (DDC)
- Appointment of General Consultants (GC)
- Packaging and invitation of bids for various contracts
- Land acquisition related issues
- Examination and appraisal of DPR by bilateral/multilateral funding agencies for possible funding
- Stakeholder consultation on environmental and social impact of the project

- Signing of an MOU between Haryana State Government and Government of India giving all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure etc.
- Agreement between the State and Central Government for financing the debt portion of the project along with the setting up of time frame for completing the Project
- Loan approval
- Providing legal cover for construction as well as O&M stages of the Project.
- Memorandum of Understanding between various service providers to provide seamless integration between various transport modes



A Trusted Partner In Business Across The Globe

URBAN TRANSPORT DIVISION

RITES Bhawan

Plot No. 1, Sector 29, Gurgaon – 122001 (INDIA)

Tel: 0091-124-2571666, 2818769, 2818742

Fax: 0091-124-2571638