NATIONAL HIGHWAYS AUTHORITY OF INDIA (NHAI)

Consultancy Services for Preparation of Feasibility Report of Access Controlled Delhi-Jaipur Expressway (Greenfield): Additional Works

DRAFT FEASIBILITY REPORT INCLUDING SCHEDULES TO THE CONCESSION AGREEMENT

DWARKA EXPRESSWAY (NH 248-BB)

PACKAGE -2 (Km 5+300 to Km 9+500)

Volume I : Main Report

September, 2017

AECOM

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EXECUTIVE SUMMARY

1. BACKGROUND

Considering NH-8 as one of the busiest highways in North India, as it connects the National capital Delhi to the financial capital Mumbai, as well as important cities Gurgaon, Jaipur, Ajmer, Udaipur, Ahmedabad, Vadodara and Surat, NHAI commissioned the preparation of Feasibility and DPR of Greenfield Delhi Jaipur Expressway. The Consultancy services for Feasibility Study of Delhi – Jaipur Expressway to be executed as BOT (Toll) project on DBFO pattern under NHDP Phase VI- was awarded to M/s. AECOM Asia Company Ltd. in consortium with AECOM India Pvt. Ltd., Consulting Engineers Group Ltd., G-Eng Advisory Services Pvt. Ltd.

In the vicinity of Gurgaon and NH 8 there are many other important road network connections which are being planned and development of which might affect the traffic to proposed Delhi Jaipur Expressway. These include Dwarka Expressway, Extension of Nelson Mandela Marg, proposed Gurgaon Manesar Expressway and extension of UER-II to Ryan International School south of Rangpuri. These projects will help to reduce traffic on NH-8 and will provide an alternate route to the traffic movement between Delhi and Gurgaon and therefore have to be seen in an integrated manner. Considering this NHAI further awarded Feasibility of these new projects to the above mentioned consortium as *additional work as a variation to consultancy service of Delhi-Jaipur Expressway vide* commencement letter no. *NHAI/ CGM (T)BSS/Del-Jai Exp/2012/2/91994 dated 05.12.2016*.

In line with the work order the Draft Feasibility Report (km 9+500 to km 19+700) section of Dwarka Expressway in the State of Haryana is being submitted.

2. PROJECT DESCRIPTIONS

General

As part of Development Plan 2031 of Gurgaon Manesar Urban Complex (GMUC), Dwarka Dwarka Expressway also known as Northern Peripheral Road (NPR) is proposed to be developed as northern ring road thereby providing additional connectivity between Gurgaon and Delhi apart from NH 8, Old Delhi Road and MG Road. Due to rapid increase in traffic between Delhi and Gurgaon on NH 8 and other road network, there has been a constant demand to complete Dwarka Expressway at the earliest.

As per the development plan of GMUC, the alignment of Dwarka Expressway / NPR was planned to start from Km 42 near the toll plaza and another arterial road known as Connecting Peripheral Road (CPR) was proposed to connect NPR near Sector 83 and passing through north of Gurgaon cutting across Pataudi Road, Jhajjar Road, Najafgarh Road and finally connecting UER 2 in Dwarka.. However due to land acquisition issues, NPR/ Dwarka Expressway intersection with NH 8 is not possible as it will also affect the Km 42 toll plaza. Therefore, it was decided that Dwarka Expressway will include entire section of CPR and will terminate at the intersection

of CPR-NH 8-SPR. The Dwarka Expressway is proposed to take off from NH-8-SPR-CPR intersection, 1.5 Km before Km 42 toll plaza.

Once operational, this expressway will provide an alternate route to the commuter traffic between residential centres of Dwarka , Najafgarh and West Delhi destined towards employment centres of Eastern and Western Gurgaon completing bypassing the NH 8. It will also facilitate the regional traffic movement from Western Delhi towards Southern Haryana & Rajasthan via Pataudi Road, NH 8 and the proposed Delhi Jaipur Expressway.

The total length of Dwarka Expressway is 27.6 km out of which 21.5 Km is original alignment length which was earlier proposed to terminate at the intersection Urban Extension Road (UER)-II in Dwarka. Out of 21.5 Km, 18.1 Km length falls in Haryana and remaining 3.2 Km in Delhi. Government of Haryana later handed over the construction of Dwarka Expressway to NHAI. Therefore, in order to keep the continuity of connectivity between sections of National Highway, it was decided to include section of UER-II between Dwarka Expressway intersection and Shiv Murti also as part of Dwarka Expressway. The length of section of UER II is 6.3 Km thereby increasing the total length of Dwarka Expressway to 27.6 Km and total length in Delhi to 9.50Km.

Contract Packaging

The total project has been further subdivided into 4 contract packages as per the meeting held on 1st June 2017 under the Chairmanship of Honourable Minister for Road Transport & Highways. The recommended contract packages and their respective lengths are described below:

S.No	Contract Package	Description	Chainage	Length (Km)
1.	Package 1	Shiv Murti to Tail under Bridge (RuB)	Km 0.000 to Km 5.300	5
2.	Package 2	Rail under Bridge (RuB) to Delhi Haryana Border	Km 5.300 to Km 9.500	4.5
3.	Package 3	Delhi Haryana Border to Rail over Bridge (RoB)	Km 9.500 to Km 19.700	10.2
4.	Package 4	Rail Over Bridge (RoB) till End Point Km 40 NH-8-SPR Intersection near Kherki Daula	Km 19.700 to Km 27.6	7.9

The present report being submitted is only for Package 3.

The project road section passes through Gurgaon district of Haryana.

Table 0-1**: Details of Project Districts**

Sl. No.	Name of Districts	Existing Chainage		Length (km)	Percentage
		From	To		
1	Gurgaon	9+500	19+700	10.2	100%

3. TRAFFIC FOPRECAST

Traffic Volume

Dwarka Expressway has been divided into five homogenous sections in such a way that traffic intensity within a particular section will be more or less uniform. The homogenous sections (HS) identified and their estimated average annual daily traffic in PCU are listed below:

Table 0-2**: Annual Average Daily Traffic (PCUs)**

S.NO.	SECTION	Contract Package	2017	2021	2025	2030	2035	2040	2045
I	NH-8 Shiv Murti to Dwarka Sec-21	Package 1	47,196	68,641	1,03,940	1,26,357	1,61,267	2,05,822	2,62,687
II	Dwarka Exp. Sec 21 to Delhi Haryana Border	Package 2	23,605	34,130	71,602	98,813	1,26,113	1,60,956	2,05,425
III	Delhi Border to Pataudi Road	Package 3	17795	31165	68271	94472	120573	153885	1,96,400
IV	Pataudi Road to Sec 36 A	Package 4	17,238	32,277	73,560	1,02,690	1,31,061	1,67,271	2,13,485
V	Dwarka Exp. Sec 36A to SPR Intersection		18,566	33,887	75,519	1,05,144	1,34,193	1,71,268	2,18,587

The current package of which this report is being submitted falls under Homogenous section III. Hence the project corridor under this study is expected to serve average annual daily traffic of more than 1,20,000 in next 20 years design period.

4. ALIGNMENGT DESIGN:

The report details out the alignment design considerations for entire project however, the section below describes the alignment design of Package 3 only

Section 4 (Package 3): Haryana Border to approach of Rail over Bridge (RoB) (Km 9.500 to Km 19.500)

The section passes through Sectors 102, 103, 104, 105, 106, 107, 110, 111, 112 and 113. The major intersections in this section are Sector 104/105 dividing road, sector 105/110 dividing road, Village Bajghera Road towards Najafgarh near Sector 110 A and intersection with Village road at Delhi border.

After entering Haryana Border, the alignment initially remains at grade. Since this section has continuous intersections of Sector roads, it was decided to keep the main carriageway elevated for the entire length of the section having dual carriageway of 4 lanes.

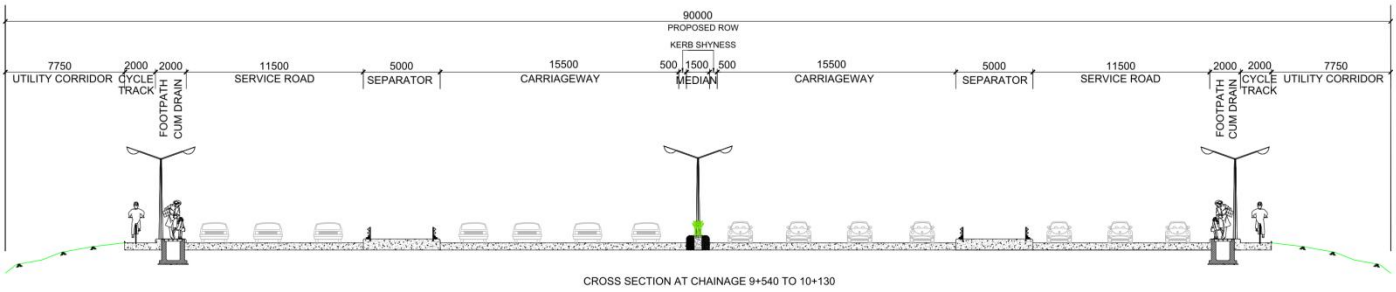


Figure 0-1: Typical at Grade Cross Section (TCS-5) between Km 9.540 and Km 10.2

The elevated main carriageway takes off from Km 10.250 and terminates at Km 19.200.

There are 7 major intersections with existing/ proposed Sector Roads. The service road is proposed to have 3 lanes (11.5 m width).

At all major intersections 2 lane (8 m width) flyovers along with 4 lane underpasses on cross roads have been proposed. The at grade arrangement will only be for facilitating right turns by using rotary.

The section also has the 2 main hindrances in the Dwarka Expressway where land is yet to be acquired these are located between Km 11.500 to Km 11.900 and between Km 12.250 to 12.750, these also include 2 sector roads including sector 106/109 dividing road and sector 109/112 dividing road in this stretch where land acquisition is not complete.

Elevated entry exit is provided in this section at Chainage Km 14.900.

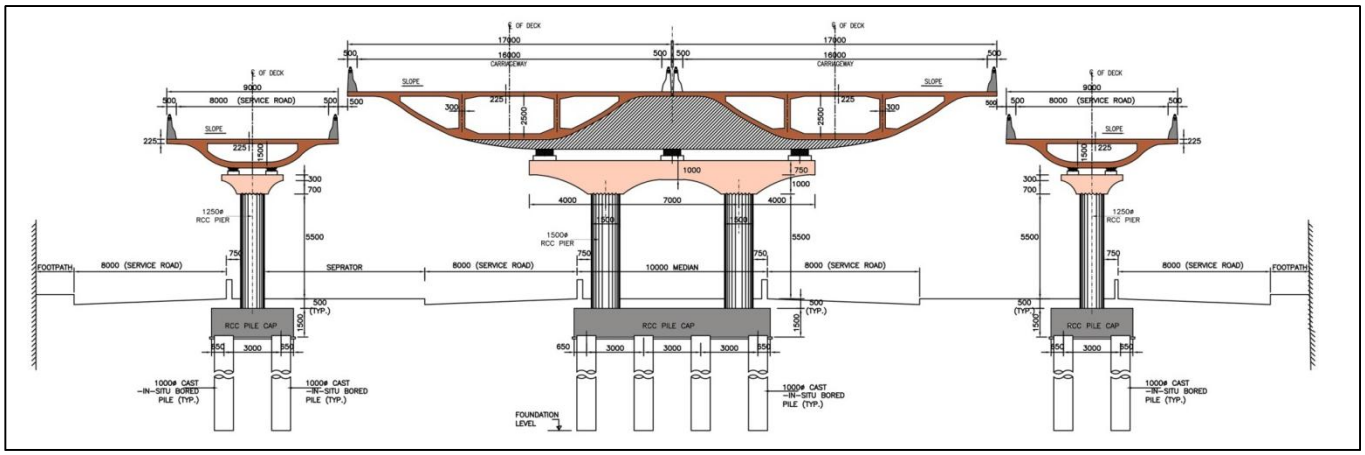


Figure 0-2: Typical Cross Section (TCS – 1) of Elevated Portion with Elevated Service Road

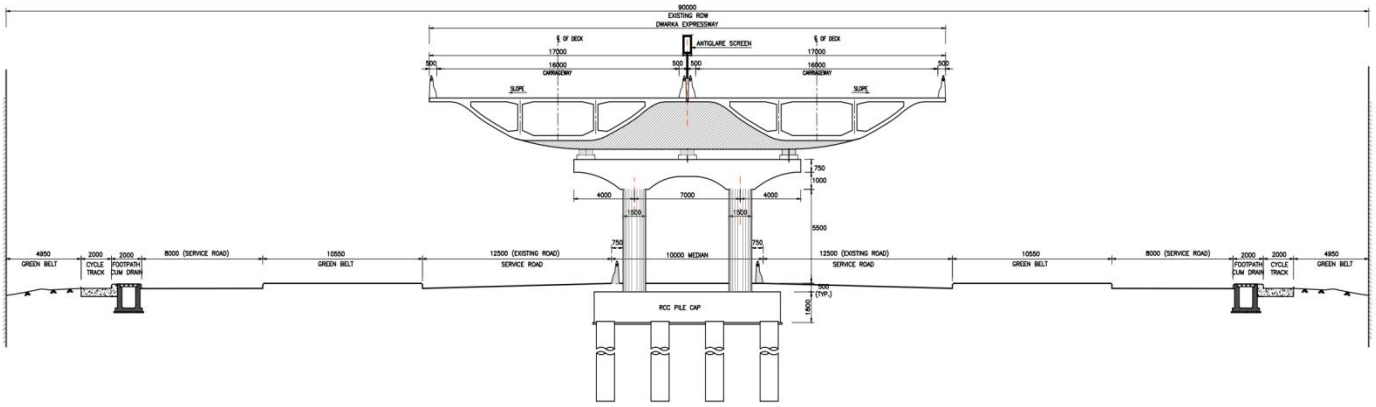


Figure 0-3: Typical Cross Section (TCS – 2) of Elevated Portion with at grade Service Road

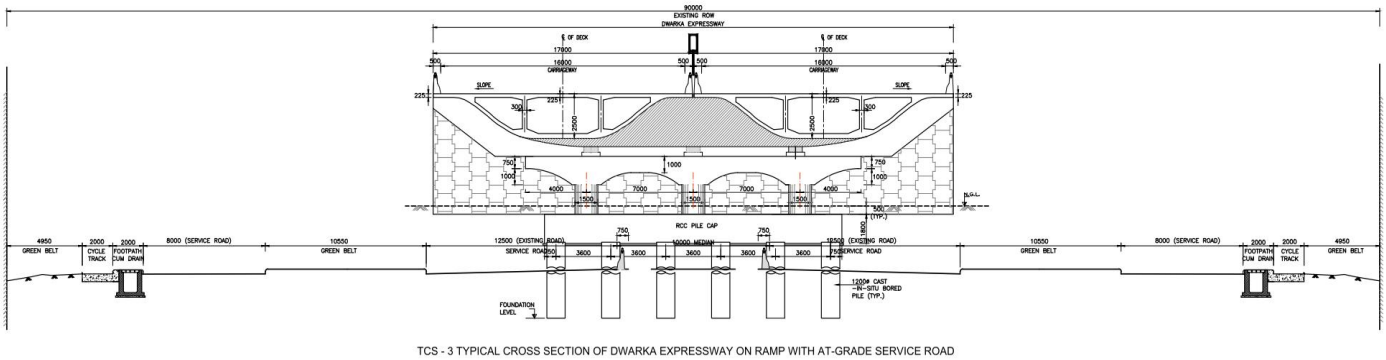


Figure 0-4: Typical Cross Section (TCS – 3) of Elevated Portion on Ramp with at grade Service Road

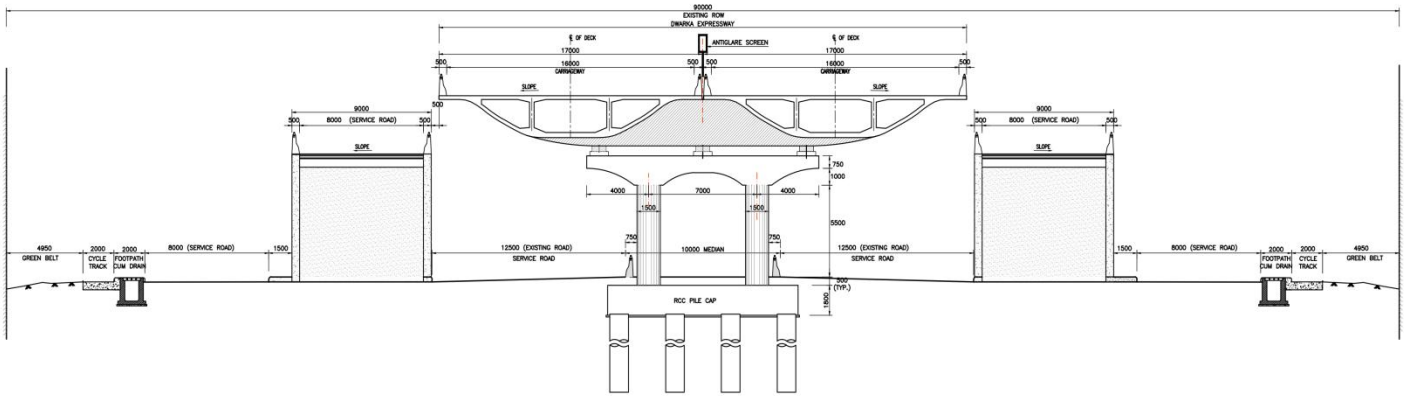


Figure 0-5: Typical Cross Section (TCS – 4) of Elevated Portion with Service Road on Ramp

5. PROJECT DEVELOPMENT DESCRIPTION

Proposed Pavement

Wherever Dwarka Expressway is at-grade, flexible pavement is proposed. The proposed pavement is tabulated below:

Table 0-3: Proposed Pavement Thickness of Main Carriageway of Dwarka Expressway and all Link Roads

Effective Subgrade CBR	Design MSA (20 years)	Pavement Thickness (mm)			
		BC	DBM	WMM	GSB
8%	75	40	105	250	200

Proposal for Widening of Main Carriageway

For Dwarka Expressway and all ramps merging to or exiting from the Expressway under this scope of work, the paved carriageway including shyness shall be as per the table below:

Table 0-4: Details of Main Carriageway for Dwarka Expressway

S. No.	Chainage of Dwarka Expressway		Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To	From	To			
Main Carriageway							
1	5+300	8+915	5+300	6+577	1277	30	14 m wide Main Carriageway and shyness in both directions
2			6+740	8+915	2175	30	14 m wide Main Carriageway and shyness in both directions
3	8+915	9+220	8+915	9+220	305	As per the requirement of Toll Plaza	
4	9+220	9+500	9+220	9+500	280	30	14 m wide Main Carriageway and shyness in both directions
Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka							
1	5+719	5+931	5+730	5+936	206	0 to 11.5m	10.5 m wide main carriageway and Shyness on both sides
2	5+931	7+347	5+936	7+101	1165	11.5	10.5 m wide main carriageway and 0.5 m wide Shyness on both sides
Ramp from ECC Dwarka merging with Right Carriageway of Dwarka Expressway							
1	7+100	7+354	7+100	7+354	254	0 to 11.0m	10.5 m wide main carriageway and 0.25 m wide Shyness on both sides

S. No.	Chainage of Dwarka Expressway		Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To	From	To			
2	7+354	7+440	7+354	7+701	347	11.0	10.5 m wide main carriageway and 0.25 m wide Shyness on both sides

For the link road coming out of Dwarka Expressway near the Sector 21 Metro Station junction (MSJ) and leading to Najafgarh and all the ramps merging to or exiting from this link road, the paved carriageway shall be as per the table below:

Table 0-5: Details of Main Carriageway for Link Road to Najafgarh along UER 2

Sl. No.	Design Chainage of LME / RME* of Link Road to Najafgarh		Design Chainage of Individual Road / Ramp		Length (m)	Width of Paved Carriageway (m)		Remarks
	From	To	From	To		Left	Right	
Main Carriageway of the Link Road from Dwarka Sector 21 Metro Station Junction (MSJ) to Najafgarh								
1	5+755	8+300	5+755	8+300	2545	11.5		
2	5+316	5+508	5+316	5+508	192	-	11.5	
3	5+508	5+725	5+508	5+725	217	-	Varying from 11.5 to 9.25	
4	5+725	6+180	5+725	6+180	455	-	9.25	7 m wide main carriageway, 2 m wide paved shoulder and 0.25 m wide Shyness on inner side
5	6+180	6+213	6+180	6+213	33	-	Varying from 9.25 to 11.5	
6	6+213	8+300	6+213	8+300	2087	-	11.5	
Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ								
1	5+730	5+982	5+730	6+093	363	-	7.5	7 m wide main carriageway and 0.25 m wide Shyness on both sides
2	5+982	6+234	6+093	6+250	157	-	Varying 7.5 to 0	
Ramp from Dwarka Sector 23 towards RUB / Shiv Murty								
1	5+316	5+508	5+316	5+506	190	-	Varying from 0 to 7.5	
2	5+508	6+182	5+506	6+184	678	-	7.5	7 m wide main carriageway and 0.25 m wide Shyness on both sides
Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka								

Sl. No.	Design Chainage of LME / RME* of Link Road to Najafgarh		Design Chainage of Individual Road / Ramp		Length (m)	Width of Paved Carriageway (m)		Remarks
	From	To	From	To		Left	Right	
1	6+302	6+425	6+302	6+425	123	0 to 9.25m	-	
2	6+625	6+921	6+425	6+930	505	9.25	-	
3	6+921	7+065	6+930	7+120	190	Varying from 9.25m to 11.0m	-	
4	7+065	7+100	7+120	7+317	198	11.0	-	
Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ								
1	6+470	6+660	6+594	6+784	190	-	0 to 9.25m	
2	6+660	7+100	6+784	7+330	546	-	9.25	
Ramp from ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ								
1	6+872	7+100	7+106	7+663	557	-	9.25	
Ramp from ECC Bus Drop-off going towards Sector 24								
1	7+150	7+500	7+330	7+629	299	-	9.25	
Ramp from Left Carriageway from Dwarka Sector 21 MSJ to Golf Course Road								
1	7+000	7+650	-	-	650	9.25	-	

**LME – Left Median Edge of Link Road to Najafgarh; RME – Right Median Edge of Link Road to Najafgarh*

For the link road coming out of Dwarka Expressway after the existing Road under Bridge (RUB) and leading to Dwarka Sector 21, the paved carriageway shall be as per the table below:

Table 0-6: Details of Main Carriageway for Link Road to Dwarka Sector 21

Sl. No.	Design Chainage of Dwarka Expressway		Design Chainage of Link Road		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To	From	To			
1	5+300	5+700	5+300	6+150	850	11.5	

For the link road from Dwarka Sector 23 and merging with Dwarka Expressway going towards Kherki Daula, the paved carriageway shall be as per the table below:

Table 0-7: Details of Main Carriageway for Link Road from Dwarka Sector 23

S. No.	Design Chainage of Link Road		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To			
Left Carriageway					
1	5+466	7+010	1544	11.5	
2	7+010	7+185	175	Varying from 11.5m to 0	
Right Carriageway					
1	5+465	6+645	1180	11.5	
2	6+645	6+904	259	Varying from 11.5m to 0	

The road connecting Bijwasan and Najafgarh will have combination of underpass and flyover along the road having a carriageway width of 9 m (7 m wide main carriageway and 2 m wide paved shoulder) in each direction for a length of 1000 m. in addition a slip road will also be provided having 7.5 m width on both sides for a length of 800 m

Intersections

7 major and 9 minor junctions are proposed to be improved as a part of upgradation project. The improvement proposals of major and minor junctions are given respectively in Table 0-8.

Table 0-8: Junction Improvement Proposal

SL No.	Location	Salient Features	Road to be carried under the structure	Remarks
1	5+700 of Dwarka Expressway	• Elevated Dwarka Expressway; • Elevated Link road to Najafgarh; • Depressed link road to Dwarka Sector 21	Service roads	Necessary improvement of the at-grade junction with the service road is also included in the scope of work
2	6+300 of Link Road to Najafgarh	• Elevated Dwarka Expressway; • Elevated Link road to Najafgarh; • Elevated Link road from Dwarka Sector 23 to Kherki Daula • 3-lane Roundabout for all at-grade service road movements	Service roads	Necessary improvement of the at-grade junction with the service road with a 3-lane roundabout is also included in the scope of work
3	8+000 of Dwarka Expressway	Elevated Dwarka Expressway	Cross-road	Necessary improvement of the at-grade junction with the service road is also included in the scope of work
4	8+600 of Dwarka Expressway	• Service road on Elevated Structure • Cross-road through underpass	Service roads	Necessary improvement of the at-grade junction with the service road is also included in the scope of work
5	7+600 of Link Road to Najafgarh	Elevated Link Road to Najafgarh	Golf Course road	Necessary improvement of the at-grade junction with the service road is also included in the scope of work

Proposal of Flyovers, Bridges, Culverts and other Structures

a) Bridges

There are no major bridge under Package 2. Only one new bridge is necessary to cross the proposed slip road across an existing drain. The proposal of this new bridge is presented below:

Table 0-9: Development Proposal of New Bridge

Sl. No	Chainage (km)	Type of Structure	Span /Opening with span length (m)	Width (m)	Remarks
1	5+340 of Dwarka Expressway	Slab	1 x 11.0m	100	Crossing of Storm water drain from Airport

b) Flyovers

About 80% of the project road section has been proposed to be elevated. 2 x 15m wide elevated corridor has been proposed. While service road shall run beneath the elevated corridor, for cross movement service road has also been elevated at all the major junction locations. At all the major junction locations, the cross-road has been depressed by an underpass. This would ease the at-grade turning movement at the major junctions. The proposed Elevated Structure/ Flyover are tabulated in ***Table 0-8.***

Table 0-10: Proposal for Elevated Structure/ Flyover

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
1	Dwarka Expressway	5+460	5+812	352	Elevated Structure	33.5	As per Design Profile	Ramp on Structure
		5+812	6+480	668			5.5	
		6+680	8+338	1658			5.5	
		8+338	8+560	222			As per Design Profile	Ramp on Structure
2	Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka	5+745	5+936	191	Elevated Structure	Varying from 0 to 12.5	5.5	Merging portion
		5+936	6+349	413		12.5	5.5	
		6+349	6+575	226		12.5	As per Design Profile	Ramp on Structure
3	Ramp from ECC Dwarka merging with Right	7+300	7+360	60	Elevated Structure	Varying from 0 to 12.0	5.5	Merging portion
		7+354	7+384	30		12.0	5.5	

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
	Carriageway of Dwarka Expressway	7+384	7+570	186		12.0	As per Design Profile	Ramp on Structure
4	Link Road to Najafgarh *(Left Carriageway)*	6+050	6+212	162	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		6+212	6+720	508			5.5	
		6+720	7+009	289			As per Design Profile	Approach from +1 level to +2 level
		7+009	7+115	106			5.5 over and above +1 level	At + 2 level
		7+115	7+458	343			As per Design Profile	Approach from +2 level to +1 level
		7+458	7+675	217			5.5	
		7+675	8+010	335			As per Design Profile	Ramp on Structure
5	Link Road to Najafgarh *(Right Carriageway)*	5+480	5+740	260	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		5+740	6+721	981			5.5	
		6+721	7+010	289			As per Design Profile	Approach from +1 level to +2 level
		7+010	7+116	106			5.5 over and above +1 level	At + 2 level
		7+116	7+459	343			As per Design Profile	Approach from +2 level to +1 level
		7+459	7+677	218			5.5	
		7+677	8+010	333			As per Design Profile	Ramp on Structure
6	Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ	5+860	6+009	149	Elevated Structure	8.5	As per Design Profile	Ramp on Structure
		6+009	6+093	84		8.5	5.5	
		6+093	6+100	7		Varying from 8.5 to 0	5.5	Merging portion
7	Ramp from	5+491	5+506	15	Elevated	Varying	As per	Merging portion

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
	Dwarka Sector 23 towards RUB / Shiv Murty				Structure	from 7.9 to 8.5	Design Profile	Ramp on Structure
		5+506	5+635	129		8.5	As per Design Profile	Ramp on Structure
		5+635	5+718	83		8.5	5.5	
		5+668	5+885	217		8.5	As per Design Profile	Ramp on Structure
8	Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka	6+430	6+425	5	Elevated Structure	0 to 10.25m	5.5	Merging portion
		6+425	6+566	141		10.25	5.5	
		6+566	6+710	144		10.25	As per Design Profile	Ramp on Structure
9	Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	6+700	6+784	84	Elevated Structure	0 to9.25m	5.5	Merging portion
		6+784	7+117	333		9.25	5.5	
		7+117	7+230	113		9.25	As per Design Profile	Ramp on Structure
10	Ramp from ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	7+110	7+402	292	Elevated Structure	10.25	5.5	
		7+402	7+520	118		10.25	As per Design Profile	Ramp on Structure
11	Ramp from ECC Bus Drop-off going towards Sector 24	7+340	7+520	180	Elevated Structure	10.25	As per Design Profile	Ramp on Structure
12	Ramp from Left Carriageway of	6+910	7+050	140	Elevated Structure	0 to 10.25	On Ramp from +1 to +2 level	Merging portion

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
	Link Road to Najafgarh from Dwarka Sector 21 MSJ to Golf Course Road	7+050	7+120	70		10.25	5.5 over and above +1 level	
		7+120	7+455	335		10.25	As per Design Profile	Ramp on Structure
13	Link Road to Dwarka Sector 21	5+651	5+851	200	Underpass	12.5	5.5	
14	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Left Carriageway)*	5+800	6+260	460	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		6+260	6+651	391			5.5 over and above +1 level	At +2 level
		6+651	7+006	355			As per Design Profile	Approach from +2 level to +1 level
		7+006	7+010	4			5.5	
		7+010	7+186	176		Varying from 12.5m to 0	5,5	Merging portion
15	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Right Carriageway)*	5+800	6+260	350	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		6+260	6+309	49		12.5	5.5 over and above +1 level	At +2 level
		6+309	6+645	336			As per Design Profile	Approach from +2 level to +1 level
		6+645	6+658	13		Varying from 12.5m to 11.9m	As per Design Profile	Approach from +2 level to +1 level
		6+658	6+660	2		11.9m to 0	5.5	Merging portion
16	Right turn beneath Dwarka Expressway from ECC Dwarka towards Kherki Daula	Crossing Dwarka Expressway at 7+470		120	Underpass	12.0	5.5	
17	U-turn beneath Dwarka	Crossing Dwarka		440	Underpass	12.0	5.5	

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
	Expressway from left Service road towards Sector 23ECC Dwarka	Expressway at 8+009						
18	Right Turn towards Najafgarh above Dwarka Expressway from left Service Road	Crossing Dwarka Expressway at 8+600		150	Elevated Structure	8.5	As per Design Profile	Ramp on Structure
				60		8.5	5.5	
19	Right Turn towards Shiv Murti from Elevated Cross-Road coming from Bijwasan	Crossing Dwarka Expressway at 8+600		60	Elevated Structure	8.5	5.5	
				150		8.5	As per Design Profile	Ramp on Structure
20	Najafgarh – Bijwasan Cross Road (Left Carriageway)	Crossing Dwarka Expressway at 8+600		10.5	Depressed Cross Road through Underpass structure	130	5.5	Length and width are w.r.t. Main Carriageway; Width of main carriageway on the Underpass – 33.5m; Both side approaches of the depressed cross-road through underpass are included in the scope of work;
21	Najafgarh – Bijwasan Cross Road (Right Carriageway)	Crossing Dwarka Expressway at 8+600		10	Elevated Cross-Road	130	5.5	Length and width are w.r.t. Main Carriageway; Width of main carriageway on the Underpass – 33.5m; Both side approaches of

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
								the depressed cross-road through underpass are included in the scope of work;

c) Details of Grade Seperated Strcutres

The summarised details of proposed grade separated structures are given below in table:

Table 0-11: Details of all Grade Separated Structures

Sl. No.	Design Chainage	Length (m)	Proposed Structure	Remarks
1	5+460 to 8+560	3100	Elevated Structure	Dwarka Expressway
2	5+745 to 6+575	830	Elevated Structure	Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka
3	7+100 to 7+570	470	Elevated Structure	Ramp from ECC Dwarka merging with Right Carriageway of Dwarka Expressway
4	6+050 to 8+010	1960	Elevated Structure at +1 and +2 level	Link Road to Najafgarh *(Left Carriageway)*
5	5+480 to 8+010	2530	Elevated Structure at +1 and +2 level	Link Road to Najafgarh *(Right Carriageway)*
6	5+860 to 6+100	240	Elevated Structure	Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ
7	5+491 to 5+885	394	Elevated Structure	Ramp from Dwarka Sector 23 towards RUB / Shiv Murty
8	6+430to 6+710	280	Elevated Structure	Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka
9	6+700 to 7+230	530	Elevated Structure	Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ

Sl. No.	Design Chainage	Length (m)	Proposed Structure	Remarks
10	7+110 to 7+520	410	Elevated Structure	Ramp from ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ
11	7+340 to 7+520	180	Elevated Structure	Ramp from ECC Bus Drop-off going towards Sector 24
12	6+910 to 7+455	545	Elevated Structure	Ramp from Left Carriageway of Link Road to Najafgarh from Dwarka Sector 21 MSJ to Golf Course Road
13	5+651 to 5+851	200	Underpass	Link Road to Dwarka Sector 21
14	5+800 to 7+185	1385	Elevated Structure at +2 and +1 level	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Left Carriageway)*
15	5+800 to 6+660	860	Elevated Structure at +2 and +1 level	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Right Carriageway)*
16	Crossing Dwarka Expressway at 7+470	120	Underpass	Right turn beneath Dwarka Expressway from ECC Dwarka towards Kherki Daula
17	Crossing Dwarka Expressway at 8+009	440	Underpass	U-turn beneath Dwarka Expressway from left Service road towards ECC DwarkaSector 23
18	Crossing Dwarka Expressway at 8+600	210	Elevated Structure	Right Turn towards Najafgarh above Dwarka Expressway from left Service Road
19	Crossing Dwarka Expressway at 8+600	210	Elevated Structure	Right Turn towards Shiv Murti from Elevated Cross-Road coming from Bijwasan
20	Crossing Dwarka Expressway at 8+600	9.0	Depressed Cross Road through Underpass structure	Najafgarh – Bijwasan Cross Road (Left Carriageway) Length and width are w.r.t. Main Carriageway;
21	Crossing Dwarka Expressway at 8+600	9.0	Elevated Cross-Road	Najafgarh – Bijwasan Cross Road (Right Carriageway) Length and width are w.r.t. Main Carriageway;

d) Pedestrian Facilities

The details of proposed subways are given below:

Table 0-12: Proposal for Subway

Sl. No.	Location	Type of Structure	Clear Size (Horizontal x Vertical)	Tentative Length	Remarks
1	Km 6+200 of Link Road to Najafgarh	Box	5m x 3m	70m	
2	Km 6+400 of Link Road to Najafgarh	Box	5m x 3m	80m	Subway shall be beneath the existing Drain coming from Airport to Najafgarh Drain
3	Km 6+200 to Link Road from Dwarka Sector 23 to Kherki Daula	Box	5m x 3m	70m	
4	Km 6+400 to Link Road from Dwarka Sector 23 to Kherki Daula	Box	5m x 3m	85m	
5	Km 6+950 of Link Road to Najafgarh	Box	5m x 3m	90m	Subway shall be beneath the existing Drain coming from Airport to Najafgarh Drain

Besides the above, 2.0m wide footpath and 2.0m wide cycle track is proposed on both sides of the entire project stretch.

e) Culverts

All existing culverts which are newly constructed is to be used as it is. Only one new culvert has been proposed at the location given below:

Table 0-13: Proposal for New Culvert

Sl. No	Chainage (km)	Type of Culvert	Span /Opening with span length (m)	Width (m)	Remarks
1	5+950 of Link Road to Dwarka Sector 23	Slab	1 x 3.75m	75.0 (Skewed)	Oil Pipe line Crossing

f) Earth Retaining Structure

Table 0-14: Proposal for RE Wall along Main Carriageway

S. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level
1	Dwarka Expressway	5+348 to 5+517	169	Both	4.0m (Varying from 1m to 8 m)
		8+536 to 8+645	109	Both	3.0m (Varying from 1m to 6 m)
2	Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka	6+515 to 6+678	163	Both	3.0m (Varying from 1m to 6 m)
3	Ramp from ECC Dwarka merging with Right	7+550 to 7+651	101	Both	3.5m (Varying from 1m to 7 m)

S. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level
	Carriageway of Dwarka Expressway				
4	Link Road to Najafgarh *(Left Carriageway)*	5+990 to 6+135	145	Left	5.5 (Varying from 1m to 11 m)
		7+933 to 8+180	247	Left	3.0m (Varying from 1m to 6 m)
5	Link Road to Najafgarh *(Right Carriageway)*	5+355 to 5+523	168	Right	4.0m (Varying from 1m to 8 m)
		7+932 to 8+143	211	Right	3.5m (Varying from 1m to 7 m)
6	Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ	5+760 to 5+860	100	Both	3.0m (Varying from 1m to 6 m)
7	Ramp from Dwarka Sector 23 towards RUB/Shiv Murty	5+360 to 5+491	131	Both	3.0m (Varying from 1m to 6 m)
		5+840 to 5+960	120	Both	4.0m (Varying from 1m to 8 m)
8	Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka	6+683 to 6+763	80	Both	3.5m (Varying from 1m to 7 m)
9	Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	7+210 to 7+320	110	Both	3.0m (Varying from 1m to 6 m)
10	Ramp from ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	7+465 to 7+545	80	Both	3.0m (Varying from 1m to 6 m)
11	Ramp from ECC Bus Drop-off going towards Sector 24	7+500 to 7+620	120	Both	3.5m (Varying from 1m to 7 m)
12	Ramp from Left Carriageway of Link Road to Najafgarh from Dwarka Sector 21 MSJ to Golf Course Road	7+455 to 7+550	95	Both	3.0m (Varying from 1m to 6 m)
13	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Left Carriageway)*	5+718 to 5+840	122	Left	3.5m (Varying from 1m to 6 m)
14	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Right Carriageway)*	5+725 to 5+855	130	Right	4.0m (Varying from 1m to 8 m)
15	Right Turn towards Najafgarh above Dwarka Expressway from left Service Road	8+235 to 8+385 *(Chainage is w.r.t. Dwarka*	150	Both	3.0m (Varying from 1m to 6 m)

S. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level
		Expressway)			
16	Right Turn towards Shiv Murti from Elevated Cross-Road coming from Bijwasan	8+235 to 8+385 *(Chainage is w.r.t. Dwarka Expressway)*	150	Both	3.0m (Varying from 1m to 6 m)
17	Najafgarh – Bijwasan Cross Road (Right Carriageway)	Crossing Dwarka Expressway at 8+600	2 x 150	Both	3.0m (Varying from 1m to 6 m)

Table 0-15: Proposal for RE Wall along Service Road

Sl. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level	Remarks
1	Link Road to Dwarka Sector 21	5+397 to 5+651	254	Both	4.5m (Varying from 1m to 9 m)	
		5+851 to 6+051	200	Both	5.0m (Varying from 1m to 10 m)	
	Right turn beneath Dwarka Expressway from ECC Dwarka towards Kherki Daula	Crossing Dwarka Expressway at 7+470	2 x 200m	Both	4.0m (Varying from 1m to 8 m)	On both side approaches
	U-turn beneath Dwarka Expressway from left Service road towards ECC Dwarka	Crossing Dwarka Expressway at 8+009	2 x 200m	Both	4.0m (Varying from 1m to 8 m)	On both side approaches
	Najafgarh – Bijwasan Cross Road (Left Carriageway)	Crossing Dwarka Expressway at 8+600	2 x 200m	Both	4.0m (Varying from 1m to 8 m)	On both side approaches

g) Drains

The location of RCC Cover drains are given in *Table 0.13* and *Table 0.14*:

Table 0-16: Construction of New RCC Cover Drain

SL No.	Stretch	Length (m)	Type	Width (m)	Remarks
Along Dwarka Expressway					
1	5+300 to 9+500	4037	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain
Along Link Road to Najafgarh					
1	6+300 to 8+300	2000	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain
Along Link Road to Dwarka Sector 21					
1	5+800 to 6+150	350	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain
Along Link Road to Dwarka Sector 23					

SL No.	Stretch	Length (m)	Type	Width (m)	Remarks
1	5+465 to 6+300	835	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain

Table 0-17: Realignment of Existing RCC Cover Drain

S. No.	Existing Chainage	Approx. Length (m)	Left / Right	Width	Remarks
Dwarka Expressway section between (5+300 to 6+300)					
1	Between 5+340 to 5+800	600	Left	11 m	Existing Storm water drain from Airport discharging into Najafgarh Drain needs to be realigned

h) Bus Bays with Bus Shelters

The locations of proposed bus bays with bus shelters is given in Table 0.15:

Table 0-18**: Locations of Bus Bays with Bus Shelter**

S. No	Chainage (km)	Length* (m)	Left Hand Side/ Right Hand Side	Remarks
Dwarka Expressway Section between (5+300 to 9+500)				
1	5+300	30	Both Sides	Bus Bay with Shelter
2	6+100	30	Both Sides	Bus Bay with Shelter
3	6+900	30	LHS	Bus Bay with Shelter
4	8+500	30	Both Sides	Bus Bay with Shelter
Link Road to Najafgarh (6+300 to 8+200)				
1	6+900	30	RHS	Bus Bay with Shelter

i) Toll Plaza

As stipulated in Manual of Specifications and Standards for Six laning of Highways through Public Private Partnership (IRC: SP: 87), Toll Plaza shall be provided at locations given below:

Table 0-19**:** Location of Toll Plaza

S. No.	Design Chainage (Km)	Section	No. of Lanes
1	9+045	From km 0+000 to 9+500	17 lanes on each side, including one lane for over-sized vehicles

6. PRELIMINARY COST ESTIMATES

The project cost on above items has been worked out based on development proposal. Total civil cost is assessed at this stage is given in Table 0- 21.

Table 0-20: Total Civil Cost

S.No.	Bill no	Description	Amount (in crores)	Percent (%)
1	A	Road Works (Main Carriageway)	59,96,00,875	4.13%
2	B	Bridges & Structures		
3		Major Bridges		
4		Minor Bridges	4,95,00,000	0.34%
5		Flyover / Grade Separator	10,67,84,51,194	73.50%
6		Flyover / Grade Separator on Service Road		
7		Underpass	81,90,05,363	5.64%
8		Subway	9,87,50,000	0.68%
9		Culvert	4,14,37,500	0.29%
10	C	Other Road Appurtenances / Miscellaneous Items / Toll Plaza	2,24,26,91,039	15.44%
		TOTAL CIVIL COST (in crores)	1,453	100.00%

The total project cost is given below:

Table 0-21: Total Project Cost

S No.	Description	Amount (In Crores)
I	Civil Construction Cost (Rs. In Crores)	1452.94
	Grand Total of Civil Constructions Cost	1452.94
II	Centages (Rs in Crores)	
1	Contingencies @ 2.8%	40.68
2	Construction Supervision @ 2%	29.06
3	Administrative Charges @ 1%	14.53
4	Quality Control Charges @ 1%	14.53
5	Road Safety @ 0.5%	7.26
6	Maintenance During DLP @ 5%	72.65
7	Escalation during Construction @ 5% per annum	145.30
	Total Cost (including Centages) (Rs. In crores)	1776.95
	Cost of Preconstruction Activities (Rs. In Crores)	
1	Land Acquisition	0
2	Utility Shifting (Electrical Overhead & Underground, Water supply, Sewarage,Gas pipe line & OFC)	45
	Total Capital Cost (Rs. In Crores)	1821.95

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

Considering NH-8 as one of the busiest highways in North India, as it connects the National capital Delhi to the financial capital Mumbai, as well as important cities Gurgaon, Jaipur, Ajmer, Udaipur, Ahmedabad, Vadodara and Surat, NHAI commissioned the preparation of Feasibility and DPR of Greenfield Delhi Jaipur Expressway. The Consultancy services for *Feasibility Study of Delhi – Jaipur Expressway to be executed as BOT (Toll) project on DBFO pattern under NHDP Phase VI*- was awarded to M/s. AECOM Asia Company Ltd. in consortium with AECOM India Pvt. Ltd., Consulting Engineers Group Ltd., G-Eng Advisory Services Pvt. Ltd.

In the vicinity of Gurgaon and NH 8 there are many other important road network connections which are being planned and development of which might affect the traffic to proposed Delhi Jaipur Expressway. These include Dwarka Expressway, Extension of Nelson Mandela Marg, proposed Gurgaon Manesar Expressway and extension of UER-II to Ryan International School south of Rangpuri. These projects will help to reduce traffic on NH-8 and will provide an alternate route to the traffic movement between Delhi and Gurgaon and therefore have to be seen in an integrated manner. Considering this NHAI further awarded Feasibility of these new projects to the above mentioned consortium as *additional work as a variation to consultancy service of Delhi-Jaipur Expressway vide* commencement letter no. *NHAI/CGM(T)BSS/Del-Jai Exp/2012/2/91994 dated 05.12.2016*.

1.1.1 Dwarka Expressway at a Glance

As part of Development Plan 2031 of Gurgaon Manesar Urban Complex (GMUC), Dwarka Dwarka Expressway also known as Northern Peripheral Road (NPR) is proposed to be developed as northern ring road thereby providing additional connectivity between Gurgaon and Delhi apart from NH 8, Old Delhi Road and MG Road. Due to rapid increase in traffic between Delhi and Gurgaon on NH 8 and other road network, there has been a constant demand to complete Dwarka Expressway at the earliest.

Also, as per the development plan of GMUC, the alignment of Dwarka Expressway / NPR was planned to start from Km 42 near the toll plaza and another arterial road known as Connecting Peripheral Road (CPR) was proposed to connect NPR near Sector 83 and passing through north of Gurgaon cutting across Pataudi Road, Jhajjar Road, Najafgarh Road and finally connecting UER 2 in Dwarka.. However due to land acquisition issues, NPR/ Dwarka Expressway intersection with NH 8 is not possible as it will also affect the Km 42 toll plaza. Therefore, it was decided that Dwarka Expressway will include entire section of CPR and will terminate at the intersection of CPR-NH 8-SPR. The Dwarka Expressway is proposed to take off from NH-8-SPR-CPR intersection, 1.5 Km before Km 42 toll plaza.

Once operational, this expressway will provide an alternate route to the commuter traffic between residential centres of Dwarka , Najafgarh and West Delhi destined towards employment centres of Eastern and Western Gurgaon completing bypassing the NH 8. It will also facilitate the regional traffic movement from Western Delhi towards Southern Haryana & Rajasthan via Pataudi Road, NH 8 and the proposed Delhi Jaipur Expressway.

1.2 PROJECT OBJECTIVE

The objective of this consultancy is to undertake feasibility studies and prepare a Feasibility Report of the Project Highway for the purpose of firming up the Authority's requirements in respect of development and construction of the Project Highway and Project Facilities and enabling the prospective bidders to assess the Authority's requirements in a clear and predictable manner with a view to ensuring:

- enhanced safety and level of service for the road users;
- superior operation and maintenance enabling enhanced operational efficiency of the Project Highway;
- minimal adverse impact on the local population and road users due to road construction; minimal adverse impact on environment;
- minimal acquisition of land; and
- Phased development of the Project Highway for improving its financial viability consistent with the need to minimize frequent inconvenience to traffic that may be caused if additional works are undertaken within a period of seven years from the commencement of construction of the Project Highway.

1.3 SCOPE OF SERVICES

As per the Terms of Reference (TOR) the scope of services for the project includes the following:

- Traffic survey and demand assessment
- Engineering surveys and investigations.
- Study the possible locations and design of toll plaza, truck laybyes, bus bays and bus shelters. Wayside amenities required on tolled highway shall also be planned.
- Environmental Impact Assessment
- Social Impact Assessment
- Preliminary design of roads, bridges and structures
- Preparation of Land Plan schedules and Utility Relocation Plans.
- Preparation of technical schedules of the Concession Agreement

- Assist NHAI appointed financial consultant and legal advisor in preparation of bid documents and also assist the authority during pre-bid conferences.

1.4 PROJECT PACKAGING

The total length of Dwarka Expressway is 27.6 km out of which 21.5 Km is original alignment length which was earlier proposed to terminate at the intersection Urban Extension Road (UER)-II in Dwarka. Out of 21.5 Km, 18.1 Km length falls in Haryana and remaining 3.2 Km in Delhi. Government of Haryana later handed over the construction of Dwarka Expressway to NHAI. Therefore, in order to keep the continuity of connectivity between sections of National Highway, it was decided to include section of UER-II between Dwarka Expressway intersection and Shiv Murti also as part of Dwarka Expressway. The length of section of UER II is 6.3 Km thereby increasing the total length of Dwarka Expressway to 27.6 Km and total length in Delhi to 9.50Km.

The total project has been further subdivided into 4 contract packages as per the meeting held on 1st June 2017 under the Chairmanship of Honourable Minister for Road Transport & Highways. The recommended contract packages and their respective lengths are described below:

S.No	Contract Package	Description	Chainage	Length (Km)
5.	Package 1	Shiv Murti to Tail under Bridge (RuB)	Km 0.000 to Km 5.300	5
6.	Package 2	Rail under Bridge (RuB) to Delhi Haryana Border	Km 5.300 to Km 9.500	4.5
7.	Package 3	Delhi Haryana Border to Rail over Bridge (RoB)	Km 9.500 to Km 19.700	10.2
8.	Package 4	Rail Over Bridge (RoB) till End Point Km 40 NH-8-SPR Intersection near Kherki Daula	Km 19.700 to Km 27.6	7.9

The present report being submitted is only for Package 3.

1.5 DRAFT FEASIBILITY STUDY REPORT (PACKAGE 2)

As decided by Client and in line with Terms of references (TOR) the Draft Preparation of Draft Feasibility Report of Dwarka Expressway for Package 2 falling in the State of Delhi is now being submitted. Report would include cost estimates, Design Standards, Development Proposals, Traffic survey analysis, detailed cost estimates etc.

1.6 REPORT STRUCTURE

The structure of the Feasibility Study report is presented as below:

- ✓ *Executive Summary*
- ✓ *Chapter -1: Introduction*
- ✓ *Chapter -2: Project Road Description*
- ✓ *Chapter -3: Methodology for Feasibility study*
- ✓ *Chapter- 4:* Socio-Economic Profile of the project areas
- ✓ *Chapter- 5:Traffic Survey and Analysis*
- ✓ *Chapter -6: Design Standards*
- ✓ *Chapter- 7: Alignment Design*
- ✓ *Chapter- 8: Development Proposals*
- ✓ *Chapter-9: Cost Estimates*
- ✓ *Chapter-10: Conclusion and Recommendations*

CHAPTER 2 PROJECT ROAD DESCRIPTIONS

2.1 GENERAL

The alignment of Dwarka Expressway takes off from Km 20 Shiv Murti of NH 8 and terminates at Km 40 (near Kherki Daula) of NH 8 at CPR-NH 8-SPR intersection. The present alignment is proposed to connect Sector 21 in Dwarka with NH 8 passing through Sectors 88, 84, 83, and 99-113 in Gurgaon and the proposed Global City before terminating at NH 8 near SPR Junction where it intersects NH 8 at Km 40.070, approx. 2 km before the Kherki Daula toll plaza. Dwarka expressway intersects SH-26 (Pataudi Road) near Harsaru and SH-15A (Farrukhnagar Road) near Basai. It also crosses Delhi- Rewari Railway line near Sector-88 B Gurgaon and at UER-II near Bharthal.

The proposed Expressway alignment Comprise of CPR & NPR in Haryana and 80 m Sector Road and Urban Extension Road 2 (UER-II) in Delhi. The total length of Dwarka Expressway is 27.600 Km, out of which 21.5 Km is original alignment length which was earlier proposed to terminate at the intersection Urban Extension Road (UER)-II in Dwarka. Out of 21.5 Km, 18.1 Km length falls in Haryana and remaining 3.2 Km in Delhi.

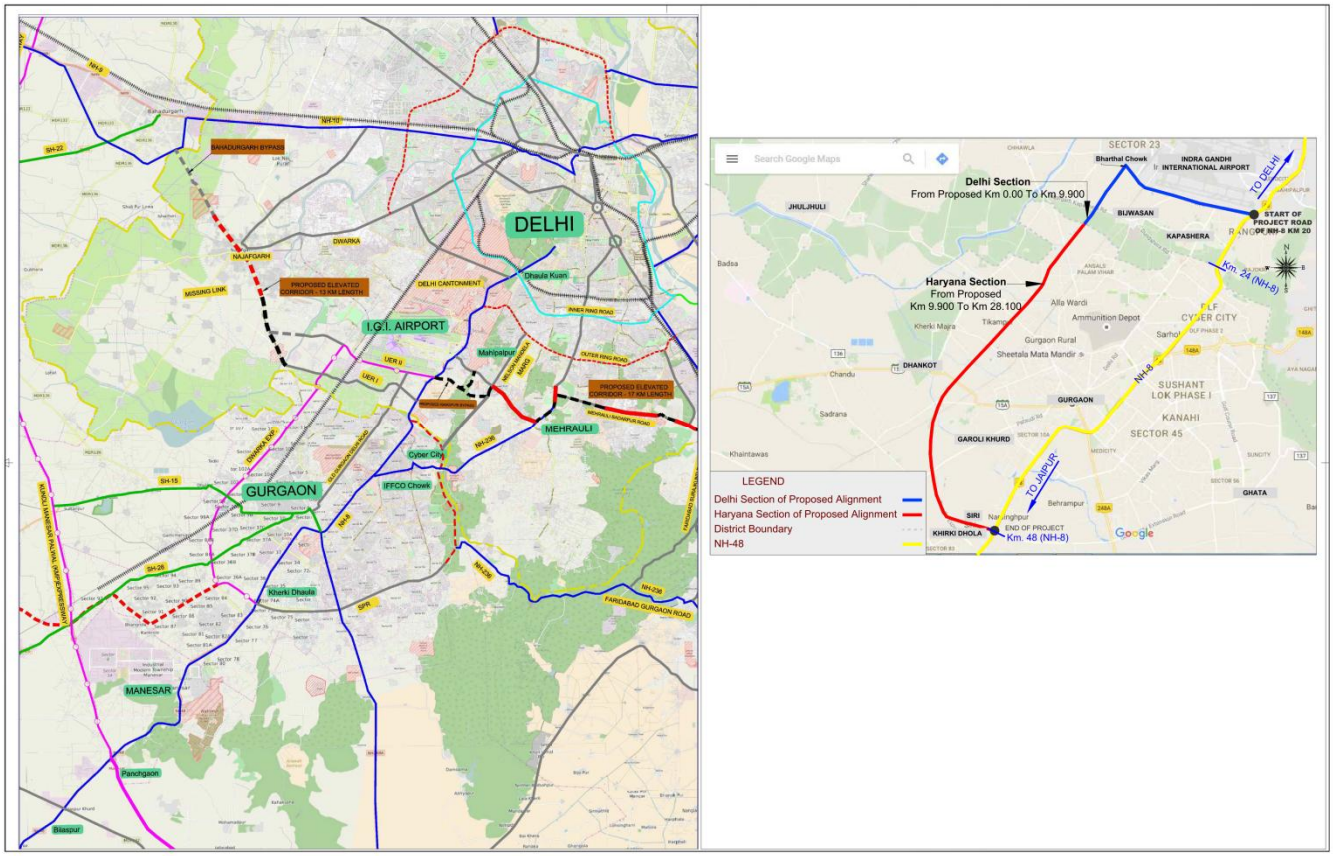


Figure 2-1: Dwarka Expressway Alignment

Government of Haryana later handed over the construction of Dwarka Expressway to NHAI. Therefore, in order to keep the continuity of connectivity between sections

of National Highway, it was decided to include section of UER-II between Dwarka Expressway intersection and Shiv Murti also as part of Dwarka Expressway. The length of section of UER II is 6.3 Km thereby increasing the total length of Dwarka Expressway to 27.6 Km and total length in Delhi to 9.50Km.

2.2 STUDY OF PROJECT CORRIDOR

The consultant's team during their several site visits have collected field data to understand the project and its constraints which has been subsequently used to formulate the project improvement/ development proposals. The salient existing features of the project are discussed in the subsequent paragraphs to give an overview of the project corridor. The proper understanding of the existing project features and constraints form the basis of the design proposals to follow. The project features discussed are as follows:

- Terrain and Land use
- Climatic Conditions
- Physiographic Features
- Geological Features
- Existing Roadway
- Right of Way
- Cross-Drainage Structures
- Highway Geometrics
- Pavement Condition
- Major Developments
- Cross-road and Junctions
- Drainage Condition
- Railway Crossings
- Utility Lines
- Environmental and Social Status
- Alternate Routes

2.1.1 Terrain and Land use

The project road runs through plain terrain and semi-arid to sub humid region only. Barring the built-up locations, agriculture is the predominant land use in some semi-arid areas while it is barren in the arid patches along the road. In the built-up areas both residential and commercial buildings have developed abutting the road corridor.

2.1.1.1 Major Developments Planned along Dwarka Expressway

The present alignment is proposed to connect Sector 21 in Dwarka with NH 8 passing through Sectors 88, 84, 83, and 99-113 in Gurgaon. Major developments proposed along Dwarka expressway include following:

2.1.1.2 Exhibition cum Convention Center (ECC), Sector 25 Dwarka

ECC is planned as international grade exhibition cum convention centre in Sector 25 of Dwarka west of Dwarka Expressway in a site area of 90 hectares. The proposal of ECC includes exhibition centres, convention centre, arena and mixed use development including offices, retail and hotels. The combined footfall of this facility will be 3.14 lakh per day. Once operational this will generate huge traffic which will use Dwarka expressway.

2.1.1.3 Global City, Sector 36 B, Gurgaon

Another major development proposed along Dwarka expressway is Global City in Sector 36 B of Gurgaon in a site area of 1000 acres. This will include office, residential areas and retail. The combined population including employment will be around 5 lakh. This will also have huge traffic impact on Dwarka expressway.

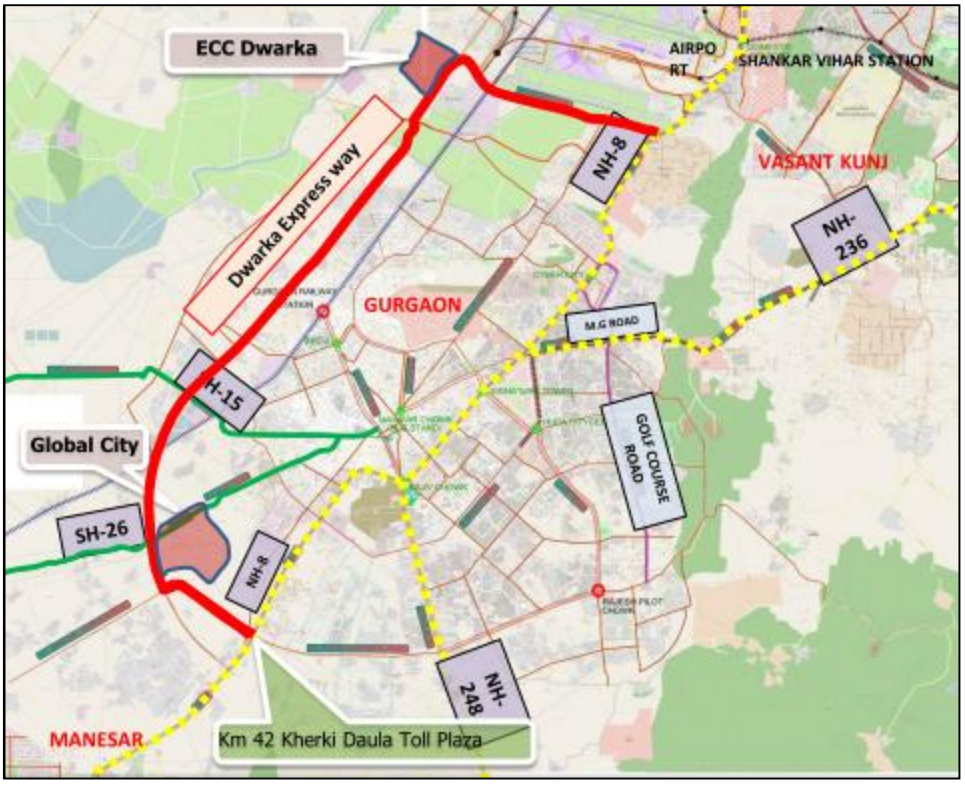


Figure 2-2: Location of ECC Dwarka and Global City w.r.t to Dwarka Expressway

2.1.2 Existing Scenario along Proposed Corridor

2.1.2.1 Existing and Planned Right of Way (RoW)

Existing Right of Way (RoW)

Since maximum portion of alignment of Dwarka Expressway is greenfield, there is no existing RoW. Government of Haryana implemented portions of Expressway having RoW of 150 m. the constructed portion include 12.5 m wide main carriageway either side with 7 m central median. There is also a provision for service roads and dedicated utility corridor for trunk services. The expressway

Government of Haryana later decided that main carriageway portion to be developed by NHAI. 90 m RoW out of 150 m excluding the space for trunk utilities was transferred so that NHAI can develop the main alignment of Dwarka Expressway.

The expressway being partially built has few hindrances within Haryana portion. The prime hindrances include residential colony of Palam Vihar near Sector 110.

Within Delhi, the portion of Dwarka expressway was proposed to be 80 m as part of Sector 25/26 dividing road near village Bhartal. The original alignment was proposed till the intersection of Dwarka Expressways with UER 2 at Sector 22-23-25-26 intersection. Since, the Dwarka Expressway also includes section of UER-II, RoW of which varies. The RoW width of UER-II between NH 8 and Railway line varies from 55-65 m (approx.) and between Railway line and intersection with Dwarka Expressway the RoW width is 100 m.

Proposed Right of Way (RoW)

As per the development plan of GMUC, the original planned RoW of Dwarka Expressway is 150 m in Haryana portion and in Delhi it was proposed to be 80 m wide sector road. Government of Haryana while handing over the Dwarka Expressway to NHAI limited the RoW width to 90 m within Haryana. In Delhi portion land parcels between village Barthal till Haryana border were not acquired, it was then agreed to have the RoW width of 120 m within the un-acquired section in Delhi. Remaining portion of expressway will continue to same RoW as existing without any further acquisition.

2.1.3 Major Intersections along the Corridor

2.1.3.1 Section between NH 8 (Shiv Murti) and Railway Line

This section is located along the southern boundary of airport. Existing carriageway is 6 lane divided with service road. Major intersections in this section include NH 8 and Smalkha both are 3 arm intersections. The other major crossing will the railway line near south west boundary of Aiprort. The existing road crosses below the railway line by mean of 8 lane underpass. Additional underpass boxes will be required for the expressway carriageway.

2.1.3.2 Section between Railway Line and Haryana Border

Beyond railway line the RoW width is 100 m. this section has 2 major intersections that include Sector 21 and Sector 23. The expressway alignment turns right from Sector 23 intersection. The proposed Exhibition cum Convention Centre (ECC) is located west of expressway at this location. Due to the requirement of direct access to ECC, various additional structures will be required for providing signal free access to ECC. Next major intersection is with Bijwasan Najafgarh road.

2.1.3.3 Section between Haryana Border and Km 40 NH 8 (near Kherki Daula)

After entering Haryana, the expressway portion is built with 12.5 m wide main carriageway. Major intersections in this section include, Basai Road, Pataudi Road, Sector 84/ 88 dividing road and NH 8-SPR intersection.

Full cloverleaf is proposed at the NH 8-SPR intersection Apart from above 2 more major intersections are proposed between Pataudi Road and NH 8 Km 40 section. These are primarily proposed for direct access to proposed Global City in Sector 36B which will have employment potential of 3 lakh people when developed.

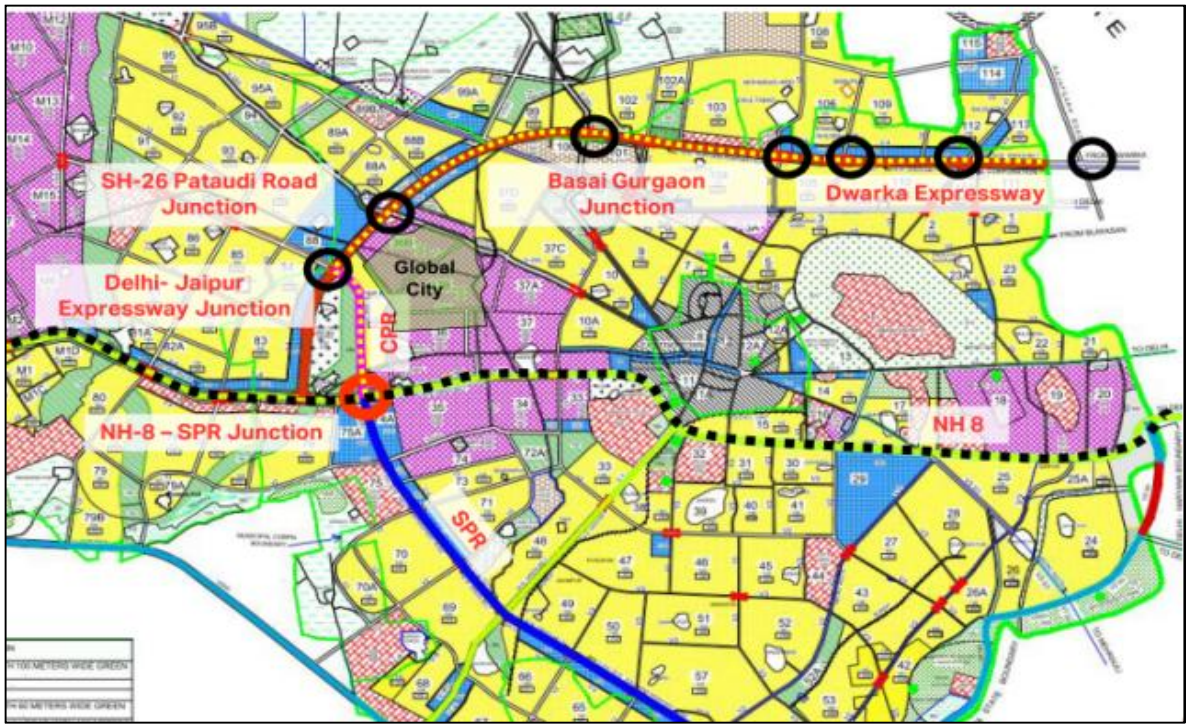


Figure 2-3: Major Intersections in Haryana Portion

2.1.4 Highway Geometries

The horizontal alignment of the project road is mostly straight and with flatter curves. Both the horizontal and vertical alignment of the road is apparently seems to meet the National Highway standards almost at all locations.

2.1.5 Cross Roads and Junctions

Local traffic from one destination to another is supposed to travel only on service road and all the junctions of cross road are proposed with service roads to avoid the traffic hazards on the high speed main highway corridor. Grade separators and vehicular underpasses are provided for roads carrying appreciable traffic. Direct access to main road will generally be closed and connected to service road with proper left-in left-out.

2.1.6 Railway Crossings

Delhi Rewari Alwar railway line intersects the alignment at 2 locations the first is in Delhi and second in Haryana near Sector 99. The existing UER 2 has underpass for road section below the railway line. Since the proposed alignment will have separate carriageways, additional underpass boxes will be required for the expressway for crossing the railway line.

The other location is near Sector 99, where the same railway line is crossing the alignment. A Rail over Bridge (RoB) is under construction at this location.

Table 2-1: Detail of Existing Intersections with Dwarka Expressway

S. No.	Design Chainage	Type of Intersection	Road leading to		Remarks
			LHS	RHS	
1.	0+000	T	Delhi (NH8)	Gurgaon (NH 8)	intersection near Shiv Murti connecting Airport and Gurgaon
2.	1+600	T	IGI Airport	Kapashera	Intersection with Old Delhi Gurgaon Road connecting Kapashera and Old Gurgaon
3.	3+350	T	IGI Airport	Pushpanjali Farms	Minor road from Puspanjali Farms. Existing carriageway has right turn restricted.
4.	3+600	T	IGI Airport	Pushpanjali Farms	major road from Pushpanjali farms serving traffic from Bijwasan and Gurgaon towards Delhi
5.	5+000	Railway line crossing			Existing Road crosses below the railway line through 8 lane underpass having 4 boxes having 2 lane carriage way each.
6.	5+500	T	Sector 21, Dwarka	Sector 26 Dwarka	Existing Signalised intersection connecting Sector 21 metro station

S. No.	Design Chainage	Type of Intersection	Road leading to		Remarks
			LHS	RHS	
7.	6+300	+	Najafgarh	Dwarka Sector 23	Major crossing of UER 2 and Dwarka Expressway at Sector 25-26-22-23 intersection
8.	7+400	T	-	Bhartal	internal sector roads of Sector 26
9.	7+700	T	-	Bhartal	internal sector roads of Sector 26
10.	8+000	T	Sector 28 Dwarka	-	Sector dividing roads of Sector 28/26
11.	8+600	+	Najafgarh	Bijwasan	Najafgarh Bijwasan Road is major intersection as it further connects to Bahadurgarh Bypass
12.	7+700 to 9+500				Un-acquired portion in Delhi State
13.	9+500				Haryana – Delhi border
14.	10+900				Internal Road of Sector 111.
15.	11+100	+	Bajghera, sector 112	Sector 110	Gurgaon Bajghera Road
16.	11+500 to 11+900		Hindrances		Un-acquired portion of RoW
17.	12+250 to 12+750		Hindrances		Un-acquired portion of RoW
18.	13+900	T	Sector road 106	Sector Road 109	Sector 106/ 109 dividing road.
19.	14+850	+	Daulatabad	Gurgaon	Sector 103/106 dividing road
20.	16+800	T			Sector 102A/103 dividing road
21.	17+500	+	Kherki Majra	Gurgaon	Sector 102/102 A dividing Road
22.	18+800	+	Faruknagar (SH 15A) Sector road 102	Gurgaon (SH 15A) Sector road 101	Basai Road, Sector 102/101 dividing Road
23.	20+600	Rail line crossing	Rewari	Delhi	Rail over Bridge (RoB)

S. No.	Design Chainage	Type of Intersection	Road leading to		Remarks
			LHS	RHS	
24.	23+200	+	Pataudi (SH 26)	Gurgaon (SH 26)	
25.	23+850	T	-	Proposed road	Proposed Sector Road for connecting Global City
26.	24+700	+	Diverging point of Delhi - Jaipur Expressway (DJE).	-	From km 24+700 to 27+500 alignment is common for Dwarka expressway and DJE.
27.	25+950	T	-	Proposed road	Proposed Sector Road for connecting Sector 36 A and Global CIty
28.	27+500	+	NH 8 to Delhi (North side)	NH 8 to Jaipur (South side)	Intersection of Souther Peripheral Road (SPR) with NH 8 and Dwarka Expressway

2.1.7 Utility Diversions

There are no major utilities that are required to be diverted along Package 2. However, there conflicts that can arise with the High Tension lines and existing gas pipeline.

HT Line

The Bamnauli 220 Kv HT line is also crossing the Dwarka expressway at chainage Km 8+200. Height of the lowest cable at the point of crossing as observed in our survey is 6.86 m above the existing road.

The expressway carriageway between this section is elevated with an finished road level (FRL) of 12 m. a minimum of 8 m height clearance is further required above the elevated expressway.

In the light of above, it is therefore requested that the height of the pylons of 220 Kv HT line be raised to a minimum of 20 m from the ground level, for the purposed of providing desired height clearance for Dwarka Expressway elevated section.

IGL Gas Pipe Line

The IGL gas pipe line is running on extreme left side of carriageway towards Gurgaon. There is minimum disruption that will be caused to the gas line as there is minimum widening proposed along left side of RoW. However, some widening is required near the existing RuB. At this location, diversion will be required.

IOCL Oil Pipe Line

The oil pipeline of IOCL is crossing the link road from Sector 23. Since elevated road is proposed, the oil pipe line has been adjusted in between the span arrangement of the elevated road. Therefore no diversion will be required.

Airport Strom Water Drain

The airport drain having an approx. box size of 8m by 8 m runs along the left edge of RoW of the Dwarka expressway. this drain carries the strom water of airport to the Najafgarh Drain. At present a 3 lane road runs on the top surface of this covered drain. For the purpose of construction of Sector 21 underpass and pier arrangement of elevated portion of Dwarka Expressway, this drain is required to be realigned for a length of 1 Km.

2.1.8 Physical Hindrances

The project alignment also has few physical hindrances where land is yet to be acquired for clearing the RoW. Table 2-2 presents the list of physical hindrances.

Table 2-2: Detail of Physical Hindrances in RoW

S.No	Location	Chainage	Obstructions in ROW
1.	Sector 112	Km 11.500- Km 12.000	 Village : Bajghera
2.	Sector 109	Km 12.300- Km 12.800	  Various Establishments at New Palam Vihar Colony

3.	Sector 110	Km 13.300	 Establishment of Mr. Prabhujot Singh , New Palam Vihar
4.	Sector 106	Km 13.400	 Temple in the Middle of Carriageway near Jahajgarh Village, Sector-106 Gurgaon
5.	Sector-110	Km 13.400	 Compound Wall of a Private Establishment inside the Carriageway
6.	Sector 105	Km 14.600	 Compound wall of a Private Establishment inside the ROW
7.	Sector 102 A	Km 16.500	 Low Height of H T lines and Construction of Culvert

8.	Sector 102	Km 17.600	 Low Hieght of H T lines
9.	Sector 102 , Near ROB	Km 19.700- Km 19.800	 HT Pylon inside Northbound Carriageway
10.	Near Harsaru Village, Pataudi Road Junction	Km 23.100 – Km 23.200	 Temple inside the Carriageway  HT Pylon inside the Carriageway towards Dwarka
11.	Near Harsaru Village, Pataudi Road Junction	Km 23.250	 HT Pylon inside the Northbound Carriageway
12.	Sector 88	Km 24.300	  HT Pylon inside the Carriageway and Absence of Southbound Carriageway

13	Village Sihi	Km 27.100 – Km 27.600	 Various Establishments of Village Sihi

2.3 OTHER PLANNED TRANSPORT INFRASTCRUTRE PROJECTS

DMRC is planning to extend the Airport Metro Line from Sector 21 till Sector 25 in proposed ECC and the line will pass through Sector 26. The Airport Metro Line will cross Dwarka Expressway at 2 locations. First near Chainage Km 5+500 and second near Chainage Km 6+700. The metro line will also cross below the right turn underpass approach on the link road to Sector 21. The Metro line alignment is also proposed below the existing Airport Drain. The metro line is almost 13 m below the ground level near Sector 21.

CHAPTER 3 METHODOLOGY FOR FEASIBILITY STUDY

3.1 GENERAL

The Feasibility study consists of:

- Traffic Surveys
- Engineering Surveys and Investigations
- Environmental and Social Screening
- Assessment of required development
- Preliminary cost estimates
- Financial viability
- Economic viability
- Mode of Implementation and Packaging
- Feasibility report

3.2 TRAFFIC SURVEYS

To appreciate the characteristics of traffic along the project road sections in terms of size, desire, speed, load and lead, number of surveys were carried out. Traffic surveys primarily consist of manual classified mid-block counts namely to determine the existing volume and composition of traffic using key links and nodes within the study area. All types of traffic surveys and studies done for feasibility study are discussed below:

3.2.1 Classified Traffic Volume Count

Classified Traffic Volume Count Survey has been conducted to appreciate traffic characteristics in terms of volume, composition, hourly variation, peak hour and directional split. The Average Daily Traffic at each count station will be presented by total number of vehicles and by PCUs.

The survey was conducted for 24 hours for continuous 7 days to capture both the hourly and diurnal variation of traffic. Disaggregated classification system has been used due to the requirements of the vehicle operating cost modelling. As the inputs for modelling traffic congestion effects require an hourly distribution of traffic volume, the data was collected at 15-minute intervals and aggregated to hourly volumes, direction wise. From the data so collected, seasonal correction factor has been estimated and applied to convert the Average Daily Traffic (ADT) to Annual Average Daily Traffic (AADT).

3.2.2 Origin- Destination and Commodity Movements Survey

These surveys have been conducted to anticipate the Origin-Destination (O-D) characteristic in order to establish the pattern of travel on the Expressway.

With the help of local police assistance, the survey at all locations was conducted for 24 hours using a systematic random sampling. The classified volume count carried out along with the O-D survey was used to arrive at the sample coverage/expansion factor. The objective was to sample as many vehicles as practical given the constraints of the storage capabilities of the interview bay.

A traffic zone system has been developed for coding and analysing the O-D data. The zones have been defined based on the traffic on each linear and spatial segment. The data collected has been coded and processed to eliminate all illogical data and entry errors.

The processed data has been used to generate O-D matrices (by category, purpose, and overall). Desire line diagrams have been prepared to give an understanding of the travel pattern in the region and along the corridor.

3.2.3 Turning Movement Survey

Turning Movement Surveys were carried out to determine the directional movement of traffic at intersections. Enumerators were stationed at each arm of the junction to note the number of vehicles entering through the arm and the direction of their exit. Classified traffic volume counts of all vehicle types were made separately for all directions. The survey was conducted for 24 hours at each of the locations.

3.2.4 Survey Programme

The table below gives the details of the traffic surveys carried for the project road.

Table 3-1 Traffic Survey Locations

Survey ID	Type of Survey	Section/Location
TVC-1	7-days Classified Traffic Volume Count Survey (TVC)	KM-24 Toll Plaza
TVC-2		Km 42 Kherki Daula Toll Plaza
OD-1	1 day Origin-Destination Survey (OD)	KM-24 Toll Plaza
OD-2		Km 42 Kherki Daula Toll Plaza
OD-3		Near Samalkha Crossing
OD-4		Near Dwarka sector 21 metro station
OD-5		Bharthal Chowk
OD-6		Dwarka Sector 24, Near Najafgarh Road
TMC-1	1- day Turning Movement Count Survey (TMC)	Near Samalkha Crossing
TMC-2		Near Dwarka sector 21 metro station
TMC-3		Bharthal Chowk
TMC-4		Dwarka Sector 24, Near Najafgarh Road

3.3 TRAFFIC FORECAST

Traffic Volume Characteristics

The traffic volume data has been compiled and processed in order to establish the link volumes in the base year. The daily and hourly fluctuations in the traffic flow has been examined, the peak hour factor has been determined and the volume capacity ratios at disaggregated links has been calculated (once the capacity of the different links of project road is estimated considering the pavement width and speed flow relationships). At this stage the road sections that are in distress from traffic point of view has been distinctly identified. Subsequently, the Uniformity in Capacity Utilization of the Road Sections has been studied and an estimation of the time-based users versus non-time based users and the local traffic versus the regional traffic is proposed. In order to establish the base year link traffic volume in terms of ADT, the utmost care has been taken to reduce errors and variations.

Travel Desire Patterns

The traffic desire pattern, both for passenger vehicles and goods vehicles has been established through analysis and interpretation of the O-D matrix developed from the roadside interviews.
It helped to establish the level of interaction between different traffic zones in terms of trip ends, which enabled a subsequent development of the shortest path matrix and the traffic from other corridors to the project road.

Trip Characteristics

This task was focused on understanding the travel characteristics by all vehicular modes which include purpose, frequency, trip distance, travel time etc. in the case of passenger vehicles, and type of commodity, value of commodity, loading pattern etc. for goods vehicles.

Forecasting Socio-Economic Base

The economic growth in the region has a major impact on the Expressway. The impact is expected to be due to growth in local demand and development of industrial centres.
The study also included reviewing the impact of plans, programs and schemes with focus being primarily on appreciation of implications of envisaged development scenarios on the proposed project facility and on operationalization of activities proposed in the region along the corridor. The review study had prime focus on the impact on travel demand levels in the corridor. In addition, the phasing, expected level and time of operation of these projects and consequent traffic generation levels were also evaluated. Based on the detailed review of the socio-economic parameters a set of economic indices per traffic zone was generated. On the basis of the expected

economic growth for each traffic zone, these indicators have been projected annually up to the design year.

Estimate Generated and Induced Traffic

Some development activities in the project influence area of Dwarka expressway are expected. The alignment is expected to yield benefits and might result in a rise in traffic demand on the surrounding roads. Keeping in view the large potential of development, information on related issues has been collected from concerned organizations and agencies to study likely traffic and to arrive at realistic traffic projections. Generated traffic is also expected in the Influence Area by implementations of new town plans.

Estimate Diverted Traffic

A project of such nature is expected to attract a significant volume of traffic from NH-8, Hence, diverted traffic on the project corridor was also estimated based on shortest path route choice modelling after an in depth analysis of the journey speed and delay surveys and the Origin-Destination surveys. The divertible traffic has been projected independently and added to the stream flow of the project corridor at different phases of development.

Traffic Assignment

This most important task of assigning traffic on the corridor from other adjoining roads has been assessed by using the Capacity Restraint Assignment Technique. To establish the capacity of roads, the recommended capacity values in Indian Roads Congress (IRC: 64 and IRC: 106-1990) has been reviewed, and based on the speed-flow relations developed from the present study, the capacity values has been derived. The assessment of traffic load on the corridor has been made by mode and year. Travel time, distance and cost have been considered as affecting parameters for user assignment modelling. The traffic loads on the corridor has also been assessed with alternate toll structures.

3.4 ENGINEERING SURVEYS AND INVESTIGATIONS

3.4.1 Topographic Surveys

Formulate Survey Program

The senior Survey Engineer visited the project corridors to gain knowledge on specific site problems, which enabled him to estimate the number of survey teams and survey equipment's to be deployed.

Establish Horizontal and Vertical Controls

In order to ensure high degree of accuracy of survey, control points (cement concrete pillars) has been established at an interval of about 5 km apart along the road, using differential GPS techniques. Twin pillars has been fixed at these locations so as to

enable further densification of control (200 to 300 m apart) along the road using total station traverse. Care was taken while establishing these points to locate them at safe places within the RoW and away from main construction area so that they can serve as permanent benchmarks for survey and layout at later stage.

The elevations (ellipsoidal heights) as obtained by GPS observations are not accurate for highway work and cannot be used. Therefore, the elevation of the control points has been established with respect to the GTS (Great Trigonometric Survey) benchmarks established by Survey of India. The exact elevations (RL) of these benchmarks were obtained, with the assistance of the client, and precision levelling was carried out by two levelling teams in fore and back direction and mean was taken to establish the elevation of all cement concrete pillars, and other control points using auto-levels.

For quick referencing additional benchmarks were established prior to initiation of the survey work and the intermediate distance between two BMs was kept not more than 250m, as specified in the ToR.

All these benchmarks will be tabulated with the following details and incorporated in the Final DPR for further reference during the construction period.

- Unique Identification Number
- Co-ordinates (X, Y and Z)
- Description of GPS Pillar/Bench Mark
- Sketch of GPS Pillar/Bench Mark with reference to permanent ground features

Collection of Cross Section Data

Collection of DTM data was started after completion of traversing and leveling as described in the previous activity. The data was collected using Total Station along the project corridor. The survey corridor width was kept as 30m from the centre line on either side of road. The detailed field survey essentially covered the following:

All natural and manmade features such as buildings, trees, fences, transmission links, water lines, and others utility lines which fall within the RoW. As per requirements, intersections, bridges and culvert location survey data were collected as described below.

Intersection / Cross Roads: Where existing roads cross the alignment, the survey was extended till 100m on either side of the road centre line to allow improvements, including at grade intersections, to be designed.

Finalization of Strip Plans

The strip plans are updated based on the exact location of the physical features utility lines, property lines, location of CD structures, archaeological structures, bypass alignments etc., captured during the topographic survey.

3.4.2 Investigation of Quarry and Borrow Area Material

Samples were collected from the existing quarry and borrow area and appropriate tests as suggested in the ToR was carried out on the same to determine the suitability of the material to be used in embankment and pavement structures.

3.5 ASSESSMENT OF REQUIRED DEVELOPMENT

From the existing field data a few scheme alternatives were evolved. This task made use of available data, site reconnaissance desk studies and preliminary findings. The standards, codes of practice and other relevant controlling documents were listed thereby establishing the procedures, design controls and general engineering practice required. In the review of project alignment due consideration was given to the environmental implications land take and impact on project affected people, using information provided in the discipline Desk Study Reports undertaken earlier.

3.5.1 Widening and strengthening scheme

The project section under the scope of study has multidimensional facets in terms of geometry, pavement composition/ condition, existing utilities, religious structures, etc. and considering all these aspects the section-wise policy was adopted for strengthening and widening based on the initial investigations.

3.5.2 Pavement Design

Pavement is the most significant component of a road and therefore its design strengths must be assured to support the projected traffic loading throughout the design period. The pavement option study consist of analysis of different pavement alternatives to provide a basis for selection of the most advantages solution, considering all costs occurring during the life of the pavement, viz., construction costs, future maintenance costs and future costs for the road users.
In pavement option study, following has been studied in detail:
Flexible pavement over the existing pavement

- Flexible pavement over the existing pavement
- New flexible pavement with flexible hase (WMM + GSB)
- New flexible pavement with rigid base (CTB + CTSB)
- Flexible Pavement for full reconstruction stretches of existing pavement.
- New Rigid Pavement

Rigid Pavement has been proposed in heavily built-up locations where roadside ponding has been noticed to damage the existing flexible pavement and consequential traffic jam during monsoon.

3.6 PRELIMINARY COST ESTIMATES

Cost Estimates were made based upon the improvement proposals and rates mostly derived from Basic Schedule of Rates, Haryana (2014) but suitably modified to update with the existing market rates. Where alternatives have been identified within

the design, each will be evaluated to an accuracy of +/- 15% so that a reasonable assessment can be made on the balance of costs against benefits. Cost estimates were compared with recent designed, ongoing and executed National Highways Projects.

3.7 FEASIBILITY REPORT

The Feasibility Report culminates with the production and submission of the Feasibility Study.

CHAPTER 4 SOCIO-ECONOMIC PROFILE OF THE PROJECT AREAS

4.1. INTRODUCTION

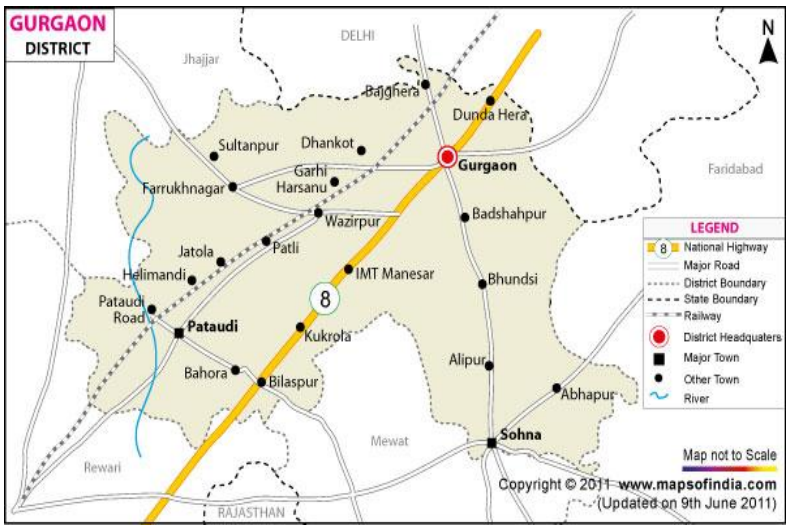
The project influence areas of the proposed project are located in the districts of Gurgaon in the state of Haryana and Delhi. The project road in starts at Shiv Murti on NH 8 and terminates at Km 40 (near Kherki Daula) of NH 8 at CPR-NH 8-SPR intersection. In order to appreciate the socio-economic profile of the influence area of the project corridor, a micro-level analysis has been done.

The description of socio-economic features of the districts through which the project road traverses comprises the demographic, social and economic aspect of the population, it includes the features of population distribution, density of population, workforce and share of workers in major economic categories; and the vulnerable groups.

The physical and socio-economic profile of both the districts concerned is illustrated separately in the following sections.

4.1.1 Gurugram (Gurgaon) - The Physical Features and the District Profile

Area and Location



Gurgaon district is situated in NCR of Delhi, the capital of India. It is just 10 kms away from Indira Gandhi International Airport, Delhi. The district derived its name from the name of Guru Dronacharya; the village was given as Gurudakshina to him by his students; the Pandavas and hence it came to be known as Guru-gram, which in course of time got distorted to Gurgaon. Thus the district has been existence since the times of Mahabharata. The district is surrounded by Delhi & Rajasthan.

Gurgaon district is the southern-most district of Haryana. The district lies between 27º39' and 28º32' 25" latitude, and 76º39' 30" and 77º20' 45" longitude. On its north, it is bounded by the district of Rohtak and the Union Territory of Delhi. Faridabad district lies to its east. On its south, the district shares boundaries with the states of Uttar Pradesh and Rajasthan. To its west lie the district of Rewari and the State of

Rajasthan. Gurgaon town is about 32 km away from New Delhi, the National Capital of India.

Administratively, Gurgaon district is divided into 3 sub-divisions: Gurgaon North, Gurgaon South and Pataudi, which are further divided into five revenue tehsils, namely, Gurgaon, Sohna, Pataudi, Farukh Nagar, Manesar. It also comprises four rural development blocks, Pataudi, Sohna, Gurgaon and Farrukhnagar.

Climate and Rainfall

The district 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 later 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 winter that further adds 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 millimeters (28.1 in).

Agriculture

The main crops of Gurgaon district are Wheat, Bajra, Paddy, Rapeseed Mustard, vegetables (Chilli, tomato, etc.) Fruits (Guava, Aonla, etc.), and fodder crops etc. are chief cash crops of district. Some of the more enterprising formers have now taken to a crop each of Kharif onion which is providing to a very good in terms of yield and the returns for the formers.

The predominate farming system in Gurgaon district is Agriculture integrated with Animal Husbandry. The major cropping systems under the existing farming system are bajra, wheat, bajra-mustard guar-wheat and guar-mustard. Buffalo is the main component under animal husbandry. Wheat and Mustard are the main crops in rabi, which occupy 49,833 ha and 21,967 ha, respectively with an average productivity of 36.80 and 12.40 q/ha. In kharif, bajra is the major crop occupying 32,833 ha with the productivity of 14.25 q/ha.

Forest

The district is almost bereft of vegetation, as the area under forests in the district is merely 3000 hectare. There is 2.5% of total geographical area of district under forest cover. Mostly the xeric species dominates in the district. Tree species found are Prosopis, Acacia, Salvedora, Shisham, Albizia, Neem etc.

Industries

Gurgaon has now emerged to become the city with the third highest per capita income in India. Popularly known as Millennium City, Gurgaon has the presence of about 250 or 50% of the Fortune 500 companies. Gurgaon's proximity to Delhi means

easy access to political decision makers. Maruti Suzuki Private Limited was the first company that set up a manufacturing unit in the city in 1970s making cars. Eventually, DLF Limited, a real estate company acquired vast stretches of land in the city. The first major American brand to set up a unit in Gurgaon was General Electric in 1997. GE's setup in Gurgaon prompted other companies, both international as well as domestic, to follow suit. Today, Gurgaon has emerged as one of the most important offshoring centers in the world, providing outsourcing solutions in software, IT, service and sales through delivery facilities and call centers.

There are 22491 Registered Industrial Unit, out of that 436 are Medium & Large Unit, 2000 Engineering units, 1255 are Ready-made garments & embroidery, 1035 are Metal based (Steel Fab.) and 145 are Leather based industries.

Infrastructure in Gurgaon District

- Education

The District, public school system, managed by the government of Haryana, is administered by Haryana Board of School Education. The city also has a large number of private schools, where education is often expensive and the quality usually better than the government schools. Schools like The Shri Ram School - Aravali, the Ardee World School, Sector 52, The Heritage School, DAV Public School Sector 14 and Amity International School are among the top 10 schools in the city, according to the 2013 Hindustan Times - C fore Top Schools Survey.

There are several universities and institutes located in Gurgaon and its nearby areas, that form a part of Gurgaon district including Ansal Institute of Technology; ITM University, Sector 23A; GD Goenka University, Sohna Road; KR Mangalam University, Sohna Road; Amity University, Manesar; Apeejay Stya University, Sohna; BML Munjal University, NH8; Shree Guru Gobind Singh Tricentenary University, Budhera; and National Brain Research Centre, Manesar. Gurgaon is also home to one of India's top ranked business school, Management Development Institute.
Gurgaon district has 599 Primary Schools, 186 Middle Schools, 263 Secondary & Senior Secondary Schools and 9 Colleges.

- Health Services

Gurgaon has many hospitals and a number of medical research facilities within its city limits. Some of the private hospital include Fortis Hospital, Medanta, Max Hospital and Columbia Asia Hospital. Gurgaon has become an increasingly popular destination for medical tourism.

The District has 6 Allopathic, 12 Ayurvedic, 12 Primary Health Center, 1 Community Health Center, 8 Sub Health Center and 71 Private Hospitals.

- Airways

Gurgaon is served by Indira Gandhi International Airport, though the airport is just outside the city limits and located within the jurisdiction of Delhi near National

Highway 8. The airport is one of the busiest airports in India and provides domestic and international air connectivity.

- Railways

Intercity rail:

Gurgaon railway station operated by Northern Railway of Indian Railways. The rail station that forms a part of the larger Indian railways network, where trains connect Gurgaon to Delhi and other important cities in India like Mumbai, Kolkata, Ahmadabad and Jaipur.

Delhi Metro:

There are five stations served by Delhi Metro located on the Yellow Line, which are HUDA City Centre, IFFCO Chowk, MG Road, Sikanderpur and Guru Droncharya.
A line connecting HUDA City Centre Metro Station to Bawal via Kherki Daula has also been proposed.

Rapid Metro:

Currently Rapid Metro Gurgaon have six stations, connecting Yellow Line of Delhi Metro at Sikandarpur metro station, which are Sikanderpur, Phase 2, Vodafone Belvedere Towers, IndusInd Bank Cyber City, Micormax Moulsari Avenue and Phase 3. Two stations, Shankar Chowk and Gateway tower, are scheduled to become operational soon. The first phase of Rapid Metro became operational in November 2013 and covers a distance of 3.3 mi. Two more phases of the project are in the pipeline and would take the total number of subway stations in Gurgaon to 16. An estimated 33,000 people ride Rapid Metro everyday, which provides an exclusive elevated transit service with three coach trains that run in a loop.

- Road System

The major highway that links Gurgaon is National Highway 8, the road that runs from Delhi to Mumbai. While the 27.7-kilometre (17.2 mi) Delhi-Gurgaon border-Kherki Dhaula stretch has been developed as an expressway, the rest is expanded to six lanes. The second Highway Is Dwarka Expressway, Which Starts from Gurgaon and linked to New Delhi's various major Inter cities.

- Dedicated Freight Corridor

Western Dedicated Freight Corridor has been proposed to cross the project road in village Sohna of distric Gurgaon. It would cross the project road at PWD R.D. 27+170.

- Intercity buses:

Gurgaon bus terminal, managed by Haryana Roadways, is a busy bus station in the city that provides bus connectivity, both private and government, to other cities in Haryana and neighboring states like Delhi, Uttar Pradesh and other cities like Chandigarh.

4.2. DEMOGRAPHIC PROFILE OF THE DISTRICTS

Population

The project road under Package-I falls in the district of Gurugram (Gurgaon) in Haryana state and it is expected that about 6.0 % of the State population are likely to be directly or indirectly benefited by the project road under this package (Table 4.1).

Table 4-1**: Affected Population**

State/ Districts	Population		
	Male	Female	Total
Haryana	13,494,734	11,856,728	25,351,462
Gurugram (Gurgaon)	816,690	697,742	1,514,432

Source: Census of India 2011

Population Density

Population density of the affected districts varies considerably as per the census data of 2011 which clearly suggests that the density of population in the project influenced area is greater than that of the state. Haryana has a population density of 573 persons / sq. km. and in the affected districts about 1204 persons / sq. km in Gurgaon district as detailed in Table 4-2.

Table 4-2**: Population Density of the Affected Districts**

State/ District	Population Density	
	2001	2011
Haryana	478	573
Gurugram (Gurgaon)	716	1204

Source: Census of India 2011

Rural and Urban Population

In the state of Haryana, 65.12% of total population is rural and 34.88% is urban. In Gurgaon district 68.82% is urban of total population and 31.18% is rural area. However, majority of the population in the affected Gurgaon district is dependent on other work. The figures make it evident that the proposed road will pass through and cater to the needs of highly ruralised parts of our country.

Sex-Ratio

Sex ratio of the influenced districts presents the scenario of state. Sex-ratio of Haryana is 879 female per thousand male. Sex-ratio of the influence in Gurgaon district is lower that the state as shown in Table 4-3.

Table 4-3**: Sex ratio in the state and project district**

States/District	Overall Sex Ratio	Child Sex Ratio (Age group of 0-6 yrs)
Haryana	879	834
Gurugram (Gurgaon)	854	830

Source: Census of India 2011

Decadal Growth Rate

It is evident from 2011 census the decadal growth rate for 2001-2011 of Haryana is about 19.90% which is less than the growth rate of 1991-01. Similarly, the growth rate in 2001-11 of the Gurgaon district is higher than the growth rate in 1991-01 as shown in Table 4-4.

Table 4-4**: Decadal Growth Rate**

State/ District	1991-2001	2001-2011
Haryana	28.06	19.90
Gurugram (Gurgaon)	44.15	73.96
Mewat	45.67	37.93

Source: Census of India 2011

Vulnerable Population

As per the Government of India guidelines, people belonging to Scheduled Castes & Scheduled Tribes, physically handicapped, women headed household, families below poverty line, disabled persons and destitute persons are to be considered as vulnerable population.

The census data, 2011 reveals that the percentage of Scheduled Caste in the influenced districts is less than that of the state. With respect to Schedule Tribe population, State has no ST population as detailed in Table 4-5.

Table 4-5**: Total Schedule Caste and Schedule Tribe**

State/ District	Total Population	SC Population	ST Population	Percentage of SC out of total population	Percentage of ST out of total population
Haryana	25,353,081	5,113,615	0	20.17	0.00
Gurugram (Gurgaon)	1,514,432	197,937	0	13.07	0.00

Source: Census of India 2011

4.3. THE SOCIAL SERVICES

Literacy rate of the influenced district Gurgaon is higher than the state. Gurgaon has the literacy rate of 84.70%.

Table 4-6**: Literacy Rate**

Sl. No.	District	Literates Population	Literacy Rate (in %age)
1	*Haryana*	16,598,988	75.55
2	Gurugram (Gurgaon)	1,111,116	84.70

Source: Census of India 2011

4.4. ECONOMIC FEATURES

Distribution of Population by Workers, Non-workers & Occupation

Other work is the main occupation of its inhabitants in the Gurgaon district. As evident from Table 4-7, non-workers exceed main-workers, showing relatively low dependency ratio.

Table 4-7**: Distribution of Population by Workers and Non-Workers**

State/ District	Population	Male	Female	Total
Haryana	Main Workers	5860600	1154683	7015283
	Marginal Workers	946036	955189	1901225
	Non- Workers	6688098	9746856	16434954
	Total	13494734	11856728	25351462
Gurugram (Gurgaon)	Main Workers	400386	87055	487441
	Marginal Workers	32070	25205	57275
	Non- Workers	384234	585482	969716
	Total	27806158	24411198	52217356

Source: Census of India 2011

Table 4-8 contains occupational structure of work force in the project affected districts. Occupation in Other Work is greater than other three sectors in Gurgaon. In the project affected district, higher percentage of workers are involved in other workers and rest of workers are involved in either cultivation or agriculture activities and few are involved in HH industries as shown in Table 4-8.

Table 4-8**: Categories of Workers**

State/ District	Categories	Male	Female	Total
Haryana	Cultivators	1789122	691679	2480801
	Agricultural Labourers	1041241	486892	1528133
	HH industries/	186533	75747	262280
	Other Workers	3789740	855554	4645294
	Total	6806636	2109872	8916508
Gurugram (Gurgaon)	Cultivators	41842	14204	56046
	Agricultural Labourers	19113	7984	27097
	HH industries	13764	4464	18228
	Other Workers	357737	85608	443345
	Total	432456	112260	544716

Source: Census of India 2011

4.5. SOCIAL AND DEMOGRAPHIC PROFILE OF AREA UNDER THE INFLUENCE OF DWARKA EXPRESSWAY

A social and demographic profile of the project-affected area/population is essential to create database and develop indicators for the evaluation of the SIA. To understand the social context of the proposed project and for providing necessary inputs for social analysis of the project, relevant baseline data on social and cultural conditions were collected from various available primary and secondary sources like personal observation and enquiry, consultation with knowledgeable persons of the villages etc. Due to the implementation of project several villages or urban settlements in the affected district of Gurgaon is likely to be affected. On the basis of social survey those settlements and villages have been identified and the same has

been documented in the report. The important demographic features of the influenced area is described as a part of baseline data in the following manner:

Population

The population composition of any area is important to anticipate the extent of project impact. Keeping in mind the importance of demographic profile, the population of the existing settlements was computed.

The composition of population is shown in Table 4-9.

Table 4-9: Population of existing settlements

Sno	SECTORS	VILLAGES	POPULATION
1	SECTOR 100, SECTOR 101, SECTOR 104, SECTOR 37D, SECTOR 9B	Basai Village, Dhanwapur Village, Gharoli Kalan Village	40,581
2	SeECTOR- 36A		15,073
3	SECTOR 36, SECTOR36A,SECTOR36 B ,SECTOR 37B	Gharoli Khurd Village, Harsuru Village, Kherki Daula Village, Mohmmadpur Jharsa Village, Narsinghpur Village, Sihi Village	9,241
4		Harsaru	3,140
5	Sector, 112,113	Bajghera	3,640
6	Sector 102,102 A, 103,106,108 107	Dharampur, Mohmadheri, Kharki Majra Dhankot, Babupur ,Daultabad	34,025

Source: Census of India 2011

Land Use

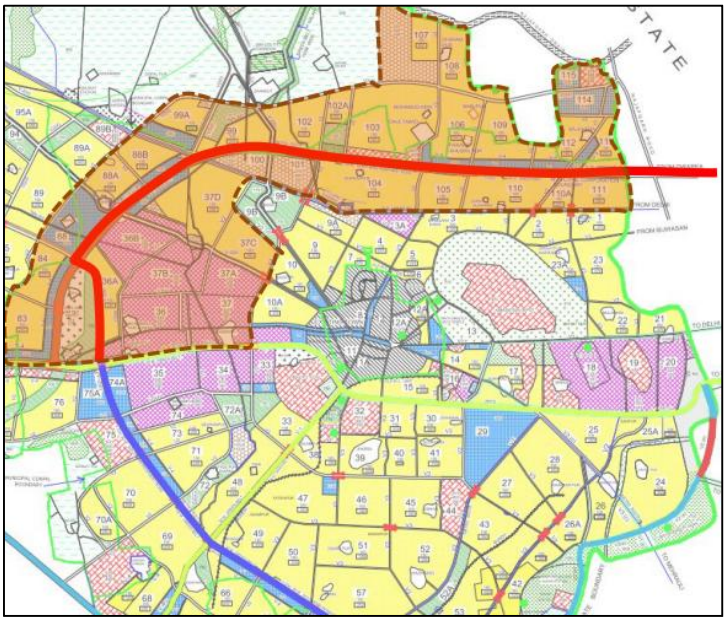


Figure 4-1: Sectors Near Dwarka Expressway

Table 4-10 below presents the land use Plan for sectors to be developed near Dwarka expressway in Gurgaon.

Table 4-10: Land use for sectors in Gurgaon near Dwarka expressway (in Ha)

Sectors	Residential	Industrial	commercial	Public & semi-public	Open space	Total Area in ha
99	786				71	858
102	1554				67	1620
102A	466					466
103	3388			451		3839
106	1771		308			2079
107	737					737
108	1317					1317
109	1461		300			1761
112	990		190			1181
113	784		211		42	1036
114			940			940
115		644				644
110	1765					1765
110A	450					450
111	1053					1053
104	2896					2896
105	1045					1045
100	Public Utility (Sewage treatment plant)					0
101						0
83	1398					1398
84	1164					1164
88			1285			1285
37C	1363					1363
37D	2263					2263
36	49333	2014				51347
37		1241				1241
37A		1102				1102
37B		478				478

4.6. PROPOSED DEVELOPMENT

4.6.1. GLOBAL CITY

Global City is being developed in the site covering an area of 1100 acres which is located south of Pataudi Road and east of Dwarka expressway at Dwarka Expressway-Pataudi road intersection. As per the recommendations of concept master plan, the Global City will house multi sector activities to be developed within

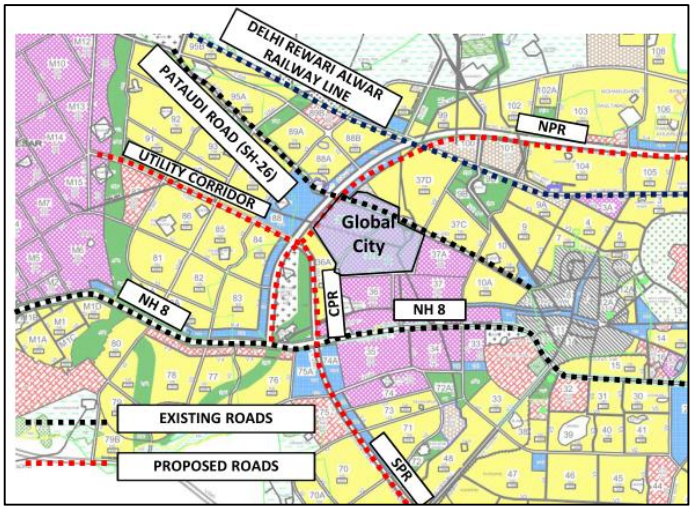


Figure 4-2: Global City

the site. These activities primarily include residential, commercial, finance center, multi-talented office spaces, knowledge center, health care, exhibition cum convention center and innovation cum incubation centers. The development will have built up area ratio of 3. The entire development once fully operational will have a combined employment potential of 4.4 lakhs and resident population of 1.78 lakhs.

This huge employment will flow not only from Gurgaon but also parts of Delhi and NCR. The traffic generated from this employment will have significant impact on the Dwarka expressway.

4.6.2. EXHIBITION–CUM–CONVENTION CENTRE (ECC), DWARKA

Exhibition–cum–Convention Centre (ECC) is proposed to be develop at Dwarka, Sector 25, at New Delhi. The proposed ECC (of approximately 90 ha) will house world class infrastructure facilities related to trade promotions activities, conventions, conferences, exhibitions, corporate meetings, specialized events and logistics facilities. Apart from exhibition and convention center, ECC shall also be positioned with hospitality, retail, commercial, and entertainment along with state of the art public transit connectivity.

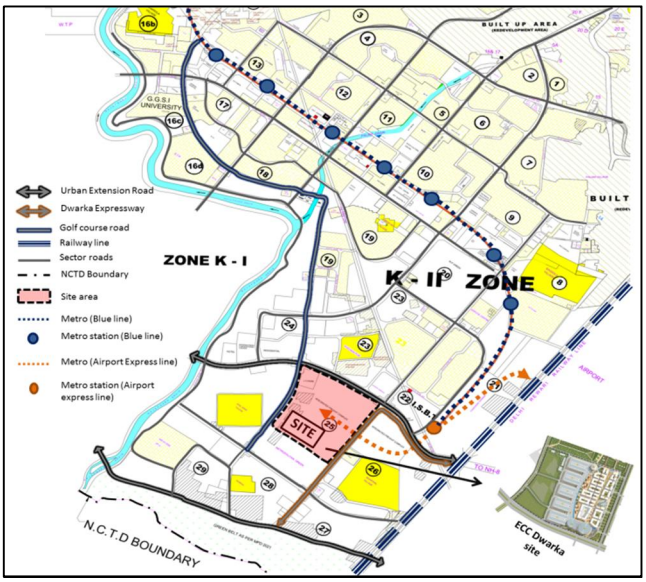


Figure 4-3: Location and Surroundings of ECC Dwarka

The components in ECC such as exhibition, convention centers, commercial, retail, hotels, office space, etc. will attract huge footfall during a normal working day.Traffic generated due to this footfall, will have a major impact on the Dwarka expressway.

CHAPTER 5 TRAFFIC SURVEY & ANALYSIS

5.1 INTRODUCTION

Analysis of the existing traffic flow data is extremely important to understand the current travel characteristics along with its problems and constraints and also to identify future improvement requirements of the project corridor.

The present chapter covers traffic and travel characteristics of the vehicles moving on the project corridor.

Traffic and travel characteristics also vary spatially and temporally. To appreciate these, extensive traffic surveys at number of locations, covering the entire corridor, have been carried out. The list of traffic and travel surveys conducted is mentioned below:

- Classified Traffic Volume Count Survey
- Turning Movement Count Survey
- Origin-Destination Survey

5.2 PRIMARY TRAFFIC SURVEYS

Different type of primary traffic surveys were conducted during the month of May 2017. Type of primary surveys conducted along with the survey locations and schedule of conducted surveys is mentioned in Table 5-1.

Table 5-1: Traffic Survey Locations

Survey ID	Type of Survey	Section/Location
TVC-1	7-days Classified Traffic Volume Count Survey (TVC)	KM-24 Toll Plaza
TVC-2		Km 42 Kherki Daula Toll Plaza
OD-1	1 day Origin-Destination Survey (OD)	KM-24 Toll Plaza
OD-2		Km 42 Kherki Daula Toll Plaza
OD-3		Near Samalkha Crossing
OD-4		Near Dwarka sector 21 metro station
OD-5		Bharthal Chowk
OD-6		Dwarka Sector 24, Near Najafgarh Road
TMC-1	1- day Turning Movement Count Survey (TMC)	Near Samalkha Crossing
TMC-2		Near Dwarka sector 21 metro station
TMC-3		Bharthal Chowk
TMC-4		Dwarka Sector 24, Near Najafgarh Road

Figure 5-1 presents Survey Location Map

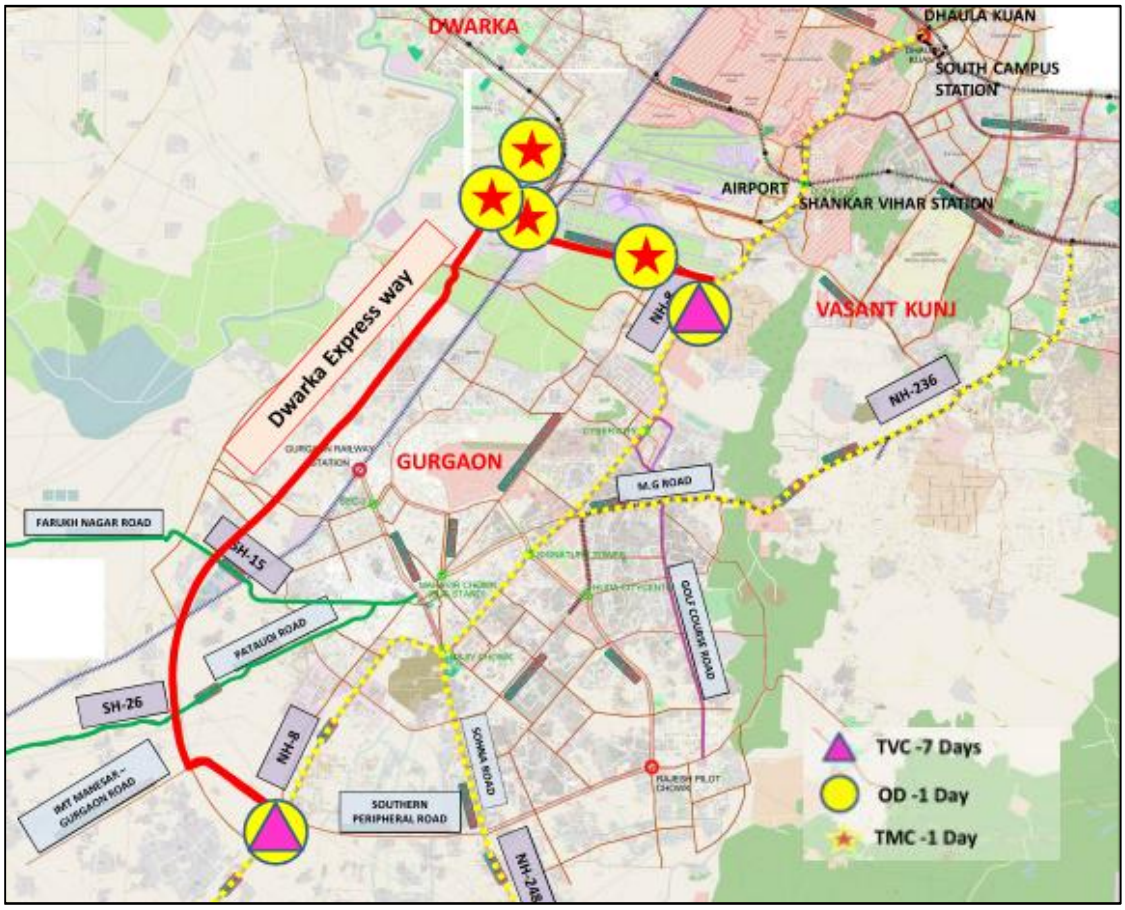


Figure 5-1: Survey Location Map

5.3 SURVEY METHODOLOGY

5.3.1 Classified Traffic Volume Count

Classified Traffic volume survey is conducted to know the quantum of vehicles passing through a given section of road over a period of time. The survey is also important to understand the following:

- To check the efficiency of the network by comparing existing traffic with LOS or with the capacity.
- To estimate future traffic flows.

Classified Traffic Volume surveys also help to appreciate the traffic characteristics in terms of total volume, hourly variation, volume/capacity (V/C) ratio, modal composition, peak hour traffic share and directional split of traffic at each survey locations.

Manual Classified Traffic Volume Counts were conducted at Two locations along the project road i.e. one in each homogeneous section. The survey was conducted round-the-clock for 7 consecutive days. The count stations were selected away from any local hindrance and the results represent the actual traffic flow in each of the homogenous section. Average Daily Traffic (ADT) and Annual Average Daily Traffic (AADT) were obtained from the seven day count data.

For recording classified traffic volume data, vehicles were grouped into the categories as mentioned in Table 5-2.

Table 5-2: Vehicle Classification System

Motorized Vehicle		Non-motorized Vehicle
2 wheelers		Bicycle
Auto Rickshaw		Cycle Rickshaw
Passenger Car : Car, Van, Jeeps, Taxi		Animal Drawn/Hand Cart
Bus	Mini Bus, , Govt. Bus, Pvt. Bus	
Truck	Mini LCV, Light Commercial Vehicle (LCV), LCV (6 - Tyre)	
	2, 3 – Axle	
	(=>7 Axle)MAV, HCM	
Tractor	Agriculture Tractor, Tractor & Trailer	

5.3.2 Origin-Destination (OD) Survey

O-D survey has been conducted at 6 locations on the project corridor. Roadside interviews have been conducted during survey to gather data on the trip purpose, trip length, socio-economic background of passengers, commodity type and value for commercial vehicles, and loading pattern of goods vehicles.

The details of OD survey location are mentioned in Table 5-1.

The objective of the OD survey was to assess the travel pattern of passenger and freight vehicles moving on the corridor and the desire of trips performed by these modes in terms of destined and through trips. OD survey record the trips in terms of its origin, destination, purpose, trip length of a trip in case of passenger vehicles and origin, destination, commodity carried, trip length in case of freight modes.

5.3.3 Turning Movement Survey

Turning Movement Surveys were carried out to determine the directional movement of traffic at intersections. Turning movement surveys were carried out at four major intersections at UER-II. Enumerators were stationed at each arm of the junction to note the number of vehicles entering through the arm and the direction of their exit. Classified traffic volume counts of all vehicle types were made separately for all directions. The survey was conducted for 24 hours at each of the locations.

5.4 ZONING SYSTEM

For better understanding of travel pattern within the study area and its interaction with regions external to this area, a total of 100 zones, called Traffic Analysis Zones (TAZs) have been identified. The zoning system has been developed considering the administrative units, nature of land use, road network and level of development.

Table 5-3 presents the traffic analysis zones adopted for this study.

Table 5-3: Traffic Analysis Zone

NEW	Area Covered by Sectors	Area Covered by Villages
1	Railway Station	Sec-3A
2	Bus Stand	
3	Gurgaon Ward 1 (SECTOR 110A, SECTOR 110, SECTOR 111).Sector 112 and 113. Sector 102,102 A, 103,106,108 107. Sector 109, sec-14&15	Pawala Khusrupur , Sarai Alawardi Village, Bajghera,Dharampur, Mohmadheri,Kharki Majra Dhankot, Babupur,Daultabad
4	sec-23 & sec-1	Chauma Khera Village
5	sec-22	Moulahera Village
6	sec-21	Dundahera Village
7	sec-18	Sarhaul Village
8	sec-19	
9	sec-20	
10	Ammunation depot, Sec-23A, Sec-2, Sec-3, Sec-5	Ammunition Depot, Ashok Vihar Phase 3, Carterpuri Village, Caterpuri, Palam Vihar Extn, , Shitla Colony ,Daulatpur Nasirabad, Bhimgarh Kheri,Sarai Alawardi
11	Sec-5, Sec-6, Sec-12	Gurgaon Village
12	SEC-13	Rajiv Nagar, Sanjay Gram
13	SEC-14	
14	SEC-11A	
15	SEC-12	Bhim Nagar, Indra Puri, Jacubpura, Jawahar Nagar, Nai Basti, Prem Nagar 1, Ram Nagar, Subhash Nagar
16	SEC-11, SEC-8	Arjun Nagar, Idgah Colony, Jyoti Park, Madanpuri, Nehru Lane, New Colony, Pratap Nagar, Rattan Garden, Vijay Park Nagar, Shivaji Nagar
17	sec-11	Heera Nagar, Laxmi Garden, Om Nagar, Shanti Nagar, Shivaji Nagar
18	sec-7, sec-4	
19	sec-9, 9A ,SEC-10 ,SEC-37C	Kadipur Village
20	SEC-10A	Aath Marla, Amar Colony, Auto Market, Baldev Nagar, Char Marla, Gandhi Nagar, Manohar Nagar, Nai Aabadi, Shakti Nagar, Veer Nagar , Khandsa Village
21	SEC-37, 37A	Anaj Mandi, Hari Nagar, Raj Nagar, Shakti Park, Shivji Park
22	SEC-104	

23	SECTOR 100, SECTOR 101, SECTOR 37D, SECTOR 9B, SECTOR36 B ,SECTOR 37B	Basai Village, Dhanwapur Village, Gharoli Kalan Village
24	Sec-17	Sukhrali Village
25	sec-17-2	
26	sec-16	
27	sec-15	
28	SECTOR 36, SECTOR36A	
29	sec-66, sec67 & sec-67A	Badshapur Village, Ramgarh Dhani
30	SEC-68 , Sec-69,Sec-70 ,Sec-70-A, sec-75	Nurpur Jharsa
31	Sec-48 , sec-72,Sec-71, sec-73, sec-74	Teekri Village,Fazilpur Jharsa Village,Behrampur Village,Begampur Khatola Village
32	sec-74A,Sec-35, SEC-34, SEC-72A	
33	Sec-49	Ghasola Village
34	Sec-50	
35	Naharpur	
36	SEC-33	
37	SEC-33	
38	Sec-38	Islampur
39	Gurgaon Ward 28 (SECTOR 31, SECTOR 32, SECTOR 32A, SECTOR 39)	Jharsa Village
40	SECTOR 29	
41	SECTOR 30,Sector 41	
42	SECTOR 40	
43	SECTOR 44	
44	SECTOR 45	
45	Gurgaon Ward 31 (SECTOR 52)	Wazirabad Village
46	SECTOR 57	Tigra Village
47	SECTOR 46,SECTOR 51	Samaspur Village
48	SECTOR 47	Fathepur
49	SECTOR 52A, SECTOR 53, SECTOR 55	
50	Sec-54	
51	SEC-42 , Radar Station	
52	SECTOR 56	
53	Sec-58, 59,60, 61, 63A Ghata Village, Gwal Pahari Village	
54	Sec-62,Sec- 63, Sec-63A,SEC-64, SEC-65,Behranpur, Qadarpur(Gurgaon)	
55	Gurgaon Ward 33 (SECTOR 43)	Chakkarpur Village, Wazirabad
56	SECTOR 27, SECTOR 28	Chakkarpur
57	Sec-26 & 26A	Sikanderpur Ghosi Village
58	SECTOR 25	
59	Cyber City	
60	Ambience mall & Mall of india	
61	Gurgaon Ward 35 (SECTOR 24, SECTOR 25 A)	Ambience Island, Dhanchiri Camp, DLF City Phase 3 Nathupur Village, National Media Center

62	Sector 99, 99A &Northern Outer Gurgaon Villages	Village-Dhanawas(119),Khetawas(118),Sultanpur(39), Iqbalpur(40),Kaliawas(41),Budhera(43),Chandu(44), Hamirpur(116),Garhi Harsaru (46) (CT)
63	Sector 89A, 89B,88A, 88B Sector 89,88, Sector 95A, 95B ,Sector 90,91,92,93,94,95	Harsaru(107), Dhorka(120)Meoka(121)Hayatpur(114)Bhang Rola(122),Harsaru(107)
64	Sector 82A, 82, 83, 84,85	Sikanderpur Badha(109)
65	Sector 81,81A,86,87	Badha, Lakhnola, Kankrola,Nawada Fatehpur
66	Sector 75A,SECTOR 76	
67	Sector 77,78,79,79A,79B & Sector M1A,M1B,M1C,M1,M1D	Shikohpur
68	IMT Manesar	Sector M96,M10,M12,M13,M11,M8,M9, M3A,Sector M2,M3,M4,M5,M6,M7,M15,Sector M96,M10,M12,M13,M11,M8,M9, M3A village:- Dhana,Basharia, Baskushla,Kasan (129) Khoh(153) Sehrawan(152), Kakrola, Bhangrola,naharpur kasan
69	Airport	
70	Dhaulakuan	
71	Mahipalpur	
72	Samalkha ,Kapashera	
73	Rajokri	
74	Dwarka	
75	Delhi-South West	Najafgarh, Jhuljhuli, Kharkhari Nahar
76	Delhi-South	Hamdard Nagar, Saket, Sultanpur, Air Indai Colony Qutub Minar, Fathehpur Beri, Mandi Pahari, Balbir Nagar
77	Central Delhi	Civil Line. Tis Hazari, Rajendra Nagar, Patel Nagar, Rajghat , IndiaGate, Lodhi Garden , Lajpat Nagar, Malviya nagar , Vsnt kunj, Hauz Khas, Minirka, Greater Kailash,Nizamuddin
78	Delhi - West	Janakpuri , Punjabi Bagh , Nangloi, Madipur, Mundka, Meera Bagh
79	Delhi- East	Across Yamuna River , Noida , Greater Noida , Dadri , Vijay nagar, Dilshad Garden , Yamuna Vihar, Shahdara, Silampur, Lakhshmi Nagar, New Ashok Nagar,Jasola Vihar, Okhala, Badrpur, Gaziabad
80	Delhi North	Azadpur , Badli , Rohini , Narela , Rithala, salimar bagh , Pitampura, Kikrari Sulemana Nagar, burari, Mangol puri, Shakurpur, Sultanpuri , Prashant Vihar, Budh Vihar, Wazirpur, Mukandpur, Kanjhwala, Jaunti
81	Manesar Village North of KMP and east of KMP	Sector- P1,P2,P3,P4,P5,P6,P7
82	Rest of Manesar	Punchgaon,Darbaripur(162) Nurpur Jharsa(165) Palra(164), Sidhrawali(139) Rathiwas(140) Bhudka(142) Bilaspur(146),Village-Bahora Kalan(134) Fakharpur(133) Mokalwas(132) Tatarpur(27) Kharkhari(131) Nurpur Bahora(135) Bahora Khurd(136) Bhun Karka(137) Prasoli(138) Binola(147)

83	Rest Of Gurgaon (Farukhnagar Pataudi)	Village-Baslambi(130) Jamalpur(28) Ghausgarh(26) Janaula(25) Jori(24) Sanpka(23) Khawaspur(29) Babra Bakipur(33) Farrukhnagar town and rest of area left in , Pataudi Town and Adjacent areas, Includes Villages lying towards north of SH 26 in Tehsil Pataudi Jatauli Town and Adjacent areas Includes Villages lying towards south
84	Dharuhera(North & South)	Includes Villages- Alamgirpur (298) Malpura (295) Joniawas (296) Kapariwas (290),Includes Villlage - Garhi Alawalpur (294)
85	Dharuhera Town	Dharuhera Town
86	Rewari District	
87	Bawal Town	Includes IMT Bawal and surrounding villages like : Suthana (42) Suthani (45) Jalalpur (43) Chirhara (39)
88	Rewari town	Rewari Tehsil excluding Rewari Urban Agglomeration,
89	Bhiwadi	BTK
90	Neemrana	Neemrana
91	Jhajjar District	
92	Sohna	
93	Rest of Haryana	Karnal , Kurukshetra , Ambala , Yamunanagar , Kaithal , All the districts of Haryana ecluding PIA and west Haryana
94	Rest of Alwar District	Rest of Alwar district excluding the above mentioned parts
95	Rest Of Rajasthan	Sawai Modhopur , Kota , Bundi , Bharatpur , Dholpur,Jodhpur , Jaisalmer , Barmer , Bikaner , Nagaur
96	Rest of Uttar Pradesh	
97	Northern India	
98	Southern India	
99	Rest of India	
100	District Faridabad	

Map 5.1 presents Traffic analysis Zones

5.5 DATA ANALYSIS

5.5.1 Traffic Characteristics

Assessment of traffic characteristics is an essential pre-requisite to appreciate quantum of traffic within the influence area, the problems with respect to traffic movement and to understand the need for organizing the same in an efficient and economical manner. Traffic characteristics help in appreciating the spatial and temporal features of travel within the area, relationship of traffic intensity with the available network capacity and level of service on existing network in the study area. This appreciation and understanding is essential for identifying the present potentials and constraints, formulating proper policies and strategies, selecting relevant systems and designing individual components of the system to meet the present and projected travel demand.

Traffic Characteristics are expressed in terms of total flow, its modal composition, hourly variations, numbers and peak traffic flows.

Also when traffic is composed of different type of vehicles, it is normal practice to convert the flow into equivalent passenger car units by using certain equivalence factors. The flow is then expressed as PCU per hour. PCU factors adopted are presented in Table 5-4 below.

Table 5-4: Passenger Car Unit Values Adopted

S. No.	Vehicle Type	Equivalent PCU factor
1	2-Wheeler	0.5
2	Car, Jeep, Taxi	1
3	Auto rickshaw	1
4	Mini LCV	1
5	Light Commercial Vehicle	1.5
6	Truck or bus	3
7	MAV	4.5
8	Cycle	0.5
9	Cycle rickshaw	2

5.5.2 Average Daily Traffic (ADT)

Traffic volume count data collected from the survey locations tabulated and analysed further to obtain the Average Daily Traffic (ADT). Hourly data collected was summarized to obtain hourly variation of traffic. The summarized Average Daily Traffic data observed at all the location by each hour of the day is presented in Table 5-5.

Table 5-5: Average Daily Traffic observed at TVC locations

Location / Chainage	Passenger Vehicles				Freight Vehicle			Total Vehicles	Total PCUs
	Autos	Car / Taxi	Mini Bus	Bus	LCV	Truck	MAV		
	1	*1*	*1.5*	*3*	*1.5*	*3*	*3*		
KM- 24	1,084	2,78,933	1,362	7,012	11,226	9,776	1,647	3,11,041	3,45,752
% Share	0.3%	90%	0.4%	2%	4%	3%	1%		
KM - 42	5,665	45,959	468	3,340	16,043	10,298	3,435	85,208	1,22,207
% Share	7%	54%	1%	4%	19%	12%	4%		

It is observed from the data that maximum ADT of 3,11,041 (3,45,752 PCU) was observed at Km 24 Rajokri toll plaza, and 85,208 (1,22,207 PCU)was observed at Km-42 Kerki daula toll plaza.

5.5.3 Peak Hour Factor

Peak Hour factor observed at Km-24 & Km-42 is shown in Table 5-6 below.

Table 5-6: Park Hour Factor

Location/ Chainage	% Share of		Total Traffic	Peak Hour Traffic (Vehicles)	Peak Hour Share
	Day Traffic	Night Traffic	(In Vehicles)		
KM- 24	3,35,035	63,560	3,98,595	31,971	8.0%
KM-42	83,744	19,144	1,02,888	7,326	7.1%

5.5.4 Traffic Composition

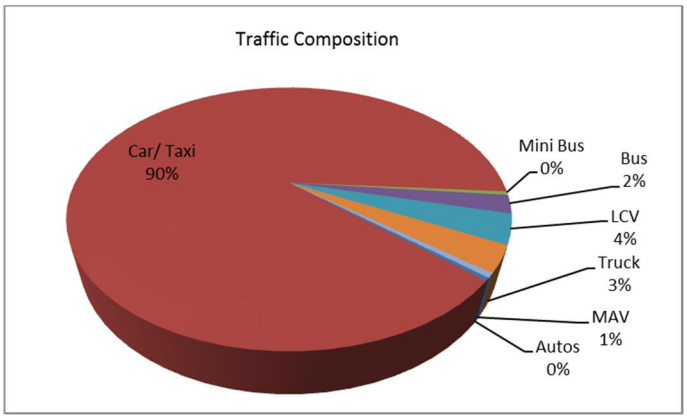


Figure 5-3: Traffic Composition at Km-24

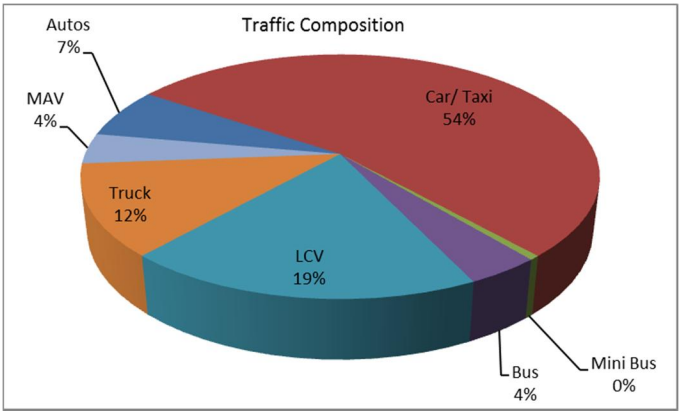


Figure 5-2: Traffic Composition at Km-42

5.5.5 Hourly Variation

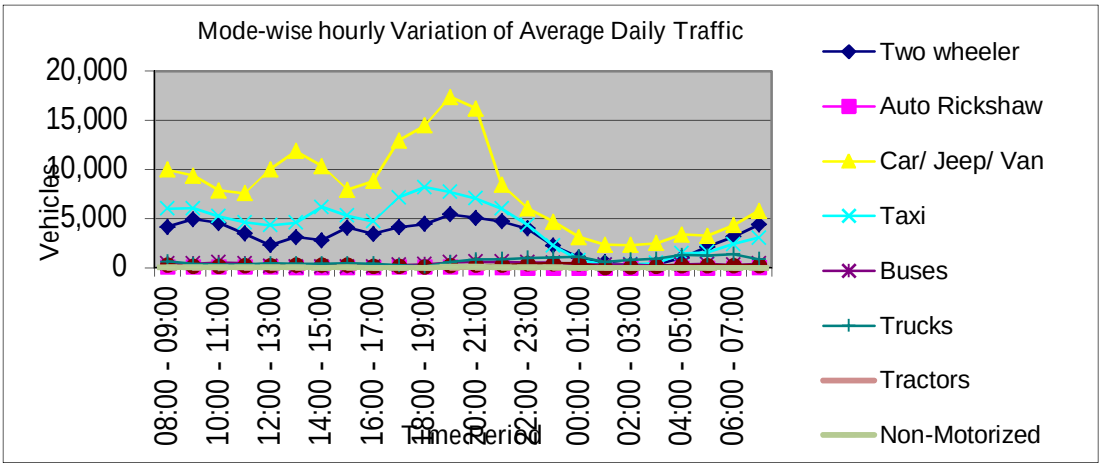


Figure 5-4: Daily Hourly Variation in Traffic at KM-24

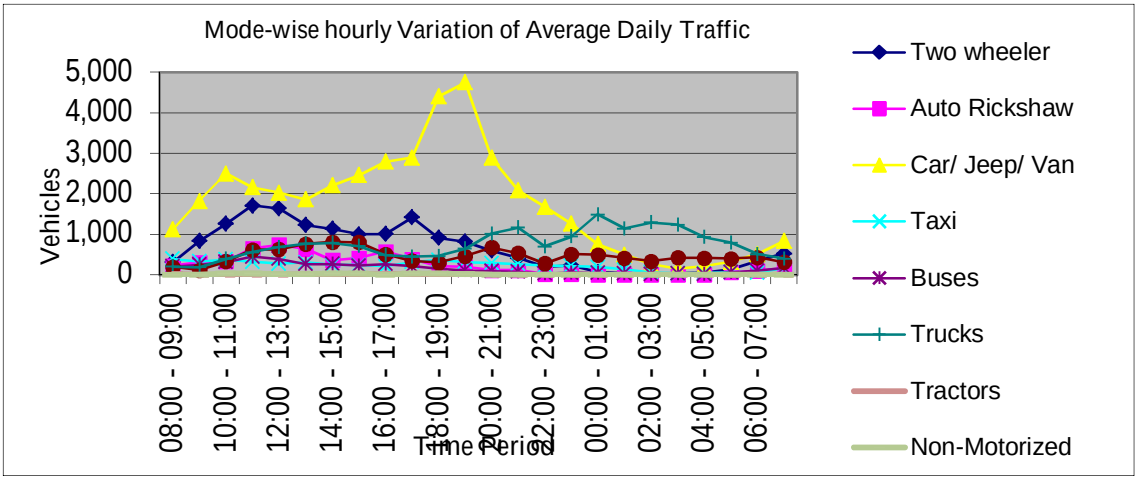


Figure 5-5: Daily Hourly Variation in Traffic at KM-42

5.5.6 Turning Movement Count Survey

Turning Movement Surveys were carried out to determine the directional movement of traffic at intersections. Turning movement surveys were carried out at five major intersections as mentioned in Table 5-7. Enumerators were stationed at each arm of the junction to note the number of vehicles entering through the arm and the direction of their exit. Classified traffic volume counts of all vehicle types were made separately for all directions. The survey was conducted for 24 hours at each of the locations. The average daily traffic, Peak traffic and Peak hour factor of these locations are presented in Table 5-7 below:

Table 5-7: ADT and peak Hour traffic at Intersections

TMC	Location Name	Total Traffic Flow (vehicles)	Total Traffic Flow (PCU)	Peak Hour	Peak Hour PCU
1	Near Samalkha Crossing	1,15,074	1,05,954	09:00-10:00	10,000
2	Near Dwarka sector 21 metro station	94,959	84,830	08:00-09:00	10,109
3	Bharthal Chowk	74,389	66,135	09:00-10:00	7,119
4	Dwarka Sector 24, Near Najafgarh Road	41,589	37,597	10:00-11:00	3,216

Turning flow at each location is presented in Figure 5-6 to Figure 5-9.

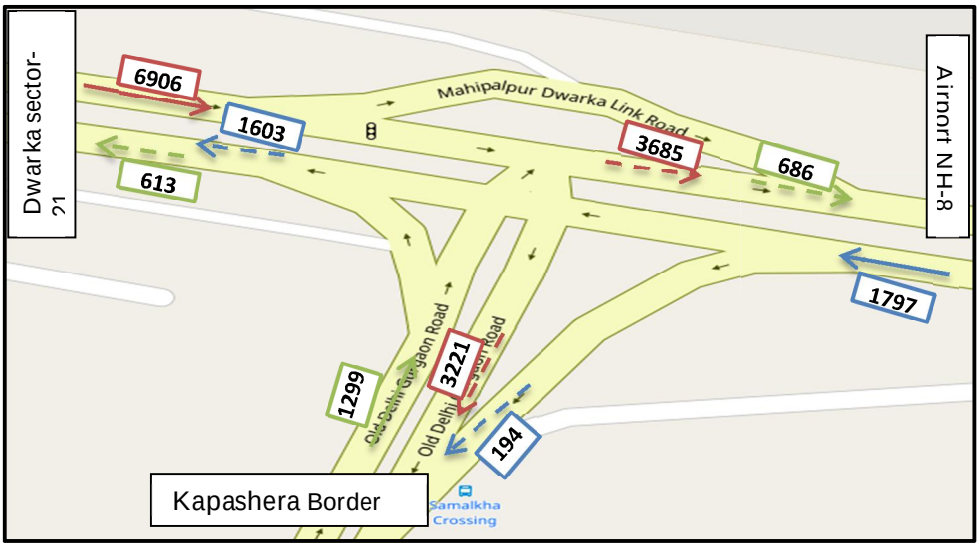


Figure 5-6 Traffic flow at intersection near Samalkha Crossing

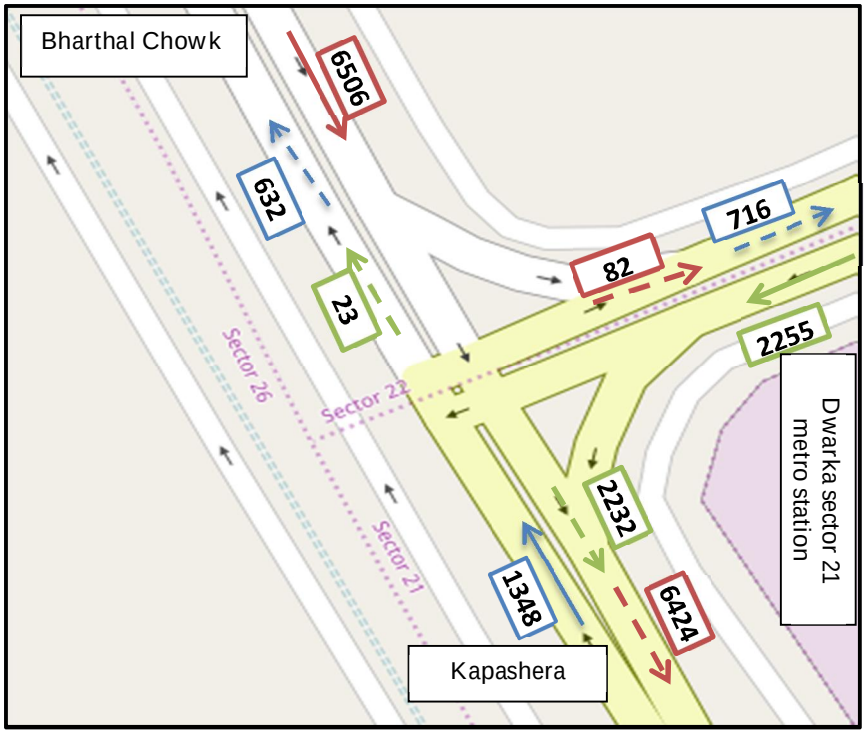


Figure 5-7 Traffic flow at intersection near sector 21 Dwarka metro station

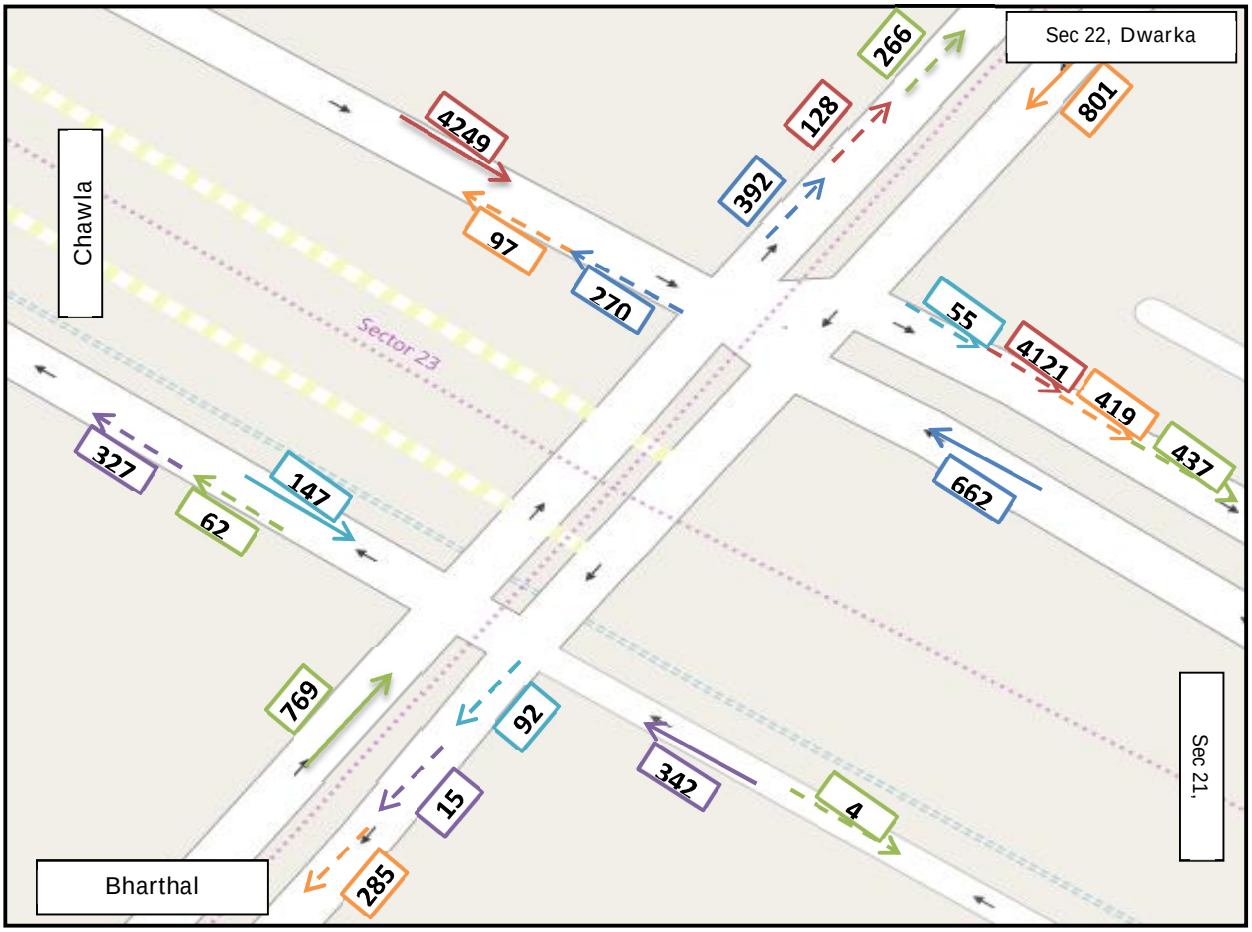


Figure 5-8 Traffic flow at Bharthal Chowk

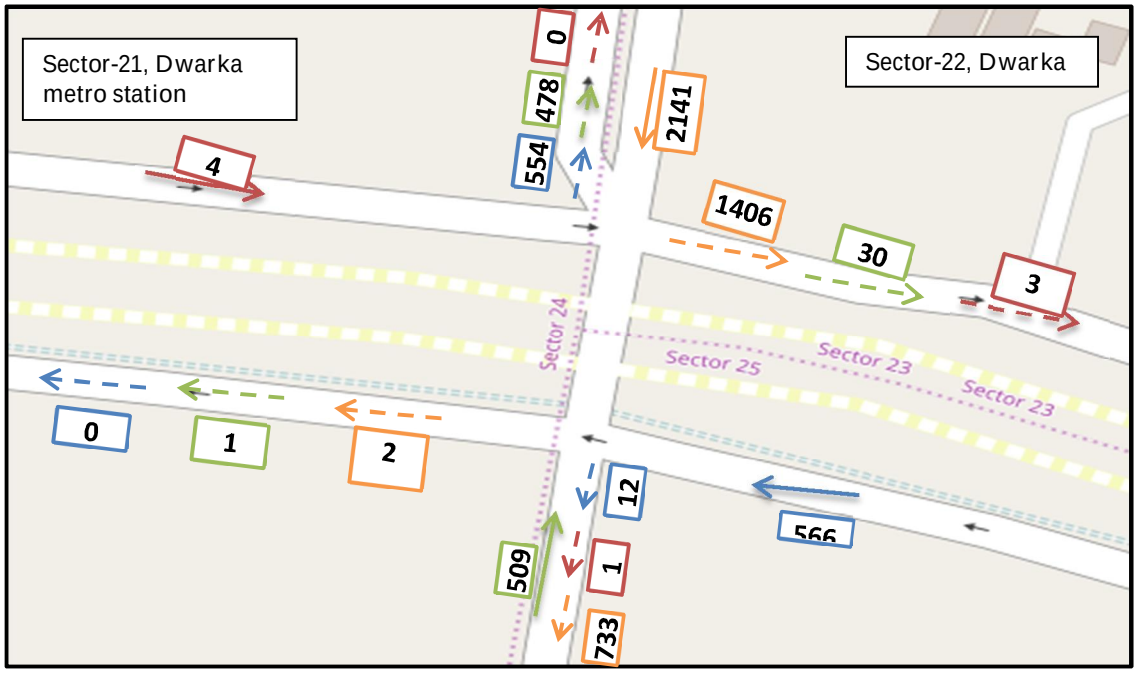


Figure 5-9 Traffic flow at Najafgarh road intersection

5.6 TRAVEL CHARACTERISTICS

Origin and destination survey was conducted to understand the travel pattern on the Project Road. The OD survey was conducted at two toll plaza locations on NH -8 and UER-II. The project influence area is divided into 100 zones based on the movement of traffic on the Project Road.

5.6.1 Origin Destination (OD) survey

After coding of Origin and Destination data, expansion factors were calculated by comparing the sample size by vehicle type with the Annual Average Daily Traffic. Vehicle wise O-D matrices were developed using these expansion factors.

Movement Pattern

The rationale of origin destination analysis is to understand the contribution of zones that are adding traffic to the exiting NH 8. After establishing the zone having substantial share suitable growth rates are worked out based on economic characteristics of each of these zones. These growth rates are then used to for forecasting and for further estimating horizon year corridor traffic. The section presents the details of zones that maximum share based on the travel pattern by survey/ toll plaza location on NH 8. Table 5-14 presents the percentage distribution of passenger traffic by TAZs as observed at each of the survey locations.

Location	KM-24	KM-42	UER-II
	Passenger	Passenger	Passenger
Gurgaon	30%	21%	21%
Dwarka	14%	1%	38%
Delhi-South	13%	2%	10%
Central Delhi	22%	13%	4%
Delhi - West	4%	2%	8%
Delhi- East	10%	5%	6%
Delhi North	3%	4%	2%
Manesar	2%	23%	2%
Rajasthan	2%	15%	0%
Rewari	0%	4%	1%
Rest of Haryana	1%	8%	8%

As evident from above table, maximum share of traffic for passengers' modes is contributed mainly by 4 zones and these are Gurgaon, Dwarka, Delhi-Central and Manesar. At Km- 24 toll plaza maximum share of traffic is originating from Gurgaon (30%) and Central Delhi (22%) followed by Dwarka (14%). At Km-42 maximum share of traffic is originating from Manesar (23%) and Gurgaon (21%) followed by

Rajasthan (15%). At UER-II maximum share of traffic is originating from Dwarka (38%) and Gurgaon (21%).

Location	KM-42	UER-II
	Goods	Goods
Gurgaon	17%	24%
Dwarka	1%	24%
Delhi-South	3%	15%
Central Delhi	7%	5%
Delhi - West	5%	9%
Delhi- East	4%	5%
Delhi North	6%	4%
Manesar	16%	3%
Rajasthan	25%	0%
Rewari	6%	2%
Rest of Haryana	10%	9%

From above table, it is observed that the maximum share of goods traffic is contributed mainly By Rajasthan (25%) and Gurgaon (17%) at Km- 42 toll plaza. At At UER-II maximum share of traffic is originating from Dwarka (24%), Gurgaon (24%) and Delhi South (15%).

Desire line diagrams representing the travel desire for passenger at each location are presented in Map 5-2 & Map 5-3.

5.7 BASE YEAR TRAFFIC DIVERSION

In order to design the Expressway, the road capacity requirements have to be ascertained. The capacity requirements in terms of carriageway widths can only be analysed by estimating the traffic that will potentially use the project corridors once it is constructed.

The traffic which will use these corridors will comprise not only from the sections that on which the corridor will be developed but will also be diverted from other sections of road network due to higher speeds and less travel time amongst the common Origin-Destination (OD) pairs. Therefore, in order to estimate the diverted traffic considering the impact of improved speeds, reduction in congestion, reduced travel time, application of toll rates 'Traffic Assignment Model' has been used. The model has been first validated for base year and then used further for estimating traffic on project corridor for both cardinal and horizon years.

The section discusses in detail the preparation of base year traffic assignment model, its parameters and traffic forecast.

5.7.1 Traffic Assignment Model

The Traffic Assignment Model for the study corridor has been developed using VISUM-13 software. The model comprises of the major road network within the study area. The same will be used for traffic assignment and its evaluation & assessment. The traffic assignment process is initiated after data collection from the site. The various stages involved in traffic assignment are as follows:

- Stage 1: Data Collection, Analysis & Compilation;
- Stage 2: Base Year Traffic Assignment (Model Calibration & Validation)
- Stage 3: Horizon Year Traffic Assignment.

Stage 1 of Data analysis & Compilation has been discussed in the previous chapters. The Steps involved in Stage 2 i.e. Base Year Data Calibration & Validation and Stage 3(Horizon year assignment) are discussed in subsequent sections.

The Transport model consists of various components like network objects, demand data/travel demand, traffic impact & result analysis. The traffic model that has been developed for the study utilises the above mentioned components for arriving at the results. The same components are briefly discussed as follows:

Network Objects: The assignment model covers complete influence area of the project & major road network serving the city of Gurgaon and Dwarka, which ensures a full assessment of demand potential. The network objects include nodes, links, zones, connectors etc. The capacity, speed & impedance of roads are fed into the network objects at this stage.

Demand Data: This component includes the volume that has been captured from ground surveys. The data is fed into the model in the form of OD (Origin & Destination).

Matrices which are further classified as mode-wise PCU matrices according to different vehicle categories.

Traffic Assignment: Traffic assignment has been done using Equilibrium assignment procedure, which is based on Wardrop's first principle, i.e. "Every road user selects his route in such a way that the travel time on all alternative routes is the same, and that switching to a different route would increase personal travel time."

Result Analysis: This step provides us the information related to the traffic assigned on the highway network, which can be in the form of PCUs, vehicles or Trips. The link wise details can also be obtained using link volumes. Further detailed analysis can also be done by using features such as Flow bundles, turn volumes etc.

5.7.2 Base Year Traffic Assignment

Trip assignment model is used to estimate traffic volume on each link and intersection of the road network. The model algorithm routes the estimated origin – destination travel demands to the actual road network based on network parameters

such as speed, capacity and distance. In a road network, trips from a particular origin to a particular destination may have more than one route to choose from. The decision to choose a route is driven by the travel time.

The methodology used for assignment of Private trips in this study is known as Equilibrium assignment. The Equilibrium assignment distributes the demand according to Wardrop's first principle. As per this model, trips from the OD matrix are assigned on all the links between the OD pairs till travel time from all the links reach equilibrium in terms of travel time, the procedure provides realistic results. As described earlier VISUM-13 software has been used for performing traffic assignment.

Impedance of the links is determined from the current travel time which is a function of speed. The current travel time is in links calculated using the capacity restraint function BPR with a, b and c values.

$$t\,cur = t\,0 * (1 + a.\,sat\,b)$$

Where;

Sat - Volume / capacity ratio sat =q / q max *C

t cur - Current travel time on a network object in loaded network

t 0 - Travel time on a network object with free flow time

q - Current volume

q max - Capacity

Based on the traffic assignment carried out by the software, traffic flow on each link was obtained. Traffic flow on each link was studied to identify the congestion points and critical junctions, check the adequacy of road network, and to formulate the traffic flow strategies.

5.7.3 Divertible Traffic Estimation

As discussed above, Traffic Assignment Model was used to model traffic flows on the study area network. Same model will now be used to estimate potential divertible traffic likely to use the proposed elevated corridors due to reduction in travel time, increase speed along with payment of toll charge. Considering the proposed alignment of elevated corridors and enhanced parameters such as increased speed, capacity and entry-exit locations, the model was first run for estimation of divertible traffic for the base year. The estimated traffic diversion in the base year as per the results of traffic assignment model is presented in Table 5-8.

Table 5-8: Mode wise divertible traffic on different sections (Base Year)

SL NO.	SECTION	CHAINAGE	LENGTH	CAR/ VAN	TAXI	BUS	MINI LCV	LCV	2 /3 AXLE TRUCK	MAV	TOTAL VEHICLES	TOTAL PCUS
I	UER II NH8 SHIVMURTI TO DWARKA SEC-21	8+600 - 9+500	900	27,691	13,845	4,615	105	428	397	115	47,196	57,837
II	DWARKA EXP. SEC 21 TO DELHI BORDER	9+500 - 14+500	5000	13,536	6,768	2,256	105	428	397	115	23,605	29,528
III	DELHI BORDER TO PATAUDI ROAD	14+500 - 21+970	7470	10,081	5,041	1,680	99	407	377	109	17,795	22,496
IV	PATAUDI ROAD TO SEC 36A	21+970 - 24+680	2710	10,183	5,092	1,697	27	109	101	29	17,238	20,992
V	DWARKA EXP. SEC 36A TO SPR INTERSECTION	24+680 - 28+000	3320	10,295	5,148	1,716	141	577	535	155	18,566	23,897

5.8 TRAFFIC FORECAST

Traffic growth rates have been estimated for the traffic flowing on the primary network in the city of Gurgaon. The overall traffic growth rates have been estimated considering the population, employment and future transport and infrastructure development proposed in the project area.

There are certain proposed developments in the vicinity of project corridor that will contribute to traffic volume. These include EEC Dwarka and Global City. The generation data for these developments has been taken from secondary sources. Apart from these developments is a proposal of developing residential area in sector 28 & 29 of Dwarka and sector 110, 111,112 and 113 of Gurgaon. These residential pockets will generate traffic that will use UER II. In the absence of data traffic from these sectors was estimated considering the population and using per capita trip rate (PCTR) of 0.9. Table 5-9 presents the total traffic generation by each of these developments on Dwarka expressway when fully operational.

Table 5-9: Total Peak Hour Traffic (PCUs) Generation from Proposed Developments

Development Type	Total	Peak Hour
Global city	16,771	1600
EEC Dwarka	23,178	2300
Gurgaon	15,766	1500
Total	55,715	5400

5.8.1 Traffic Growth rates

A growth Rate of 5% is adopted for tragic projection for various modes. Due to addition of traffic generated from various proposed Development around the project road, the adopted growth rate gradually increases in the 2017, 2021 and 2015. Year wise Growth rates adopted for traffic forecast is presented in Table 5-10 below.

Table 5-10: Year wise Growth rates adopted for traffic forecast

Modes	2017	2021	2025	2030	2035	2040	2045
CAR/ VAN	9.9%	21%	7%	5%	5%	5%	5%
Taxi	9.9%	21%	7%	5%	5%	5%	5%
Bus	9.9%	21%	7%	5%	5%	5%	5%
Mini LCV	5.0%	5%	5%	5%	5%	5%	5%
LCV	5.0%	5%	5%	5%	5%	5%	5%
2 /3 Axle Truck	5.0%	5%	5%	5%	5%	5%	5%
MAV	5.0%	5%	5%	5%	5%	5%	5%

For the present study, project corridors was divided in 5 homogenous sections for the purpose of traffic analysis, section wise traffic projections of these Homogeneous structure is presented in Table 5-11 below.

Table 5-11: Section wise traffic projections (PCUs) on Dwarka Expressway

S.NO.	SECTION	Contract Package	2017	2021	2025	2030	2035	2040	2045
I	NH-8 Shiv Murti to Dwarka Sec-21	Package 1	47,196	68,641	1,03,940	1,26,357	1,61,267	2,05,822	2,62,687
II	Dwarka Exp. Sec 21 to Delhi Haryana Border	Package 2	23,605	34,130	71,602	98,813	1,26,113	1,60,956	2,05,425
III	Delhi Border to Pataudi Road	Package 3	17795	31165	68271	94472	120573	153885	1,96,400
IV	Pataudi Road to Sec 36 A	Package 4	17,238	32,277	73,560	1,02,690	1,31,061	1,67,271	2,13,485
V	Dwarka Exp. Sec 36A to SPR Intersection		18,566	33,887	75,519	1,05,144	1,34,193	1,71,268	2,18,587

5.8.2 Toll-able Traffic Forecast

The projected vehicular matrices have been assigned on the horizon year network as discussed above to estimate link wise vehicular volume for estimating toll-able traffic for each phase till the horizon year study.

The toll Plaza is proposed at Dwarka exp. Sec 21 to Delhi border section at Km-9+500 Hence the Toll-able traffic estimates have been made on this section till the year 2046.

Projected tollable traffic for Dwarka exp. Sec 21 to Delhi border section is described in Table 5-12.

Table 5-12: Divertible Tollable Traffic

Modes	2017	2021	2025	2030	2035	2040	2045
CAR/ VAN	11,235	28,873	34,889	52,277	66,720	85,154	1,08,680
Taxi	5,617	14,436	17,444	26,138	33,360	42,577	54,340
Bus	1,872	4,812	5,815	8,713	11,120	14,192	18,113
Mini LCV	87	122	128	177	225	288	367
LCV	356	500	525	724	924	1,179	1,505
2 /3 Axle Truck	330	464	487	671	856	1,093	1,395
MAV	95	134	141	194	248	316	404
Total Passenger	18,725	48,121	58,148	87,128	1,11,200	1,41,923	1,81,133
Total Goods	867	1,220	1,282	1,765	2,253	2,876	3,670
Grand Total	19,592	49,342	59,430	88,894	1,13,453	1,44,798	1,84,803

Annexure -1 presents the mode wise and year wise traffic projections for the above described sections of Dwarka Expressway.

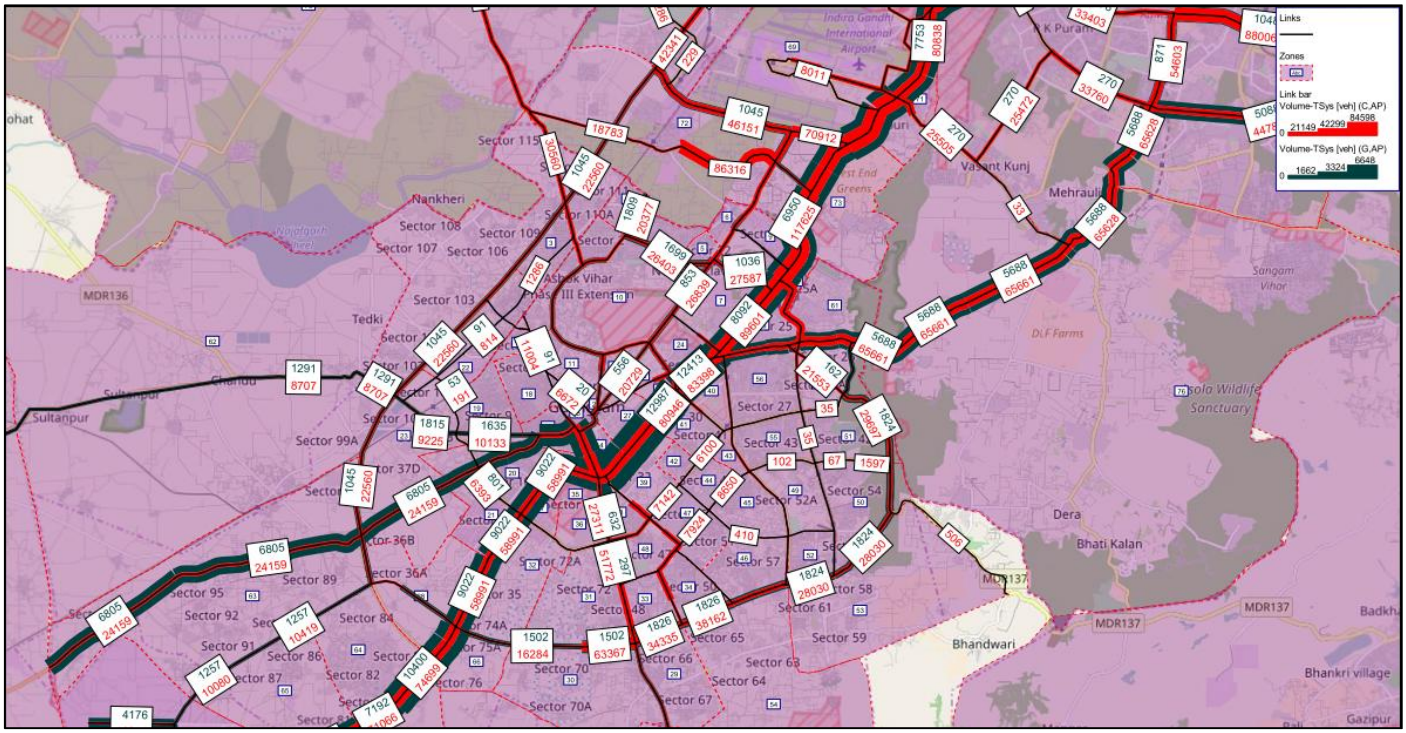


Figure 5-10: Projected Traffic Assignment, 2017

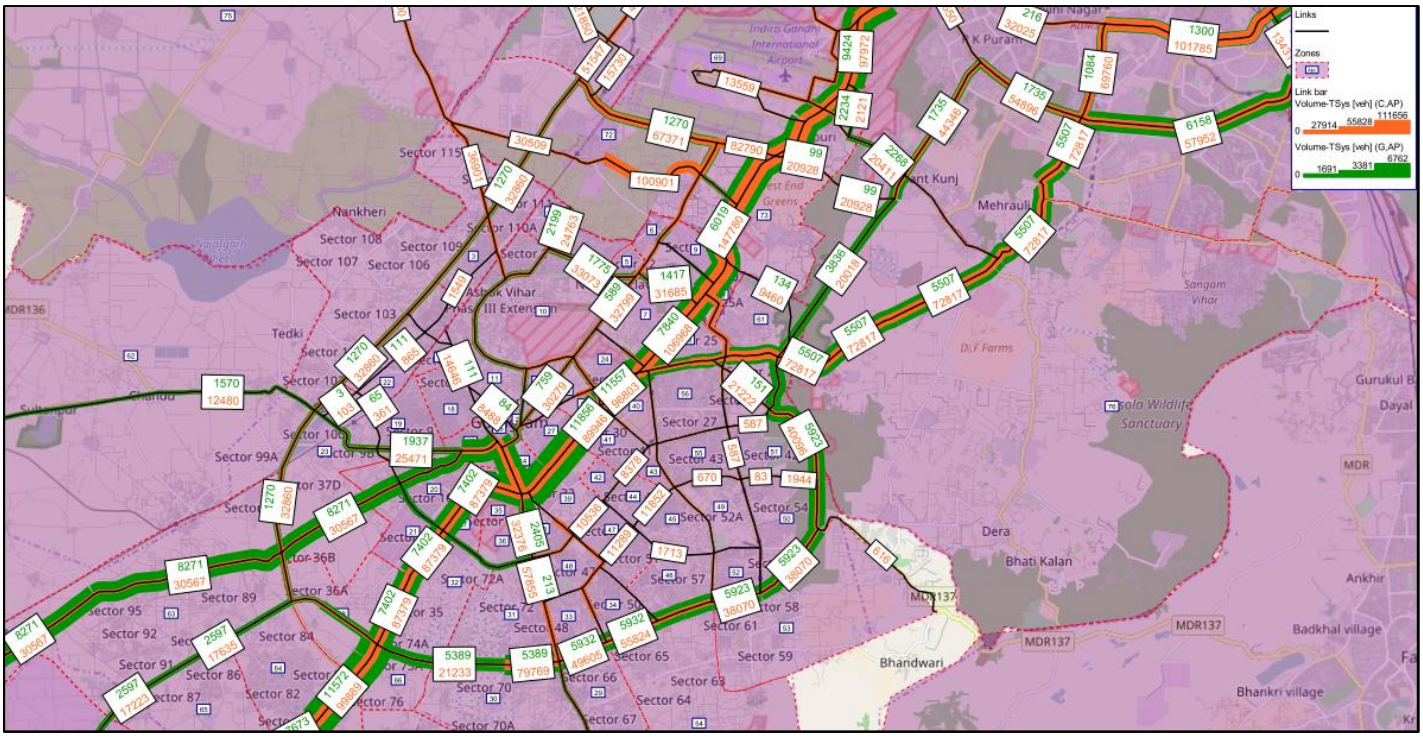


Figure 5-11: Projected Traffic Assignment, 2021

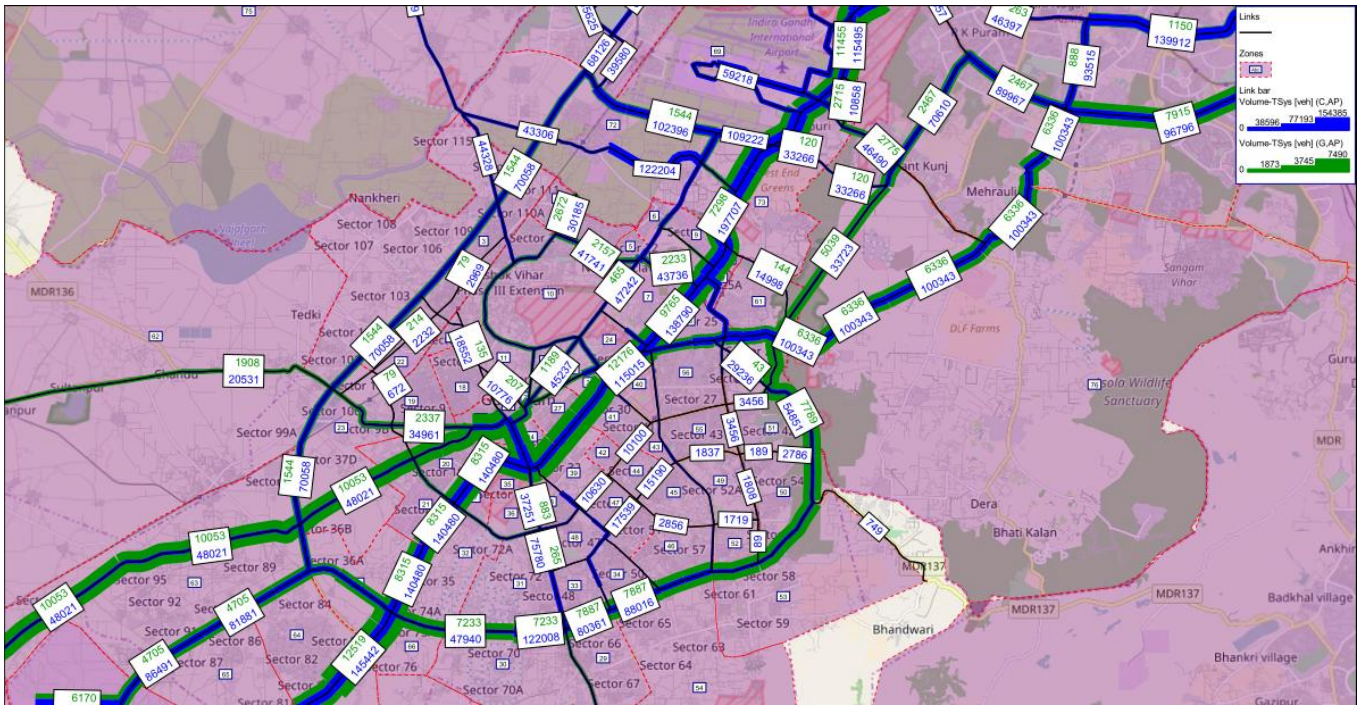


Figure 5-12: Projected Traffic Assignment, 2025

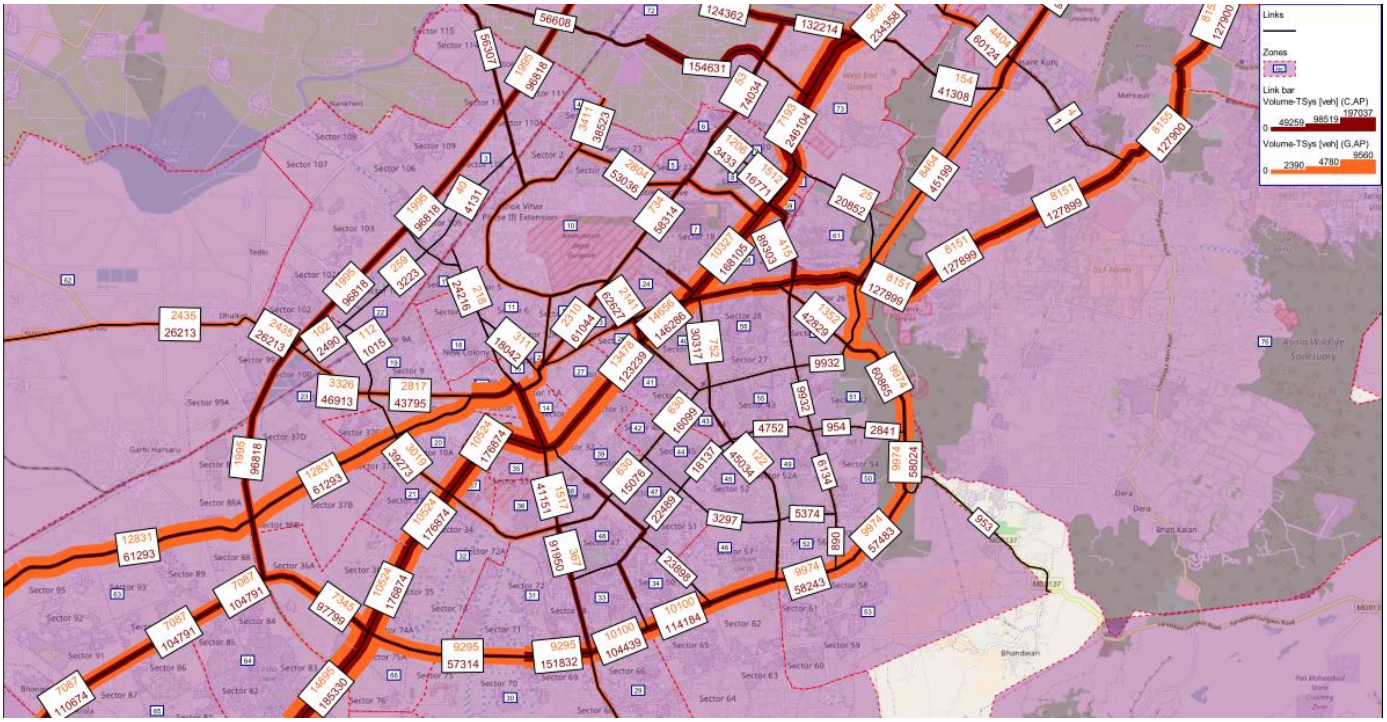


Figure 5-13: Projected Traffic Assignment, 2030

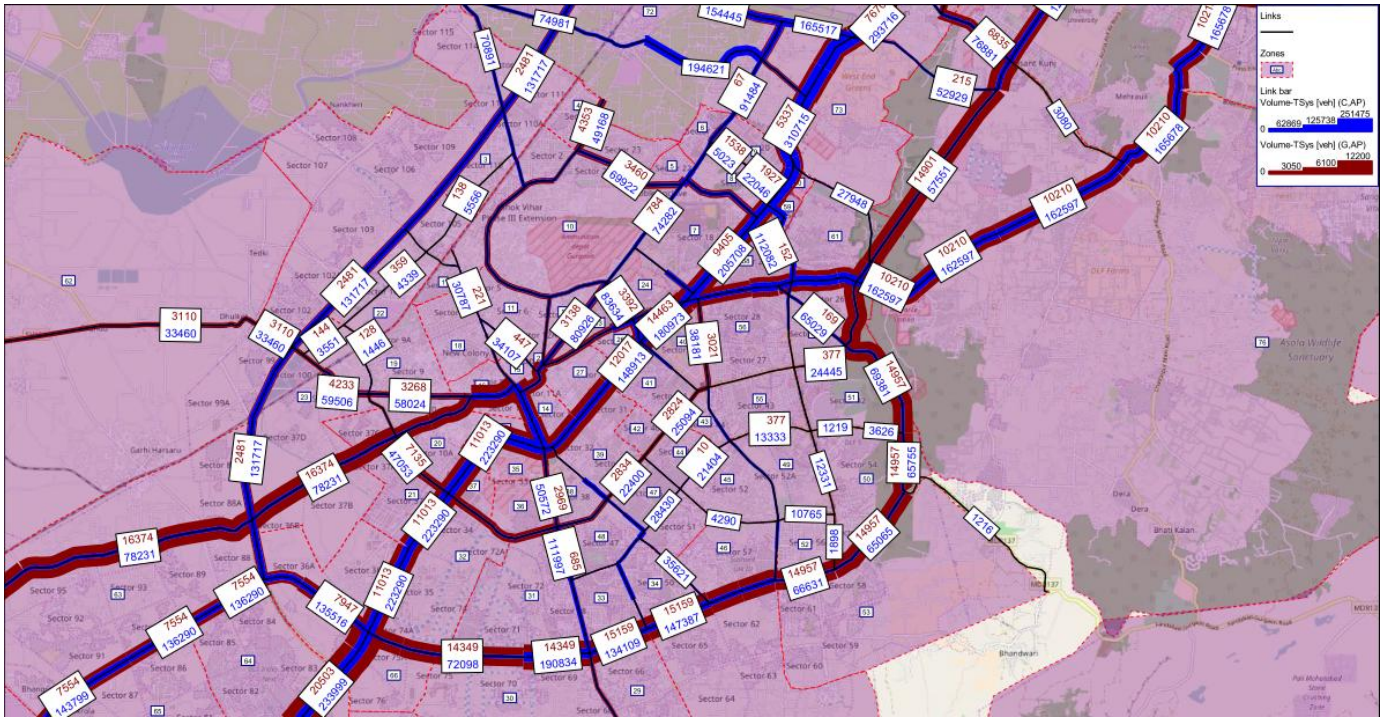


Figure 5-14: Projected Traffic Assignment, 2035

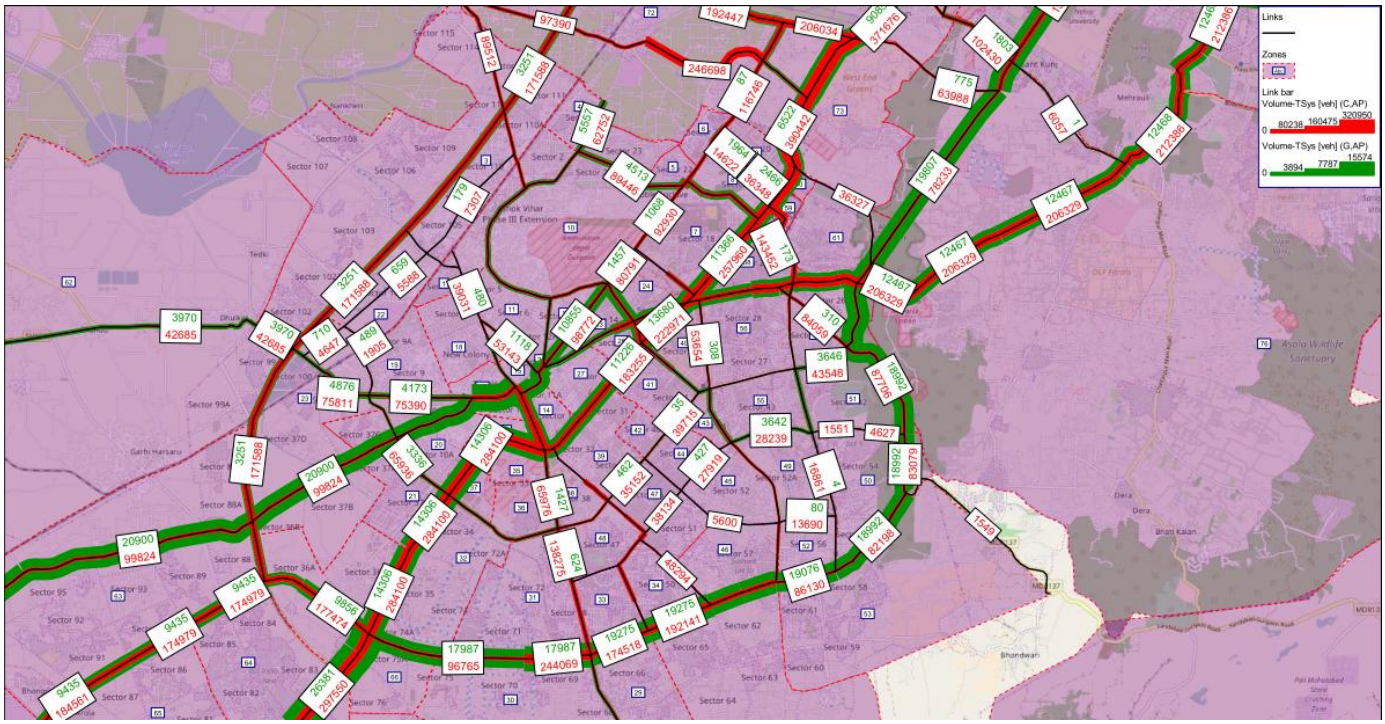


Figure 5-15: Projected Traffic Assignment, 2040

CHAPTER 6 DESIGN STANDARDS

6.1 GENERAL

The formulation of the design standards is required in order to avoid any inconsistency in design from one section to the other and provide desired level of service and safety.

As the name suggests, Dwarka Expressway qualifies for the design standards of IRC SP 99 Expressway Design Manual. However, the present alignment of Dwarka Expressway and section which has been already constructed does not comply with the expressway design norms including spacing between the interchanges, turning radius, etc. in case the expressway design are followed, the RoW requirement will increase and additional land would be required beyond the allocated RoW. Therefore, it was decided to follow the Manual of Specifications and Standards for Six Laning of National Highways through Public Private Partnership (IRC SP: 87-2013) for the purpose of design standards for Dwarka Expressway.

6.2 GEOMETRIC DESIGN STANDARDS

Ministry of Shipping, Road Transport & Highways, Government of India prepared "Manual of Specifications and Standards for Six Laning of National Highways through Public Private Partnership" (IRC:SP:87-2013) shall be used as main guidelines along with other relevant IRC codes. For parameters where there are no IRC standards, recommendations have been made on the basis of MOSRT&H circulars and International Standards.

6.3 CONCEPTUALIZATION OF PARTIALLY ACCESS CONTROLLED SIX LANES

The proposed scheme presents the six lanes in such a way that through traffic is completely segregated from local traffic. Local traffic from one destination to another is supposed to travel only on service road and all the junctions of cross road are proposed with service roads to avoid the traffic hazards on the high speed main highway corridor. Grade separators and vehicular underpasses are provided for roads carrying appreciable traffic. Direct access to main road will generally be closed and connected to service road with proper left-in left-out.

6.3.1 Horizontal Alignment

Horizontal geometry of the road is not proposed to be disturbed in the project highway as it is one of the TOR requirements and in general the horizontal geometry correspond well with the IRC standards.

- Design Speed

The design speeds as per Manual are adopted and shown in the following Table 6-1

Table 6-1: Design Speed

Terrain	Design Speed (Kmph)	
	Ruling	Minimum
Plain and Rolling	100	80
Mountainous and Steep	60	40

Service road is designed for minimum speed of 40 Kmph

- Super-elevation

  Super-elevation provided on the horizontal curves is calculated from the following formula:

  $$e = \frac{V^2}{225R}$$

  Where,

  e = super elevation in metre per metre

  V = Speed in Kmph and

  R = Radius in meter

  Super elevation shall be limited to 7% if radius of curve is less than desirable minimum radius. It shall be limited to 5% if radius is more than desirable minimum.

- Minimum Radius on Horizontal Curves

  The minimum radius of horizontal curves is calculated from the following formula:

  $$R = \frac{V^2}{127 \times (e + f)}$$

  Where,

  V = vehicle speed in Kmph

  e = Super elevation in meter per meter

  f = coefficient of friction between vehicle tyre and pavement (taken as 0.15)

  R = radius in meter

  Based on this equation and the maximum permissible value of super-elevation of 5% and 7%, minimum radii for horizontal curves for various classes of terrain will be as per Table 6-2 given below:

Table 6-2: Minimum Radii for Horizontal Curves

Nature of Terrain	Desirable Minimum	Absolute Minimum
Plain and Rolling	400 m	250 m
Mountainous and Steep	150 m	75 m

Curves without Super Elevation

When the value of super elevation obtained from the parameters stated above is less than the road camber, the normal cambered sections are continued on the curve portion, without providing any super elevation. Since the project area is under low rainfall area, low camber has been provided during construction and camber of existing carriageway is found 2.5%. Radius requiring no super-elevation has been recommended considering camber 2.5%.

Table 6-3 given below indicates the radius of horizontal curves for different rates of camber beyond which super elevation will not be required.

Table 6-3: Radii beyond which Super Elevation is not required

Design Speed (Kmph)	Radius (m)
100	1800
80	1100
65	750

- Transition Curves

Transition curves are necessary for vehicle to progress smoothly from a straight section into a circular curve or between curves of different radius. The transition curve also facilitates a gradual application of the super elevation and any widening of the carriageway that may be required for the horizontal curves.

The minimum length of the transition curve is determined from the following two considerations:

(a) As per Comfort criteria,

$$L_s = \frac{0.0215 \times V^3}{C \times R}$$

Where,

L_s = length of transition in meter

V = Speed in kmph

R = radius of circular curve in meter

C = 80 / (75 + V) (subject to maximum of 0.8 and minimum of 0.5)

(b) As per rate of change of Super-elevation,

The rate of change of super elevation will not be steeper than 1 in 150. The formula for minimum length of transitions depending on the terrain (plain/Rolling) is:

$$L_s = \frac{2.7V^2}{R}$$

Transition curves shall not be required if the radius of horizontal curves is greater than the values indicated in Table 6-4 below:

Table 6-4: Curve Radius (m) Not Requiring Transition

Design Speed (Kmph)	100	80	65
Radius(m)	2000	1200	800

The Minimum Transition Lengths for the speed of 65, 80 and 100 kmph for different radii are given in Table 6-5 below:

Table 6-5: Minimum Transition Length for Different Radii

Radius(m)	Design Speed (Kmph)		
	100	80	65
155	-	-	80
170	-	-	70
230	-	90	-
255	-	85	-
360	130	-	-
395	115	-	-

- Grade Compensation

  At horizontal curves, the gradients should be eased by an amount known as grade compensation which is intended to offset the extra tractive effort involved at curves. This is calculated with the following formula:

$$\text{Grade Compensation (\%)} = \frac{(30 + R)}{R}$$

$$= \frac{75}{R}$$

  Subject to a maximum of above two

  Where R = Radius of the curve in meters

  For grades flatter than 4 percent, no grade compensation is necessary.

- Sight Distance

  The safe stopping sight distance and desirable minimum sight distance for divided carriageway for various design speed are given in Table 6-6.

Table 6-6: Stopping Sight Distance

Design Speed (Kmph)	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m)
100	180	360
80	130	260
60	90	180
40	45	90

The desirable values of sight distance shall be adopted unless there are site constraints. As a minimum safe stopping sight distance shall be available throughout.

6.3.2 Speed Changing Lanes

Acceleration lanes

Acceleration lanes are provided so that slow moving traffic on service road can join the nearside lane of the main CW at approximately the same speed as that of nearside lane of road. Recommended lengths of the acceleration lane can be referred to table 4.8 of IRC SP 41 – 1994, Guidelines for the design of At – grade intersection in rural and urban areas. Table 6-7 shows the length of acceleration lanes depending on the speed of service lane and Inner side lane of main highway.

Table 6-7: Acceleration Lanes

Highway		Acceleration Length (m) for entrance curve design speed (kmph)								
		Stop condition	25	30	40	50	60	65	75	80
Design Speed (kmph)	Speed Reached (kmph)	And initial speed (kmph)								
		0	20	30	35	40	50	60	65	70
80	60	230	210	190	180	150	100	50	-	-
100	75	360	340	330	300	280	240	160	120	50

As per "Standard Drawings for Intersections" (Drawing no. 6) published by MOSRTH the acceleration lane length of 330m (including taper) and 40m nose length is recommended for safe operation of acceleration lane.

Deceleration lane

Deceleration lanes are provided so that fast moving traffic on main road should be able to exit to service road. Recommended lengths of the deceleration lane can be referred to table 4.9 of IRC SP 41-1994, Guidelines for the design of At-grade intersection in rural and urban areas. Table 6-8 shows the length of deceleration lanes.

Table 6-8: Deceleration Lanes

Highway		Deceleration Length (m) for design speed of exit (kmph)								
		Stop condition	25	30	40	50	60	65	75	80
Design Speed (kmph)	Average Running Speed (kmph)	For Average Running Speed of Exit Curve (kmph)								
		0	20	30	35	40	50	60	65	70
80	70	130	120	120	110	100	90	70	50	-
100	85	160	150	150	140	130	125	100	90	70

As per "Standard Drawings for Intersections" (Drawing no. 6) published by MOSRTH the deceleration lane length of 150m (including taper) and 40m nose length is recommended for safe operation of deceleration lane.

6.3.3 Vertical Alignment

- Gradients

The following gradients shall be adopted in Plain / Rolling Terrain:

- Ruling gradient at approaches to structures : 2.5 per cent (1 in 40)
- Limiting gradient at approaches to structures : 3.3 per cent (1 in 30)

The "Limiting Gradient" shall be adopted in difficult situations and for short lengths.

Vertical Curves

Parabolic curves shall be introduced to ensure a smooth transition at all changes of grade. Vertical curves are provided at all grade changes exceeding those indicated in Table 6-9.

Table 6-9: Minimum Lengths of Vertical Curves

Design Speed (kmph)	Maximum Grade Changes (per cent) Not Requiring a Vertical Curve	Minimum Length of Vertical Curve (m)
100	0.5	60
80	0.6	50
65	0.8	40

A. Summit Curves

Summit curves are designed for safe stopping sight distance.

For safe stopping sight distance the length of summit curve shall be calculated from the following formula:

When the length of curve (L) exceeds the required sight distance (S)

i.e. L > S

$$L = \frac{NS^2}{4.4}$$

Where N = Deviation angle

L = Length of parabolic vertical curve

S = Sight distance in meters.

When the length of curve (L) is less than the required sight distance (S)

i.e. L < S

$$L = 2S - \frac{4.4}{N}$$

B. Valley Curves

Valley curves are designed for head light sight distance. The length of valley curves shall be calculated by the following two criteria:

When the length of curve (L) exceeds the required sight distance (S)

i.e. L > S

$$L = \frac{NS^2}{(1.5 + 0.035S)}$$

When the length of curve (L) is less than the required sight distance (S) i.e. L < S

$$L = 2S - \frac{(1.5 + 0.035S)}{N}$$

6.3.4 Vertical Clearance

The vertical clearances as per the IRC:SP 87 – 2013, Manual of Specifications and Standards for six laning shall be adopted, as applicable:

- Vertical clearance at Grade separator and Interchanges locations

  1.) Vehicular Underpass / Flyovers 5.5m

  2.) For Cattle / Pedestrian Underpass 3.0m

  3.) For cattle / Pedestrian underpass 3.5m

  (Accompanied by light vehicles)

- Vertical clearance for power/ telecommunication lines

  Lines carrying low voltage up to 110V 5.5m minimum

  Electric power lines up to 650V 6.0m minimum

  Electric power lines > 650V 6.5m minimum

6.3.5 Cross Section Elements

Description	Width
Proposed carriageway	14.0 m
Median side paved strip	0.5 m
Proposed paved shoulder	1.5 m
Proposed earthen shoulder / Separator between main line and service road	2.0 m
Cross camber on Proposed carriageway	2.5%
Cross camber on Proposed paved shoulder	2.5%
Cross camber on Proposed Earthen shoulder	3.0%
Proposed Median width	As per existing
Proposed service road width	7.0m

6.4 TRAFFIC SAFETY FEATURES, ROAD FURNITURE, ROAD MARKINGS AND OTHER FACILITIES

For safety and operational reasons it will be necessary to provide suitable safety features, road furniture and other facilities along the project highway. These features will include safety barriers, road signs, road markings, road lighting, route markers, kilometer and hectometer stones, road delineators, ROW pillars, parking areas & rest areas, bus stops/bays, and landscaping. Where possible these features will be provided in accordance with relevant IRC or other standard, as detailed below. If no IRC Codes or the MOSRTH Specifications are available, international standards such as BIS / AASHTO / ASTM / British Standards should be used in detail design.

- Safety Barriers - The Safety Barrier shall conform to NHAI/MOSRTH Circulars/manual. Safety barriers shall be located at sharp horizontal curves, high embankments and at bridge approaches and in narrow median.
- Road Signs - The color, configuration, size and location of road signs shall be in accordance with IRC: 67-2012.
- Road Markings – Road markings shall be as per IRC: 35-1997. These markings shall be applied to road centre lines, edge line, continuity line, stop lines, give-way lines, diagonal/chevron markings, zebra crossing and at parking areas by means of an approved self-propelled machine which has a satisfactory cut-off value capable of applying broken lines automatically. The approach noses of the traffic islands will be marked for additional guidance of traffic by means of diagonal markings and chevrons.
- Road Lighting – is proposed to be provided at
    - Toll Plaza area
    - Rest Area
    - Truck Lay byes
    - Bus Bays
    - Grade Separated structures, flyovers, Underpass
    - Built-up sections
- Route Markers - The design and location of route marker signs shall be as per IRC: 2-1968.
- Overhead Signs - Standards prescribed by MOSRTH and IRC: 67 shall be followed for overhead signs.
- Kilometre/Hectometer Stones/Posts - The design and placement of Highway kilometre stones, their dimensions, size, colour and arrangement of letters shall be as per IRC: 8-1980. For the 200-metre stones, IRC: 26-1967 shall be applied. These stones are to be made of precast M-15 grade reinforced cement concrete and lettering / numbering as per the respective IRC codes.
- Road Delineators - The design and location for road delineators shall be as per IRC: 79-1981.
- ROW Pillars - Should any land be acquired for the project then new ROW pillars

at 200 m interval on each side -will be established in accordance with IRC: 25-1967.

- Parking Areas and Rest Areas - For parking in urban and semi-urban areas, IRC:SP:12-1988 will be followed. Local authorities will be consulted before making final decisions. NHAI has prepared standard drawings and details of rest areas. Rest areas shall be provided at every 50 kms interval.
- Highway Landscaping - IRC: SP: 21-1979 "Manual on Landscaping" shall guide the plantation of rows of trees with staggered pitch on either side of the road. The choice of the trees shall also be made as per the same code. Local, indigenous species that grow in the project area microclimate shall be planted. Indicative arrangements for plantation of trees shall be in accordance with the MOSRTH requirements. A spacing of 10-15m c/c is recommended for spacing of trees parallel to the roads. Setback distance of trees needed in different situations shall be as per the IRC: SP: 21-1979 and the IRC: 66-1976.

Service Road

Provision of service roads is considered as of utmost requirement and 7.0m wide service road is proposed on either side of the project highway. Service road is discontinued at the location of Major Bridges and ROBs.

Bus Stops

The layout, design and location of the bus stops in rural areas shall be as per IRC: 80-1981. In urban/semi-urban areas the recommendations given in IRC: 70-1977 will be considered, taking into account land availability. The bus stop layout shall provide safe entry and exit of buses from the service road and safe movement of passengers.

Bus stops with passenger shelter are proposed at suitable selected locations.

Truck Parking Areas

The proposed layout of truck lay bye is generally based on the recommendations of "Planning Norms and Guidelines on Wayside and Terminal Facilities" (MoSRT&H sponsored study). The truck lay bye is proposed at the location of Rest area/truck parking area.

Capacity Standards

Capacity analysis is a fundamental aspect of planning, design and operation of roads, and provides, among other things, the basis for determining the carriageway width to be provided with respect to the volume and composition of traffic.

Capacity and design service volumes for various lane configurations specified by IRC-64-1990 "Capacity of Roads in Rural areas " and as required in the Manual for Six laning has been adopted for determining the Level of Service offered by the road sections during design period. Level of service 'B' is proposed to design the capacity of the project highway.

Pavement Design

The new pavement has been designed for 10 years and overlay on existing pavement for 10 years as discussed with the NHAI officials.

6.4.1 New flexible pavement

New flexible pavement shall be designed as per IRC: 37-2001.

Depending upon the available CBR and Cumulative Million Standard axles on the road, new flexible pavement may comprise of Bituminous Concrete (BC) wearing course over laid on Dense Bituminous Macadam (DBM). Underneath the DBM, Wet Mix Macadam (WMM) shall be provided to act as a base course. To ensure internal drainage of the pavement, the GSB layer shall be provided under WMM course and shall be extended to full width across the shoulder on the embankment.

6.4.2 New Rigid Pavement

Rigid pavement shall be designed as per IRC:58-2011.

Roadside Drainage

An effective drainage system shall be planned for the drainage of roadway as per stipulations or IRC SP: 42-1994 and IRC SP: 50-1999 for maintaining structural soundness and functionality of the project highway. The following types of drains shall be provided for surface drainage of roadway and ROW:

- Longitudinal katcha drains in rural areas with outfalls at cross-drainage structure in rural sections. The drain size shape and material shall be adequate to take design run off and prevent soil erosion and stagnation of water.
- Covered RCC drains at the outer edge of service road in urban area.
- Combination of longitudinal drains and chute drains in high embankments of 3m and above.
- Providing catch pits (wherever required) with provision of outflow at suitable location through buried hume pipes.
- Part of drain water needs to be allowed to percolate or be lost by evaporation. Thus alongside drains, natural depressions and waterways and artificial ponds are recommended to drain out the water in rural stretches.

6.5 TRAFFIC SAFETY FEATURES

Safety Barriers

W-metal beam barriers shall be considered on the outer edges of roadway and where the embankment height is 3 m and above. This shall also be provided at the sharper radius curves i.e. < 395 m. Thrie beam metal barrier at depressed medians. W-metal beam barriers in medians with width <=2.5m. These shall be provided with reflective strips for guidance during night time. The crash barrier shall be design as per AASHTO guidelines or by following the Manufacturer's catalogue.

6.5.1 Traffic Control Devices

Thermoplastic road marking standards and retro-reflective road signs standards shall be as per IRC: 35-1997 and IRC: 67-2012 respectively. Overhead signs shall be provided at important locations. Other traffic control measures such as channelizing islands etc will be considered to be provided at locations wherever required for efficient and safe flow of traffic.

6.5.2 Side Slopes

Side slope shall not be steeper than 2H:1V unless soil is retained by suitable soil retaining structure.

Slope shall be designed for embankment height greater than 6.0m using MOSRT & H software for high embankment design as per IRC: 75.

However, where costs of construction and land forbid the use of such liberal slopes, the slope will be generally kept as 1V: 2H. This slope is considered adequate from stability point of view.

6.5.3 Slope Protection

Slopes on embankment height less than 3m shall be turfed and those above this height shall be protected with stone pitching or as required by Manual.

6.6 SPECIFICATIONS

The General Technical Specifications shall be as per MOSRT&H Specifications for Road and Bridge works - 2004 (Fifth revision) issued by the Ministry of Road Transport and Highways, Govt. of India and published by the Indian Roads Congress along with its updating/amendments/addendum issued from time to time.

6.7 GRADE SEPARATORS AND CROSS DRAINAGE STRUCTURES

6.7.1 Grade separators

In order to avoid incidence of major reconstruction work in the future which may result in traffic disturbances, the underpasses that carry pedestrian walkways, cart tracks, village, district and other roads, State and National highways, cross drainage, combined cross drainage cum road has been designed taking into account of the future long term developments in the vicinity of the Project Road. Design has been carried out as per MORTH circulars and Relevant IRC codes.

6.7.2 Drainage structures

Drainage structures basically comprise of Major Bridges, Minor Bridges and Culverts. The standards / specifications for classifying these are given as:

Major Bridge

Bridges having an overall length more than 60 m.

Minor Bridge

Bridges having length varying between 6 to 60 meters are termed as minor bridges.

6.8 INTERSECTIONS AND INTERCHANGES

At grade intersections adversely influence the quality of highways in terms of speed, capacity and safety because of interruptions to the flow of traffic. Thus the basic requirement for the design of intersections is not only to cater for safe movements for the drivers, but also to provide them full traffic information by way of signs and pavement markings. Further, simplicity and uniformity should be the guiding principles for intersection design to ensure the safe passage of manoeuvres and reduce conflict points, either by elimination of certain manoeuvres or separated in space, horizontally or vertically or time.

6.8.1 At Grade Intersections

At-grade intersection has been designed according to IRC Special Publication 41 'Guidelines for the Design of At-grade Intersections in Rural and Urban Areas' and the MORTH Type Designs for Intersections on National Highways. For the design of elements not covered in the said publications the AASHTO's Green Book on Geometric Design has been followed.

6.8.2 Grade Separated Intersections

IRC: 92 – 1985 gives guidelines for the design of interchanges and has been followed. However an interchange is a highly developed feature and may require the use of other international standards such as these given in the AASHTO's publication 'A Policy on Geometric Design of Highways and Streets'.

Highway Landscaping

IRC: SP: 21 "Manual on Landscaping" shall guide the plantation of rows of trees with staggered pitch on either side of the road. The choice of the trees shall also be made as per the same code. Local, indigenous species that grow in the project area microclimate has been planted. Indicative arrangements for plantation of trees have been in accordance with the MORTH Technical Circular No. NHI-41 (34)/69 dated. A spacing of 10-15m c/c is recommended for spacing of trees parallel to the roads. Setback distance of trees needed in different situations has been as per the IRC: SP: 21and the IRC: 66.

Shrubs in medians shall not normally exceed 1-1.5m in height and has been as per IRC: SP: 21. To ensure survival from herbivorous animals, shrubs/plants containing latex are recommended.

Construction of Cement Concrete (CC) (M-20) footpaths for pedestrians has been as per MORTH Specifications.

Road Furniture

Road furniture such as Traffic signs, Kilometer posts, Hectometer stones, and ROW pillar etc on the Project Highway provided as per IRC Codes shall meet requirements of MORTH Specifications. Where any item is not covered by it, then its specification

shall conform to BIS /AASHTO / ASTM /British Standards in that order of precedence.

Bus Stops and Bus Bays

The layout, design and location of the bus stops has been as per IRC: 80. The bus stop layout shall provide safe entry and exit of buses from the project corridor and safe movement of passengers. The shelter structure has been structurally safe and functional so as to protect the waiting passengers adequately from sun, rain and wind. The covered structure has been of steel pipes and with fibreglass roof. The seating and plinth of the structure has been of coursed stone masonry.

Design Methodology and Design Standard for Structures

The detailed inventory and condition survey of the existing structure has been conducted. Based on detailed survey the proposal for structural arrangement has been finalised. The tentative cost along with the proposal is being submitted to client for their review and approval.

The detailed methodology and standards to be adopted for detailed design are illustrated below:

Materials

Concrete Grade

Grade of concrete in various elements shall be kept as follows for moderate conditions of exposure;

- All RCC members - M35 for bridges with PSC spans and other major bridges,
  M35/ M30 for minor bridges, M30 for culverts
- All PCC members - M20 for bridges with PSC spans and major bridges,
  M15 for minor bridges and culverts

Reinforcement Steel

Only Thermo Mechanically Treated (TMT) bars conforming to IS: 1786 shall be used as reinforcing steel.

Exposure Condition

Moderate exposure conditions will be considered while designing various components of all the structures.

Concrete Clear Covers:

For all reinforcement - As per relevant IRC code
For Pre-stress cable - As per relevant IRC code

Pre-stressing System

System (Post tensioning)	19C15 multi-pull strand system of "Freyssinet" or

	"ISMALCCL" or equivalent
Cables (Post tensioning)	19C15 cables with strands of 15.2mm nominal diameter
High Tensile Steel	For both post/pre tensioning
Strands	Nominal 15.2mm dia. 7 ply low relaxation strands conforming to class 2 of IS: 14268-95
Area	150 sq. mm per strand (nominal cross sectional area)
Ultimate load	279.19 KN per strand
Modulus of Elasticity	1.95x105MPa
Sheathing (Post tensioning)	90mm OD Bright metal corrugated flexible sheathing for 19C15 cables respectively
Friction Coefficient (Post tensioning)	0.25/radian
Wobble Coefficient (Post tensioning)	0.0046/m
Anchorage Slip (Post tensioning)	6mm average
Loss of force due to Relaxation	2.5% at 0.7 UTS after 1000 hrs. The final relaxation value for design shall be 3.0 times the 1000 hr. value

Stressing shall be carried out simultaneously from both ends. All the strands of a cable shall be stressed in one go. Provisions for 4% emergency cables will be provided. If they are not utilized during construction, they will be pulled out and cable ducts will be grouted and plugged suitably. Access to the super-structure shall be provided to enable maintenance, inspection and future pre-stressing operations.

Structural Steel

All structural steel, castings and forgings, fasteners (bolts, nuts, washers and rivets), welding consumables and wire ropes and cables shall conform to the provisions of IRC: 24.

Bearings

Mild steel, high tensile steel, cast steel, steel forgings and stainless steel shall conform to the provisions contained in clause 925.1 of IRC: 83 (Part III).

Reinforced elastomeric bearings shall be proposed for short span simply supported superstructures. Elastomeric bearings shall be designed as per IRC: 83 (Part II) and shall conform to Cl.2005 of MORTH's Specifications for Road & Bridge Works (5th Revision).

RCC type solid slab superstructures of bridges shall be proposed to rest directly on pier / abutment caps with a tar paper in between.

Pot fixed/Pot PTFE sliding bearings shall be proposed for long span simply supported superstructures. These bearings shall be designed and supplied by the approved manufacturers. The loads and forces on the bearings shall be calculated to enable the manufacturer to design these bearings and these shall conform to Cl. 2006 of MORTH's Specifications for Road & Bridge Works (5th Revision).

Expansion Joints

The following types of Expansion Joints shall be adopted;

Filler type expansion joints

Filler type expansion joints shall be proposed for minor bridges with solid slab superstructures having span lengths not exceeding 10 metres. These types of joints shall conform to Cl. 2605 of MoRTH's Specifications for Road & Bridge Works (5th Revision).

Single Strip seal expansion joints

Single Strip seal expansion joints shall be proposed for superstructures having movements up to 80mm (± 40mm). The strip seal type expansion joints shall conform to Cl. 2607 of MORTH's Specifications for Road and Bridge works (5th Revision).

Miscellaneous

An asphaltic concrete wearing course shall be proposed over the deck slab. It shall consist of a coat of mastic asphalt 6mm thick with a prime coat over the deck before the wearing course is laid.

Drainage spouts with gratings at the top shall be provided on the bridges to ensure proper drainage of surface water.

An approach slab, 3.5m long and 300mm thick, resting on the bracket taken out from the dirt wall shall be provided on both sides of the bridge resting on the 150mm thick leveling course. The gap between the approach slab and dirt wall shall be filled with bituminous joint filler sealing compound.

Weep holes shall be provided behind abutment and wing wall to avoid building up of hydrostatic pressure behind them. Weep holes shall be provided 150mm, above the low water level or bed level whichever is higher.

MORTH Specifications

The specifications for Road and Bridge Works of Ministry of Road Transport & Highways (5th Revision) published by Indian Road Congress will be used for materials to be used for construction of bridges.

Loads and Load Combinations

Dead Loads

Following unit weights has been assumed in the design as per IRC Codes.

Pre-stressed Concrete - 2.5 t/cu.m

Reinforced Concrete - 2.4 t/cu.m

Plain Cement Concrete - 2.4 t/cu.m

Structural steel - 7.85 t/cu.m

Dry Density of Soil - 2.07 t/cu.m

Saturated Density of Soil - 2.2 t/cu.m

Superimposed Dead Loads

Wearing Coat : 65mm thick asphaltic concrete with total weight of 0.2 t/sq.m (including allowance for overlay)

Crash barriers : From design (i.e. 1.0 t/m per side)

Carriageway Live Load

Preliminary design of all the new cross drainage structures shall be done for the following loading;

Live Load : One/Two lanes/Three lanes of IRC Class A (Whichever produces worst effect) or one lane of IRC Class 70R (wheeled/ tracked) + one lane of Class A.

The impact factor shall be as per IRC: 6 for the relevant load combinations.

Footpath Live Load: The loading shall be taken 400kg/m^2 according to IRC: 6.

Longitudinal Forces

The following effects shall be considered for calculating the longitudinal forces in the design

- Braking forces as per the provision of Cl. 211 of IRC: 6.
- Frictional resistance offered to the movement of free bearings due to change of temperature.
- Distribution of longitudinal forces due to horizontal deformation of bearings/frictional resistance shall be carried out as per Cl. 211.5 of IRC: 6 by assuming stiff supports.

Centrifugal Forces

Bridges on a horizontal curve shall be designed for centrifugal forces based on the following equation;

C = W*V^2/127R,

Where, C = Centrifugal force acting normal to the traffic

W = Carriageway live load

V = Design speed of the vehicles using the bridge in Km per hour

R = Radius of curvature in meters

The centrifugal force shall be considered to act at 1.2m above the formation level of the bridge in the transverse direction. No impact value on carriageway live load shall be considered for calculating the centrifugal force.

Water Current Forces

The effect of water current forces shall be calculated in accordance with clause number 210 of IRC: 6 on sub-structure and foundations.

Earth Pressure

Horizontal forces due to earth pressure shall be calculated as per the provision of Cl. 214 of IRC: 6-2010 assuming the following soil properties;

Type of soil assumed for backfilling	:	Gamma = 2.0 t/cu. m
Angle of Internal Friction	:	$\phi = 30°$
Angle of Wall Friction	:	$\delta = 20°$

Coefficient of Friction `μ' at base: tan (2/3ϕ), where ϕ is the angle of internal friction of substrata immediately under the foundation.

Live load surcharge shall be considered as equivalent to 1.2m height of earth fill in case of abutments and equivalent to 0.6m height of earth fill in case of return/wing walls.

Wind Forces

Structures shall be checked for wind effects as stipulated in the Cl. 209 of the IRC: 6.

Seismic Effect

The project road falls under seismic zone III. Horizontal seismic force shall be calculated using the following formula;

Feq = Ah x (Dead Load + Appropriate Live Load)

Where,

Ah = horizontal seismic coefficient = (Z/2) x (Sa/g)/(R/I)

Z = Zone factor and is equal to 0.10 for seismic zone II

I = Important factor and is taken as 1.2 for important bridges

R = Response reduction factor

Sa/g = Average response acceleration coefficient depending upon fundamental period of vibration T

T = Fundamental period of the bridge in seconds in horizontal vibrations.

Combination shall be taken according to clause 219.4 of IRC: 6.

Temperature Range

The bridge structure/components i.e. bearings and expansion joints, shall be designed for a temperature variation of + 25°C considering extreme climate. The super-structures shall be designed for effects of distribution of temperature across the deck depth as per stipulations of BD 37/88; suitably modified for the surfacing thickness.

Differential Shrinkage Effects

A minimum reinforcement of 0.2% of cross sectional area in the longitudinal direction of the cast-in-situ slab shall be provided to cater for differential shrinkage stresses in superstructures with in-situ slab over pre-cast girders as per Cl. 605.2 of IRC: 22.

Construction Stage Loadings

A uniformly distributed load of 3.6 KN/m^2 of the form area shall be taken into account of construction stage loadings in the design of superstructure elements, wherever applicable, as per Cl. 4.2.2.2.2 of IRC: 87.

Buoyancy

100% buoyancy shall be considered while checking stability of foundations. Pore pressure uplift limited to 15% shall be considered while checking stresses of the substructure elements.

In the design of abutments of river bridges, the effects of buoyancy shall be considered assuming the fill behind abutments has been removed by scour.

Load Combination

All members shall be designed to safely sustain the most critical combination of various loads and forces that can coexist. Various load combinations as relevant with increase in permissible stresses considered in the design shall be as IRC: 6-2010 and Cl. 706 of IRC: 78.

Codes to be adopted for design

Following codes have been used for the preliminary design of the structures

i IRC: 5 - Standard Specifications & Code of Practice for Road bridges, Section I – General Features of Design (Seventh Revision)

ii IRC:6 - Standard Specifications and Code of Practice for Road bridges, Section I – General Features of Design (Fifth Revision)

iii IRC:7 - Recommended Practice for Numbering Bridges and Culverts (First Revision)

iv IRC: 112 –Code of Practise for Concrete Road Bridges

v IRC: 22 - Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Second Revision)

vi IRC: 24 - Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)Third Revision)

vii IRC:45 - Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well

viii IRC: 54 - Lateral and Vertical Clearances at Underpasses for Vehicular Traffic

ix IRC: 78 - Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations & Substructure (Second Revision)

x IRC: 83 (Part I) - Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearing, Part I: Metallic Bearing (First Revision)

xi IRC:83 (Part III) - Standard Specifications and Code of Practice for Road bridges, Section IX – Bearings, Part III: POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings

xii IRC: 87 – Guidelines for theDesign and Erection of False work or Road Bridges.

xiii IRC:89 - Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)

xiv BD 37/88 - (British loading)

xv BS 5400 - Part IX (For design of POT/POT-PTFE Bearings)

xvi IRC: SP: 13 Guidelines for the Design of Small Bridges & Culverts (First Revision)

xvii IRC: SP: 18 - Manual for Highway bridge Maintenance Inspection

xviii IRC: SP: 35 - Guidelines for Inspection and Maintenance of Bridges

xix IRC: SP: 40 - Guidelines on Techniques for strengthening and Rehabilitation of Bridges

xx IRC:SP:47 - Guidelines on Quality Systems for Road Bridges (Plain Reinforced, Pre-stressed and Composite Concrete

xxi IRC: SP: 87 – Manual of Specifications and Standards for 6 laning of highway through Public Private Partnership

CHAPTER 7 ALIGNMENT DESIGN

7.1 BACKGROUND

Considering above design standards, alignment design of Dwarka Expressway has been carried out. The design option considered for alignment design include fully elevated design where the entire expressway alignment remains elevated for majority of length in Haryana state and at grade portion is used for providing access to adjoining land parcels as service road have greater flexibility.

The alignment design has constraint in the starting section in Dwarka for a length of 5 Km between Shiv Murti and railway line due to height issues with Airport Authority of India (AAI).

The chapter briefly describes the alignment design in both the options.

7.2 TAKE OFF LOCATION

For the purpose of design the start chainage has been considered from Km 20 NH 8 near Shiv Murti. The 0.0 Km of the alignment will be Km 21 of NH 8 near Shiv Murti.

7.3 ALIGNMENT DESIGN

Since Dwarka Expressway is proposed within an urban area and is being designed for the purpose of serving some by-passable traffic thereby decongesting NH 8, the alignment design should be such that caters to both local and through traffic needs. Since the Right of Way is limited and further land acquisition is very difficult, Alignment Design explores the possibility of developing the entire expressway elevated with dual 4 lane carriageway and developing the road below for local traffic movement. There will be entry and exit ramps at intermediate locations for accessing the main carriageway. The section briefly explains the alignment design.

7.3.1 Section 1: From Shiv Murti intersection till Rail under Bridge (RuB) before Sector 21, Dwarka (Km 0.000 to Km 5.300) (Part of Package 1)

This is the first section of Dwarka Expressway and includes Urban Extension Road 2 right from Shiv Murti intersection on NH 8 till Sector 23 intersection in Dwarka. The section has 5 major intersections including NH 8, Smalkha, Pushpanjali, Sector 21 and Sector 23. The section of UER 2 is proposed to be extended till Nelson Mandela Marg as Rangpuri Bye-pass. Therefore, a full interchange has been proposed at the start point. The AAI land at the south east corner of airport near the intersection with NH 8 will be required. The space will be used for transition ramps and ramps of interchange with NH 8.

Since AAI has objections to the elevated corridor along the UER 2 adjoining southern boundary of airport, the alignment is proposed underground corridor comprising of twin boxes. Additional land will be required from AAI for developing ramps. The row in this section is approx. 60m. The expressway alignment continues to traverse underground for a length of approximately 5 Km. Refer Figure 7-1.

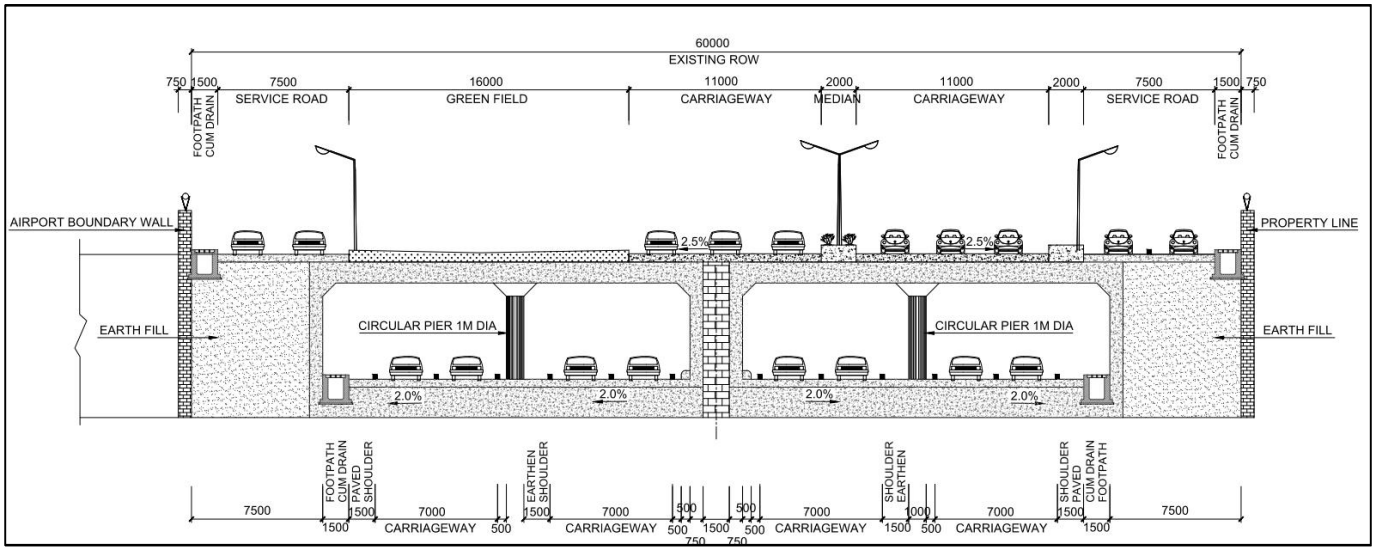


Figure 7-1: Typical Cross Section of Dwarka Expressway Underground Alignment Along Airport

The alignment crosses the railway line at Km 5.000. existing underpass will be used for the main carriageway of expressway. Parallel underpass boxes for local traffic will created in addition to existing underpass. This would require certain land parcels from the south west corner of airport land. Refer

Figure 7-2

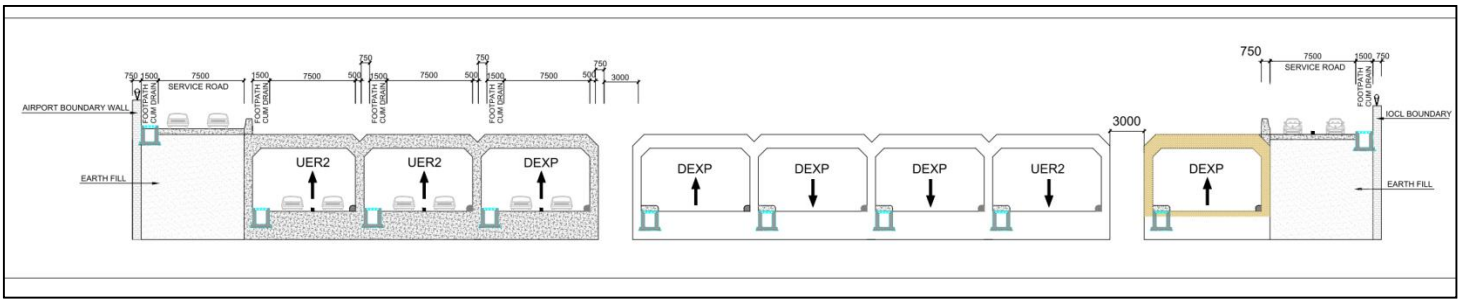


Figure 7-2: Typical Arrangement of Dwarka Expressway below the Railway Line (Km 22.500)

7.3.2 Section 2: Rail Under Bridge to Delhi Haryana Border through Sector 21, 23 and Connectivity to Exhibition cum Convention Centre (ECC) (Km 5.300 to Km 9.500) (Part of Package 2)

This section Dwarka Expressway is part of Contract Package 2 and has further 3 sub-sections. It passes thorugh Dwarka and crosses Bijwasan Najafgarg Road before entering Haryana. The subsections are described below:

7.3.2.1 RuB to Sector 23 Intersection (Bharthal Chowk)

Thi section between railway line and Sector 23 intersection has RoW of 100 m. grade separated interchanges for all the movements are proposed both at Sector 21 intersection and Sector 23 intersection at Chainage Km 5.650 and at Km 6.300. A right turn underpass loop is proposed at Sector 21 and straight elevated road along UER 2 for a length of 1.1 Km is proposed till Sector 24 intersection towards Najafgarh. Some of the components provided for connectivity in this section are described below:

- A right turn underpass for Sector 21
- A double height elevated road is proposed from Sector 23 which will merge with Dwarkak Epxressway for providing connectivity for traffic tarveling between inter-alia Dwarka Gurgaon.
- Similarly a dedicated down ramp is provided on the carriageway from Najafgarh towards Sector 21 for traffic destined from Najafgarh towards Sector 21.
- An up ramp is proposed for traffic turning left from Sector 23 destined towards Shiv Murti.
- Dedicated left ramp along elevated road towards Najafgarh after Sector 23 intersection for ECC entry.
- Dedicated left ramp along elevated road towards Najafgarh for right turning traffic towards Sector 23.

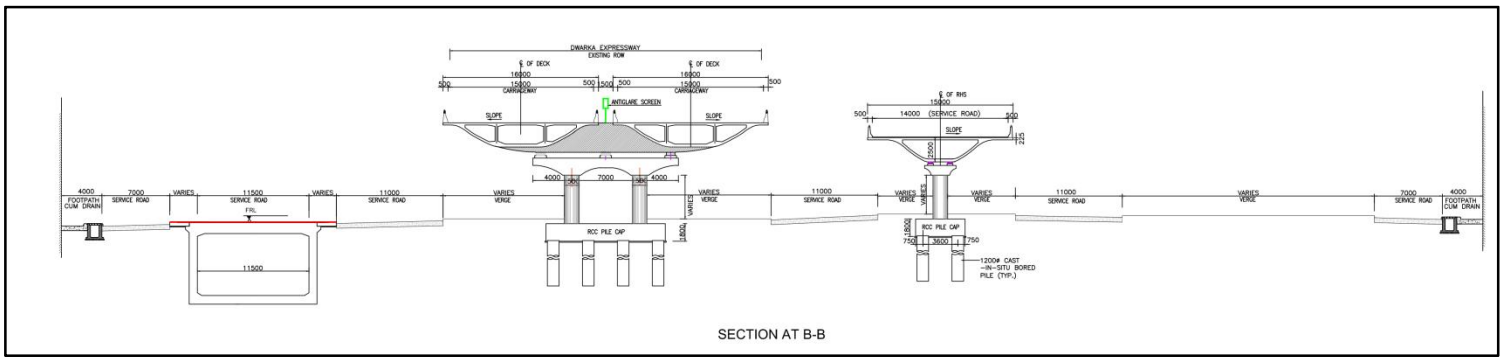


Figure 7-3: Typical Arrangement of Dwarka Expressway near Sector 21 Intersection (Km 5+600)

7.3.2.2 Connectivity to Exhibition cum Convention Centre (ECC)

As discussed in Section 1.4.1 the proposed Exhibition cum Convention Centre in Sector 25 Dwarka is being developed by Ministry of Commerce and Industries as an international convention centre with space for exhibition, arena, retail, offices and hotels. The combined footfall will be 3.14 lakh people. There is a requirement to provide grade separated access to ECC for both entry and exit towards Delhi (Shiv Murti), Airport, Dwarka and Gurgaon. In order to achieve this requirement, the alignment of Dwarka Expressway remains fully elevated in this section till the intersection with Urban Extension Road (UER) 2. Additional grade separated structures including U turn underpasses, right turn underpass and right turn elevated loops are proposed for direct connectivity to and from ECC.

The proposed connectivity is planned in a way that the traffic from ECC does not disturb the traffic movement on main carriageway of Dwarka Expressway.

Apart from connecting ECC, the road towards Najafgarh (UER 2) till its intersection with Sector 24 intersection has also been integrated with Dwarka expressway and entire corridor along this has been proposed as elevated. Salient features of the Proposal are described below:

- Grade separated UER-II has been proposed for both direction at this intersection.

- To access ECC via northern access through elevated UER-II; dedicated ramp exit has been proposed for traffic coming from NH-8/Airport to ECC.
- An at grade rotary has been proposed for the traffic from all directions to access ECC via Northern access; Drop-off zone at northern access can be accessed via this rotary.
- Straight movement from Dwarka towards Gurgaon/Eastern access of ECC from Dwarka has been proposed through underpass below proposed Rotary.
- Straight movement from ECC/Gurgaon towards Dwarka will be carried out through a flyover at level 2 above straight flyover of UER-II at level 1.
- A ramp exit has been proposed from southward turning elevated structure of Dwarka Expressway to access Eastern access of ECC.

The access planning of ECC is described in detail in Table below:

Table 7-1: Proposed Entry and Exit Circulation Scheme for ECC

S.No	Direction (To/From)	Northern Access		Eastern Access		Western Access	
		Entry(To)	Exit(From)	Entry(To)	Exit(From)	Entry(To)	Exit(From)
1.	NH- 8 / Mahipalpur	ECC can be accessed via UER-II. An exit ramp from the proposed elevated section of the corridor will be developed to provide smooth access to the development	A 3 lane grade separated exit has been proposed which will take off from inside the ECC to the elevated carriageway of UER II towards Mahipalpur.	ECC can be accessed by exiting elevated carriageway UER II towards Dwarka Expressway. A 3 lane ramp exit has been proposed for the traffic towards Sector 26 and 25 from Mahipalpur. A U-turn underpass (3lane) before Najafgarh – Bijwasan road junction has been further proposed for this traffic to access the development.	A 3 lane right turn flyover has been proposed which will directly take off from the ECC connecting the elevated carriageway of Dwarka Expressway towards Sector 21/23 and UER II	ECC can be accessed via UER II through exit ramp (3 lanes) located after Northern access of development. This ramp has been developed for the traffic from UER-II/NH8 to access Golf Course road.	A 3 lane U-turn underpass has been proposed at Bamnoli road for the traffic exiting ECC towards UER-II
2.	Gurgaon	Traffic flow from Gurgaon towards Northern Access of ECC will have to take the ramp exit (3 lanes) after Najafgarh-Bijwasan road junction towards Sector 21/23 at	Traffic flow will have to take a U-turn from UER-II – Golf course road junction towards Sector 21/23 at grade rotary to access Dwarka-Gurgaon	Traffic flow from Gurgaon towards Eastern Access of ECC will have to take the ramp exit (3 lanes) after Najafgarh-Bijwasan road junction to approach the	A right turn Underpass has been proposed at the Eastern Access of ECC exclusively for the traffic flow towards Gurgaon.	Traffic flow from Gurgaon towards Western Access of the development will have to take the ramp exit after Najafgarh-Bijwasan road junction	By accessing UER-II via 3lane U-turn underpass proposed at Sector 25 Dividing road. The traffic may then access Dwarka Expressway

S.No	Direction (To/From)	Northern Access		Eastern Access		Western Access	
		Entry(To)	Exit(From)	Entry(To)	Exit(From)	Entry(To)	Exit(From)
		grade rotary.	Expressway.	entry situated at the at grade carriageway of Dwarka expressway.		towards Sector 21/23 at grade rotary. From the rotary traffic flow will have to access Golf course road by following the at grade carriageway of UER-II. Traffic towards western access has also an alternate to use the Dwarka Expressway Bamnoli Road link after exiting the elevated carriageway of Dwarka Expressway.	from the Sector 21/23 at grade rotary.
3.	Dwarka	The traffic can approach Northern access of the development by taking right turn exit from the proposed Sector 21/23 at grade rotary.	Traffic flow will have to take a U-turn from UER-II – Golf course road junction towards Sector 21/23 at grade rotary.	The traffic flow from Dwarka towards Eastern access will have to take the straight underpass (3-lane) towards Gurgaon from Sector 21/23 junction. The traffic will then have to access U-turn underpass towards Eastern Access.	The traffic towards Dwarka via Sector 21/23 Dividing road will have to take the left turn at grade exit from the Northern access towards Sector21/23 junction.	The traffic can approach Western access of the development by taking right turn exit from the proposed Sector 21/23 at grade rotary towards Golf course road.	By accessing UER-II via U-turn underpass (3 lanes) proposed at Golf course road towards Sector 21/23 at grade rotary.
4.	Najafgarh	Traffic will have to take a U-turn from the Sector 21/23 At grade rotary towards Northern access following the at grade carriageway of UER II.	Traffic will have to take left turn at grade exit towards Najafgarh on UER-II	Traffic will have to take a right turn towards Gurgaon from Sector 21/23 at grade rotary. The traffic will then have to take a u turn from Najafgarh-Bijwasan road junction towards Eastern access.	Traffic will have to take the at grade left turn exit from the Eastern Access towards UER-II	Traffic will have to take right turn on to Golf course road towards Bamnoli at UER-II Najafgarh road junction.	By accessing UER-II via U-turn underpass proposed at Golf course road towards Najafgarh.
5.	Golf Course Road	The traffic will have to first access UER-II by taking left turn at Golf course	Traffic will have to take left turn at grade exit on UER-II towards Golf course road	After Accessing UER-II traffic will have to take a right turn towards	Traffic will have to take the left turn at grade exit from the	Traffic will have to continue straight on Golf course road to approach	Traffic will have to U-turn underpass situated towards Bamnoli and

S.No	Direction (To/From)	Northern Access		Eastern Access		Western Access	
		Entry(To)	Exit(From)	Entry(To)	Exit(From)	Entry(To)	Exit(From)
		road – UER II junction. Traffic will then have to take a U-turn from the Sector 21/23 At grade rotary towards Northern access.		Gurgaon from Sector 21/23 at grade rotary. The traffic will then have to take a u turn from Najafgarh-Bijwasan road junction towards Eastern access. Alternatively this traffic can also use southern link between Dwarka Expressway and Sector 25 dividing road.	Eastern Access towards UER-II. From Sector 21/23 junction traffic will have to take a left turn further towards Golf course road.	Western access road.	then continue straight on Golf Course road towards Dwarka.

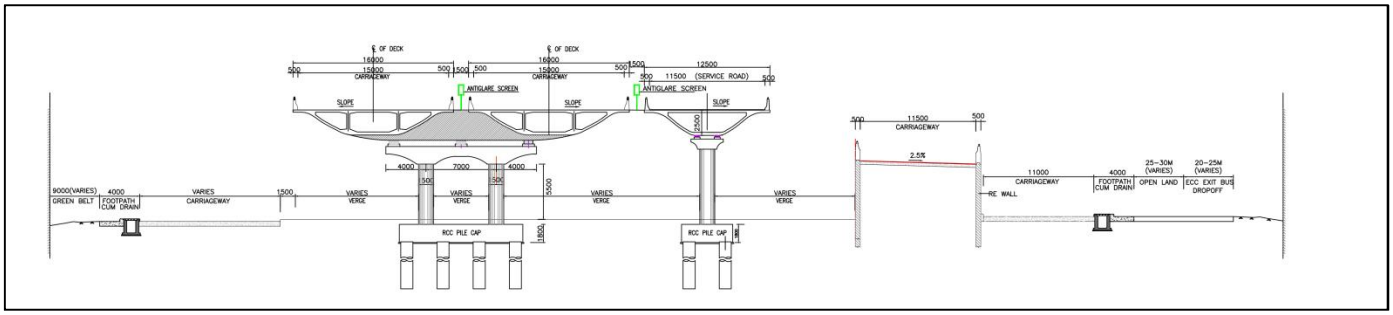


Figure 7-4: Typical Arrangement of Dwarka Expressway east of ECC (Km 6+900)

7.3.2.3 Najafgarh Bijwasan Road to Haryana Border (Km 8.600 to Km 9.500)

After ECC the alignment descends and remains at grade. The intersection with Bijwasan Najafgarh road (UER 1) is at chainage Km 8.650. The Najafgarg Bijwasan Road is proposed to be elevated and expressway crosses at grade. Elevated loops have been proposed for traffic to access the cross road to and from expressway. The section also has a provision toll plaza at chainage Km 9.050. Remaining, section till Haryana border (Km 9.500) remains at grade.

7.3.3 Section 3: Haryana Border to approach of Rail over Bridge (RoB) (Km 9.500 to Km 19.500) (Part of Package 3)

The section passes through Sectors 102, 103, 104, 105, 106, 107, 110, 111, 112 and 113. The major intersections in this section are Sector 104/105 dividing road, sector 105/110 dividing road, Village Bajghera Road towards Najafgarh near Sector 110 A and intersection with Village road at Delhi border.

After entering Haryana Border, the alignment initially remains at grade. Since this section has continuous intersections of Sector roads, it was decided to keep the main carriageway elevated for the entire length of the section having dual carriageway of 4 lanes.

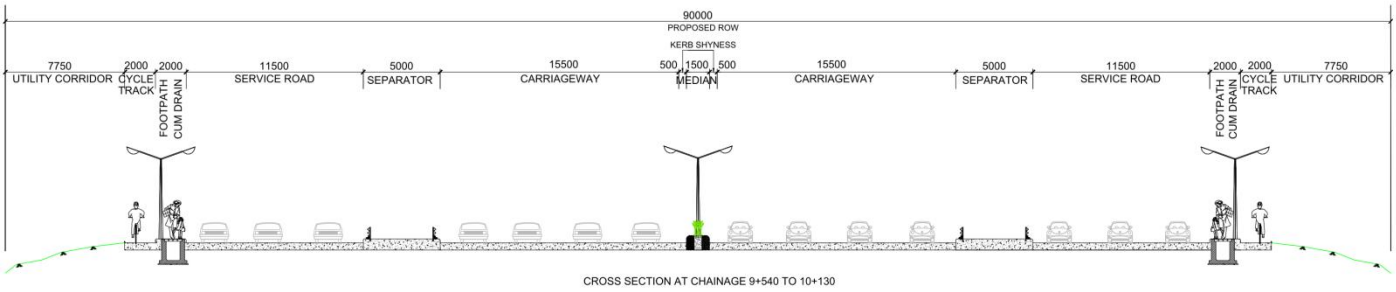


Figure 7-5: Typical at Grade Cross Section (TCS-5) between Km 9.540 and Km 10.2

The elevated main carriageway takes off from Km 10.250 and terminates at Km 19.200.

There are 7 major intersections with existing/ proposed Sector Roads. The service road is proposed to have 3 lanes (11.5 m width).

At all major intersections 2 lane (8 m width) flyovers along with 4 lane underpasses on cross roads have been proposed. The at grade arrangement will only be for facilitating right turns by using rotary.

The section also has the 2 main hindrances in the Dwarka Expressway where land is yet to be acquired these are located between Km 11.500 to Km 11.900 and between Km 12.250 to 12.750, these also include 2 sector roads including sector 106/109 dividing road and sector 109/112 dividing road in this stretch where land acquisition is not complete.

Elevated entry exit is provided in this section at Chainage Km 14.900. Refer Figure 7-6 and Figure 7-10.

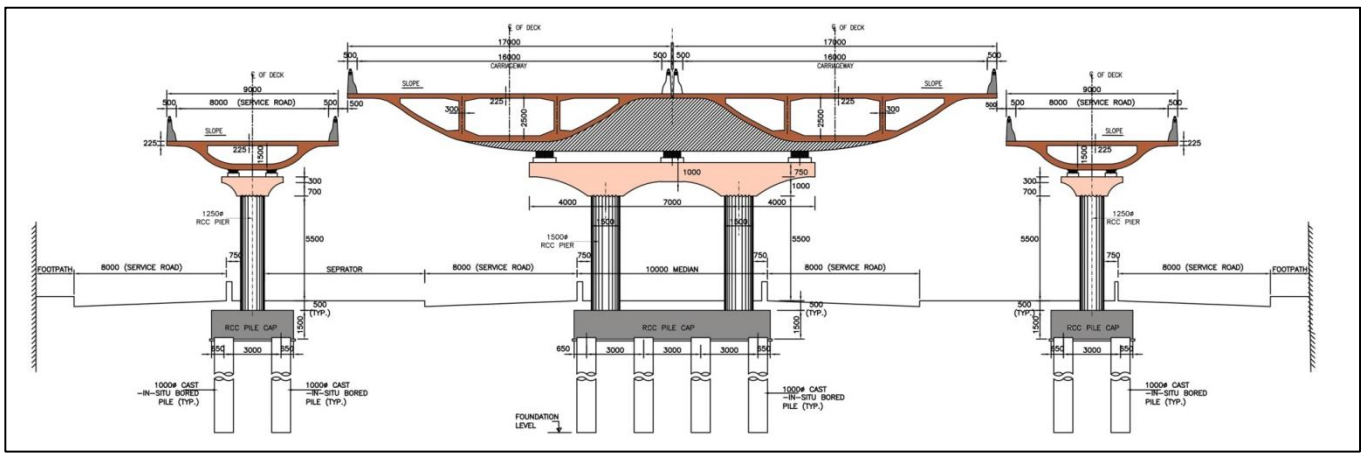


Figure 7-6: Typical Cross Section (TCS-1) of Elevated Portion of Dwarka Expressway

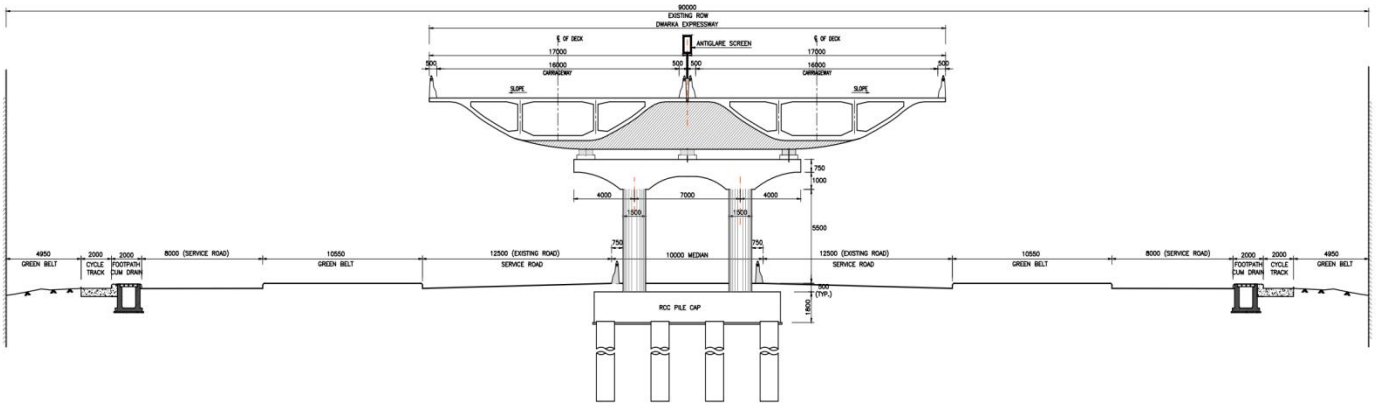


Figure 7-7: Typical Cross Section (TCS – 2) of Elevated Portion with at grade Service Road

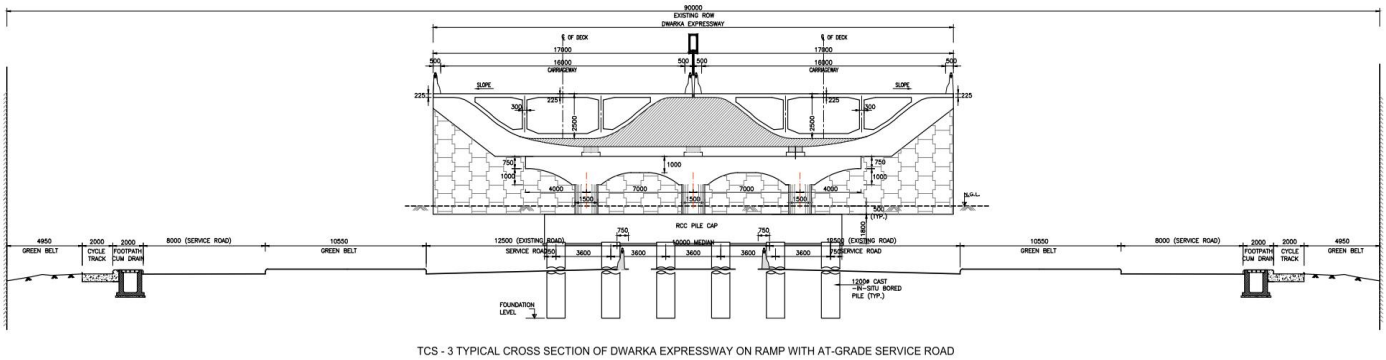


Figure 7-8: Typical Cross Section (TCS – 3) of Elevated Portion on Ramp with at grade Service Road

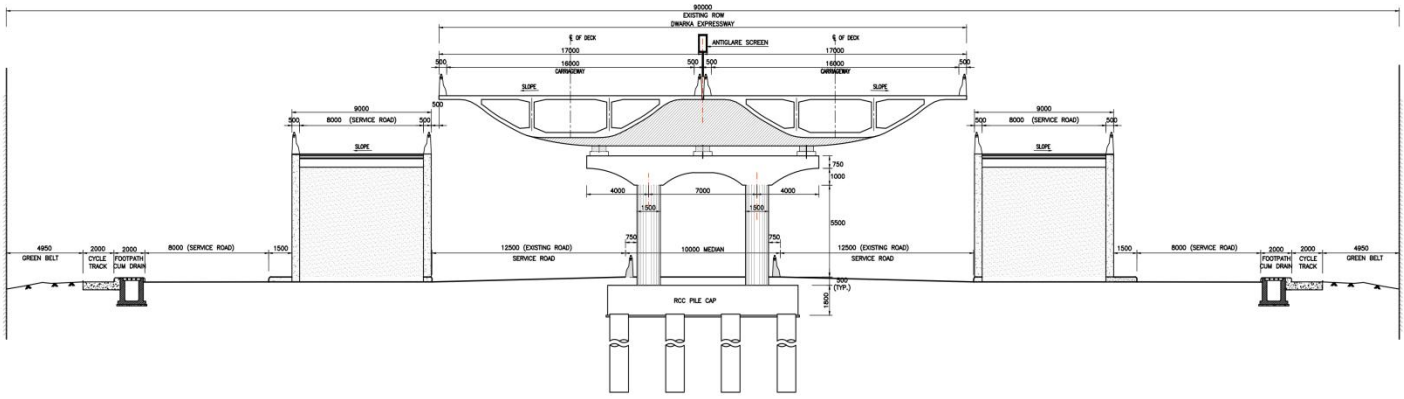


Figure 7-9: Typical Cross Section (TCS – 4) of Elevated Portion with Service Road on Ramp

7.3.4 Section 4: Approach of Rail over Bridge (RoB) till Pataudi Road Intersection (Km 19.500 to Km 23.200) (Part of Package 4)

The Rail over Bridge has been constructed by HUDA and is completed as of now. However, the bridge has a substandard 4 lane carriageway having width of 12.5 m. since the elevated portion of expressway main carriageway terminates at Km 19.800, the 4 lane dual carriageway traverses at grade towards RoB. In order to maintain the continuity of carriageway width, it was decided that for the purpose of augmentation already constructed RoB, 2 additional flyovers/ RoBs having 5 lanes each will be constructed on either side of existing RoB. Out of these 5 lanes on either side, 3 lanes will be for the service road and 2 lanes will be for the main carriageway. Refer **Figure 7-10**

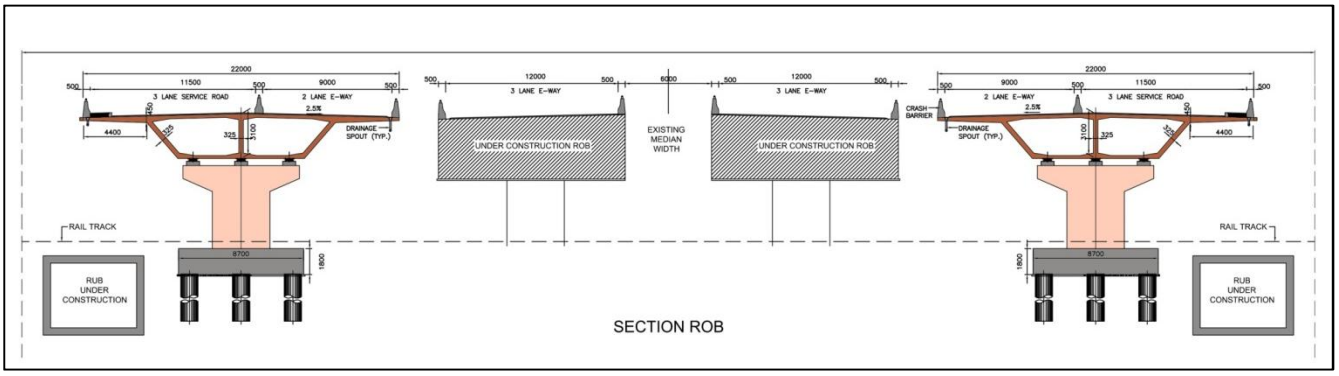


Figure 7-10: Typical Cross Section at RoB (Chainage Km 20.600)

After the RoB the alignment remains at grade till Pataudi Road intersection. The major intersection in this section is with Sector road of Sector 88B. an underpass has been provided for the sector with approaches in the service road of expressway. at Pataudi Road intersection, the main carriageway is elevated whereas an underpass is proposed for the Pataudi Road.

Provision of entry and exit is also provided in this section at chainage Km 22.400

7.3.5 Section 5: Pataudi Road Intersection to Dwarka Expressway – Delhi Jaipur Expressway Intersection (Km 23.200 to Km 24.600) (Part of Package 4)

After crossing Pataudi Road, the alignment continues to traverse elevated. A provision for grade separated crossing for entry in to the proposed Global City has been provided at Km 23.800.

The section also has intersection with proposed Delhi Jaipur Expressway at Km 24.600. The intersection here is having 4 arms but the section of Northern Peripheral Road (NPR) not being connected to NH 8 does not attract much traffic. The road dividing sectors 88 and 84 will also have the proposed Delhi Jaipur expressway alignment of which will be elevated.

The intersection is designed on the concept of trumpet interchange by taking the Dwarka Expressway alignment to double height level which will act as an interchange between Dwarka Expressway and Delhi Jaipur expressway. The alignment of Dwarka expressway turning left from Pataudi Road will be at double

height level. The Dwarka Expressway alignment rises to +2 level and has interchange with Delhi Jaipur Expressway/ CPR at +1 level. The straight portion of CPR has straight flyover towards Sector 88 whereas the service road of Dwarka Expressway has Straight underpass along NPR towards Kherki Daula. Additional land would be required for the trumpet interchange from HSIIDC.

The section from CPR intersection till intersection with NH 8 comprises of green-field alignment and is also known as Connecting Peripheral Road (CPR) as per the Development Plan of GMUC 2031. The RoW in this section is 90m. A grade separated full cloverleaf is proposed at the termination point of expressway at the intersection with NH 8 and SPR. The full cloverleaf will enable the continuity of Dwarka Expressway with SPR completing the western ring of Gurgaon.

The section also has a proposal of 1 trumpet interchange at Km 26.000 for providing connectivity to proposed Global City coming up in Sector 36-B. as described in Section 1.4.2, Global City is an upcoming state of the art smart city being developed by HSIIDC which will once developed will have a combined population potential of 5.4 lakh people. Therefore, for smooth traffic movement, a dedicated trumpet interchange has been proposed.

7.4 PROJECT PACKAGING

The total length of Dwarka Expressway is 27.6 km out of which 21.5 Km is original alignment length which was earlier proposed to terminate at the intersection Urban Extension Road (UER)-II in Dwarka. Out of 21.5 Km, 18.1 Km length falls in Haryana and remaining 3.2 Km in Delhi. Government of Haryana later handed over the construction of Dwarka Expressway to NHAI. Therefore, in order to keep the continuity of connectivity between sections of National Highway, it was decided to include section of UER-II between Dwarka Expressway intersection and Shiv Murti also as part of Dwarka Expressway. The length of section of UER II is 6.3 Km thereby increasing the total length of Dwarka Expressway to 27.6 Km and total length in Delhi to 9.50Km.

The total project has been further subdivided into 4 contract packages as per the meeting held on 1st June 2017 under the Chairmanship of Honourable Minister for Road Transport & Highways. The recommended contract packages and their respective lengths are described below:

S.No	Contract Package	Description	Chainage	Length (Km)
1	Package 1	Shiv Murti to Tail under Bridge (RuB)	Km 0.000 to Km 5.300	5
2	Package 2	Rail under Bridge (RuB) to Delhi Haryana Border	Km 5.300 to Km 9.500	4.2
3	Package 3	Delhi Haryana Border to Rail over Bridge (RoB)	Km 9.500 to Km 19.700	10.2
4	Package 4	Rail Over Bridge (RoB) till End Point Km 40 NH-8-SPR Intersection near Kherki Daula	Km 19.700 to Km 27.6	7.9

The present report being submitted is only for Package 2.

Table 7-2: Detail of Proposed Interchanges and other Major Structures

S. No.	Design Chainage	Type of Intersection	Road leading to		Interchange Type
			LHS	RHS	
1.	0+000	+	Delhi (NH8)	Gurgaon (NH 8)	Full Interchange integrating future extension towards Vasant Kunj
2.	1+600	T	IGI Airport	Kapashera	Expressway is underground
3.	3+350	T	IGI Airport	Pushpanjali Farms	Expressway is underground
4.	3+600	T	IGI Airport	Pushpanjali Farms	Expressway is underground
5.	5+500	T	Sector 21, Dwarka	Sector 26 Dwarka	Expressway is underground with provision of right turning loop from Shiv Murti towards Sector 21
6.	6+300	+	Najafgarh	Dwarka Sector 23	Full Elevated Corridor along eastern boundary of ECC with various underpasses and elevated structures
7.	8+600	+	Najafgarh	Bijwasan	Elevated Expressway, Cross Road through flyover at single height and service road through underpass.
8.	11+100	+	Bajghera, sector 112	Sector 110	Elevated Expressway including service road at single height, Cross Road through underpass.
9.	12+033	T	Sector 109	Sector 110	Sector 109/110 dividing road, yet to be constructed.
10.	13+600	+	Kherki Majra	Gurgaon	Elevated Expressway, service road through flyover at single height and Cross Road through underpass. Sector 106/109 dividing Road

S. No.	Design Chainage	Type of Intersection	Road leading to		Interchange Type
			LHS	RHS	
11.	14+800	+	Sector 105	Sector 103	Elevated Expressway, service road through flyover at single height and Cross Road through underpass. Sector 105/103 dividing Road
12.	16+500	+	Sector 104	Sector 103	Elevated Expressway, service road through flyover at single height and Cross Road through underpass. Sector 103/102-A dividing Road
13.	17+500	+	Sector road 102	Sector road 101	Elevated Expressway, service road through flyover at single height and Cross Road through underpass. Sector 103/102-A dividing Road
14.	18+800	+	Faruknagar (SH 15A)	Gurgaon (SH 15A)	Elevated Expressway, Basai Road through underpass.
15.	20+600	Rail line crossing	Rewari	Delhi	Existing Rail over Bridge along with 5 lanes elevated RoBs on either side for both main carriageway and service road
16.	21+700	T	Sector 37-D	Sector 88-A	Expressway at grade. Underpass provided for Sector 88-A / 88-B dividing Roads
17.	23+200	+	Pataudi (SH 26)	Gurgaon (SH 26)	Elevated Expressway at double height, Pataudi Road through flyover at single height and service road through underpass.
18.	23+800	T	-	Proposed road	Trumpet Interchange
19.	24+700	+	Diverging point of Delhi -	-	Trumpet interchange between Delhi Jaipur Expressway (elevated) and

S. No.	Design Chainage	Type of Intersection	Road leading to		Interchange Type
			LHS	RHS	
			Jaipur Expressway (DJE).		Dwarka Expressway (Elevated)
20.	26+000	T	-	Proposed road	Trumpet Interchange
21.	27+500	+	NH 8 to Delhi (North side)	NH 8 to Jaipur (South side)	Full Cloverleaf

CHAPTER 8 DEVELOPMENT PROPOSALS

8.1 GENERAL

This chapter is intended to give brief descriptions concerning the various improvement proposals from km 5+300 to km 9+500 of proposed Dwarka Expressway.

Improvement proposals for a highway essentially consist of two components, viz. Geometric and Structural. Geometric improvement deals with visible dimensions of roadway and is dictated by the traffic and economic considerations. Geometric design involves several design elements such as horizontal and vertical alignments, sight distance considerations, cross sectional elements, lateral and vertical clearances, intersection treatment, control of access, etc. The structural component deals with the pavement and embankment design aspects, i.e. the ability of the highway to adequately carry and support the vehicle / wheel loads over the design period.

The improvement proposals for the proposed Dwarka Expressway include the provision for the following major items:

- Road Geometrics
- Grade separators
- Pavement
- Road Junctions
- Bridges and Cross-Drainage Structures
- Safety and Special Problems and
- Road Appurtenances

8.2 GEOMETRIC DESIGN PROPOSALS

The proposals for the geometric elements of the proposed Dwarka Expressway include:

- Development of cross-sectional elements
- Alignment Design

8.2.1 Development of Cross-sectional Elements

Proposed Cross Sectional Elements

Lane Width

The width of a basic traffic lane is proposed to be 3.50 m. Thus, for 8-lane Dwarla Expressway the carriageway widths will be 28.0 m. 0.5 m wide edge strip with a composition same as that of the adjacent pavement will be provided as compensation for kerb shyness on the median side.

Paved Shoulders

Due to constraints of RoW availability, paved shoulders are not proposed in this Package..

Median

Median of 1.5 m width is proposed along the main carriageway.

Service Road / Slip Road

Service road has been proposed for the entire project corridor. Service road shall be dual carriageway with width as discussed in the subsequent section.

Footpath

Minimum 1.5m wide footpath-cum-drain has been proposed on both sides of the extreme ROW edges of Dwarka Expressway.

Utility Corridor

Adeqaute space for utilities is being proposed along the project highway .

Crossfall

In case of flexible pavement, the crossfall for the pavement and paved shoulders will be 2.5%. In rigid pavement crossfall of 2.0% has been considered. For earthen shoulders and median the corresponding value will be 3.0%.

Proposed ROW

In general minimum ROW of 100m is available for Dwarka Expressway between Chainage Km 5+300 to Km 7+700, beyond Km 7+700 RoW of 120 m is under process of acquisition. Hence the proposed ROW for Dwarka Expressway (Package 2) is kept as 100m.

8.2.2 Typical Cross Section

Typical Cross Sections are presented in Volume 4 Drwaings.

8.2.3 Alignment Design

The entire geometric design has been based on the ground modelling by highway MX design software. The design of proposed alignment Dwarka Expressway is based on the scheme as discussed in Chapter 7.

Horizontal Alignment

Horizontal alignment has been designed within the available ROW and without compromising with the design standards as adopted and as discussed in Chapter 7: Design Standard. A minimum radius of 400m has been kept along with a good balance between additional land acquisition, structure and highway geometric. The super-elevation and the length of the transition curve have been finalised with maximum super-elevation of 5%.

Vertical Alignment

Vertical Alignment has been designed for minimum criteria of Intermediate Sight Distance (ISD). The existing road profile will be reviewed on the basis of cross-sections taken at regular intervals with the help of Digital Terrain Model (DTM).

8.3 PROPOSAL FOR MAIN CARRIGEWAY

The Project Highway shall follow the alignment as shown in the alignment plans part of Volume IV – Drawing and also specified in Annex III of Schedule-A. Geometric deficiencies, if any, in the proposed horizontal and vertical profiles shall be corrected as per the prescribed standards for plain terrain to the extent land is available.

8.3.1 Width Of Carriageway

The width of the carriageway described below is including the paved shoulder and kerb shyness and excluding the median width.

8.3.1.1 Dwarka Expressway

For Dwarka Expressway and all ramps merging to or exiting from the Expressway under this scope of work, the paved carriageway including shyness shall be as per the table below:

Table 8-1: Details of Main Carriageway for Dwarka Expressway

S. No.	Chainage of Dwarka Expressway		Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To	From	To			
Main Carriageway							
1	5+300	8+915	5+300	6+577	1277	30	14 m wide Main Carriageway and shyness in both directions
2			6+740	8+915	2175	30	14 m wide Main Carriageway and shyness in both directions
3	8+915	9+220	8+915	9+220	305	As per the requirement of Toll Plaza	
4	9+220	9+500	9+220	9+500	280	30	14 m wide Main Carriageway and shyness in both directions
Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka							
1	5+719	5+931	5+730	5+936	206	0 to 11.5m	10.5 m wide main carriageway and

S. No.	Chainage of Dwarka Expressway		Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To	From	To			
							Shyness on both sides
2	5+931	7+347	5+936	7+101	1165	11.5	10.5 m wide main carriageway and 0.5 m wide Shyness on both sides
Ramp from ECC Dwarka merging with Right Carriageway of Dwarka Expressway							
1	7+100	7+354	7+100	7+354	254	0 to 11.0m	10.5 m wide main carriageway and 0.25 m wide Shyness on both sides
2	7+354	7+440	7+354	7+701	347	11.0	10.5 m wide main carriageway and 0.25 m wide Shyness on both sides

8.3.1.2 Link Road To Najafgarh

For the link road coming out of Dwarka Expressway near the Sector 21 Metro Station junction (MSJ) and leading to Najafgarh and all the ramps merging to or exiting from this link road, the paved carriageway shall be as per the table below:

Table 8-2: Details of Main Carriageway for Link Road to Najafgarh along UER 2

Sl. No.	Design Chainage of LME / RME* of Link Road to Najafgarh		Design Chainage of Individual Road / Ramp		Length (m)	Width of Paved Carriageway (m)		Remarks
	From	To	From	To		Left	Right	
Main Carriageway of the Link Road from Dwarka Sector 21 Metro Station Junction (MSJ) to Najafgarh								
1	5+755	8+300	5+755	8+300	2545	11.5		
2	5+316	5+508	5+316	5+508	192	-	11.5	
3	5+508	5+725	5+508	5+725	217	-	Varying from 11.5 to 9.25	
4	5+725	6+180	5+725	6+180	455	-	9.25	7 m wide main carriageway, 2 m wide paved shoulder and 0.25 m wide Shyness on inner side
5	6+180	6+213	6+180	6+213	33	-	Varying from	

Sl. No.	Design Chainage of LME / RME* of Link Road to Najafgarh		Design Chainage of Individual Road / Ramp		Length (m)	Width of Paved Carriageway (m)		Remarks
	From	To	From	To		Left	Right	
							9.25 to 11.5	
6	6+213	8+300	6+213	8+300	2087	-	11.5	
Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ								
1	5+730	5+982	5+730	6+093	363	-	7.5	7 m wide main carriageway and 0.25 m wide Shyness on both sides
2	5+982	6+234	6+093	6+250	157	-	Varying 7.5 to 0	
Ramp from Dwarka Sector 23 towards RUB / Shiv Murty								
1	5+316	5+508	5+316	5+506	190	-	Varying from 0 to 7.5	
2	5+508	6+182	5+506	6+184	678	-	7.5	7 m wide main carriageway and 0.25 m wide Shyness on both sides
Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka								
1	6+302	6+425	6+302	6+425	123	0 to 9.25m	-	
2	6+625	6+921	6+425	6+930	505	9.25	-	
3	6+921	7+065	6+930	7+120	190	Varying from 9.25m to 11.0m	-	
4	7+065	7+100	7+120	7+317	198	11.0	-	
Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ								
1	6+470	6+660	6+594	6+784	190	-	0 to 9.25m	
2	6+660	7+100	6+784	7+330	546	-	9.25	
Ramp from ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ								
1	6+872	7+100	7+106	7+663	557	-	9.25	
Ramp from ECC Bus Drop-off going towards Sector 24								
1	7+150	7+500	7+330	7+629	299	-	9.25	
Ramp from Left Carriageway from Dwarka Sector 21 MSJ to Golf Course Road								
1	7+000	7+650	-	-	650	9.25	-	

**LME – Left Median Edge of Link Road to Najafgarh; RME – Right Median Edge of Link Road to Najafgarh*

8.3.1.3 Link Road To Dwarka Sector 21

For the link road coming out of Dwarka Expressway after the existing Road under Bridge (RUB) and leading to Dwarka Sector 21, the paved carriageway shall be as per the table below:

Table 8-3: Details of Main Carriageway for Link Road to Dwarka Sector 21

Sl. No.	Design Chainage of Dwarka Expressway		Design Chainage of Link Road		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To	From	To			
1	5+300	5+700	5+300	6+150	850	11.5	

8.3.1.4 Link Road from Dwarka Sector 23 to Kherki Daula

For the link road from Dwarka Sector 23 and merging with Dwarka Expressway going towards Kherki Daula, the paved carriageway shall be as per the table below:

Table 8-4: Details of Main Carriageway for Link Road from Dwarka Sector 23

Sl. No.	Design Chainage of Link Road		Length (m)	Width of Paved Carriageway (m)	Remarks
	From	To			
LEFT CARRIAGEWAY					
1	5+466	7+010	1544	11.5	
2	7+010	7+185	175	Varying from 11.5m to 0	
RIGHT CARRIAGEWAY					
1	5+465	6+645	1180	11.5	
2	6+645	6+904	259	Varying from 11.5m to 0	

8.3.1.5 Najafgarh Bijwasan Cross Road

The road connecting Bijwasan and Najafgarh will have combination of underpass and flyover along the road having a carriageway width of 9 m (7 m wide main carriageway and 2 m wide paved shoulder) in each direction for a length of 1000 m. in addition a slip road will also be provided having 7.5 m width on both sides for a length of 800 m

8.4 PROPOSAL FOR SERVICE ROADS/SLIP ROAD

Service road has been proposed in the entire corridor of this package. While accommodating the project highway by an elevated corridor along the existing median, mostly the existing carriageway has been used as service road.

The summary of service road is presented in Table 8.2 below:

Table 8-5: Details of Service Road

Chainage		Length (m)	Number of lanes	Width (m)	LHS / RHS	Remarks
From	To					
Dwarka Expressway						
5+300	5+700	400	2	7.5	Both	
5+700	6+200	500	2	7.5	Both	
5+300	6+300	1000	3	11	LHS	
6+200	6+300	100	3	11	RHS	
6+300	7+800	1500	3	11	LHS	
7+100	7+600	500	3	11	LHS	
6+300	7+500	1200	4	14	RHS	
7+500	7+600	100	3	11	RHS	
7+500	7+970	470	2	7.5	RHS	
7+450	7+970	520	3	11	RHS	
7+800	7+950	150	5	18	LHS	
7+950	8+100	150	4	14	LHS	
8+100	8+700	600	4	14	LHS	
7+950	8+700	750	4	14	RHS	
Link Road to Sector 21						
5+700	6+100	400	3	11	Both	
Link Road from Sector 23						
5+600	6+250	650	3	11	Both	
Link Road to Najafgarh						
6+300	8+300	2000	3	11	Both	
6+300	7+030	730	3	11	LHS	Existing Slip Road above Airport Drain RCC Box, Only Overlay Required.

8.5 PAVEMENT DESIGN

8.5.1 Pavement Options

Pavement is the most significant component of a road and therefore its design strengths must be assured to support the projected traffic loading throughout the design period. The cost of pavement represents largest proportion of the total construction cost (i.e. about 40% for new roads and about 60% for rehabilitation projects).

The purpose of the pavement study is to make analysis of different pavement alternatives to provide a basis for selection of the most advantage solution, considering all costs occurring during the life of the pavement, viz., construction costs, maintenance costs and costs for the road users.

In pavement option study, the following would be studied in detail:

- New flexible pavement on the widening part and for full reconstruction stretches
- Flexible overlay over the existing pavement

- Flexible Pavement for partial reconstruction stretches of existing pavement.
- Flexible pavement with rigid base

The different pavement design methods for above pavement options shall be studied and applied, which are given in Table 8.3.

Table 8-6: Pavement Design Methods

Pavement Option	Option Type	Design Method
1	New Flexible Pavement	IRC: 37-2012
2	Flexible Overlay	IRC: 81-1997
3	New Rigid Pavement	IRC: 58-2015

8.5.2 IRC: 37-2012 Method of Flexible Pavement Design –Widening and for New construction

The basic objective of pavement design is to increase the fatigue life of pavement by restricting the tensile strain caused by traffic in the bituminous layer to 70 micro strains and also to construct rut resistant pavement by limiting the vertical subgrade strain to 200 micro strain during the design life. This is ensured following the guidelines laid down in IRC: 37-2012.

Design Life

For the design of pavement, the design life is defined in terms of the cumulative number of standard axles that can be carried before strengthening of the pavement is necessary.

It is recommended that pavements for National Highways in urban area should be designed for a life of 20 years in IRC: 37-2012. As the project is being implemented under EPC contract, hence stage construction is not considered in the design.

The design traffic considered for the project road section is tabulated below:

Table 8-7: Design Traffic in Million Standard Axles

Design Chainage		Length (km)	Design MSA
From	To		20 years
5+300	9+500	4.2	75

CBR Value

The 90 percentile CBR value of borrow earth to be used as subgrade material is considered as 8%. As per site condition the subgrade on the widened portion will be mostly laid on the existing ground. As the average CBR of the existing ground is found to be 8%, the effective CBR of the subgrade considered in design is 8%.

Therefore during construction it is to be ensured that minimum 500mm thick existing ground is re-compacted to achieve minimum CBR of 8%.

Pavement Materials

The general specification sections and characterization of material is presented in Table 8-8.

Table 8-8: Materials Specification and Characterization

Sl. No.	Pavement Layers and Materials	Sections Details	Remarks
1	Embankment Construction	Section 305	Minimum Soaked CBR 8%
2	Subgrade	Section 305	Minimum Soaked CBR 8%
3	Granular Sub-base Upper Layer Lower Layer	Section 401	Minimum compacted thickness 100mm Grading I of Table 400-1 Grading I of Table 400-2
4	Base Course-WMM	Section 406	Thickness of single layer shall be 75mm-200mm
5	Cement Treated Base	Section 403	
6	Cement Treated Sub-base	Section 403	
7	Prime Coat	Section 502	
8	Tack Coat	Section 503	
9	Bituminous Macadam	Section 504	Thickness of single layer shall be 50mm-100mm
10	Dense Bituminous Macadam	Section 507	Thickness of single layer shall be 50mm-100mm
11	Bituminous Concrete	Section 512	Thickness of single layer shall be 50mm for Grade-1 and 30-40mm for Grade-2
12	Dry Lean concrete	Section 601	Thickness of single layer shall be 100 mm and 150 mm
13	Pavement Quality Concrete	Section 602	Minimum compacted thickness of 140mm

Based on the above CBR and design traffic, the adopted pavement thickness of the at-grade project highway is given below:

Table 8-9: Proposed Pavement Thickness of Main Carriageway of Dwarka Expressway and all Link Roads

Effective Subgrade CBR	Design MSA (20 years)	Pavement Thickness (mm)			
		BC	DBM	WMM	GSB
8%	75	40	105	250	200

As design traffic of 20 MSA has been considered for service road, hence based on subgrade CBR of 8% the proposed pavement thickness of service road is presented below.

Table 8-10: Proposed Pavement Thickness of Service Road

Effective Subgrade CBR	Bitumen Grade	Design MSA (20 years)	Pavement Thickness (mm)			
			BC	DBM	WMM	GSB
8%	VG30	20	40	85	250	200
8%	VG40	20	40	70	250	200

As VG40 grade bitumen is to be used for main carriageway, hence considering the same grade to be used for service road as well, the proposed pavement thickness corresponding to VG40 grade bitumen is to be adopted.

8.6 INTERSECTIONS DESIGN

Road junction / intersection is a key element of highway design. The efficiency, safety, speed, cost of operation and capacity of road system depends very much on the intersection design. The choice between an at-grade and grade separated junctions at a particular site depends upon various factors such as traffic, economy, safety, aesthetic delay etc. Grade separated junctions generally are more expensive initially and are justified in certain situations. The main objective of intersection design is to reduce the severity of potential conflicts between motor vehicles, buses, trucks, bicycles, pedestrians and facilities while facilitating the convenience, ease, safety and comfort of people traversing the intersections. The design should be fitted closely to the natural transitional paths and operating characteristics of the users.

Design of a safe intersection depends on many factors as given below:

- Human factors
- Traffic considerations (mainly design hour turning movements, type of movement and vehicle speeds)
- Road and environmental considerations (sight distance, conflict area, geometric features)
- Economic factors.

Generally intersections can be classified in to three categories depending on the traffic conditions. These are

- Uncontrolled intersections at-grade;
- Intersections with Priority Control;
- Time separated / signalised intersection at-grade;
- Space separated intersections / Grade separated intersections

8.6.1 General Criterion for improvement proposal at junctions

- A signalised intersection besides other warrants is justified if the major street has a traffic volume of 650 to 800 vehicles per hour (both directions) and Minor Street has 200 to 250 vehicles per hour in one direction only. The detailed warrants for signalised intersection are laid down as per IRC: 93-1985.

- The vehicular under/overpass structures will be provided at the intersection of the Project Highway with all the National Highways and State Highways. Such under/over passes will also be provided across other categories of roads carrying an average daily traffic of more than 5000 PCUs on the date of inviting bids.(As per Clause:2.13.2, IRC:SP:84-2009)
- An interchange, besides any overriding necessity, is justified when the total traffic of all the arms of the intersection is in excess of 10,000 PCU's per hour. The detailed warrants for interchanges are given in IRC: 92-1985.

The turning movement surveys for estimation of peak hour traffic for the design of major intersection have been carried out. The details regarding composition and directional movement of traffic is furnished in Chapter 5. The data derived from surveys were analysed to identify requirements of suitable remedial measures, such as construction of underpasses, flyovers, interchanges, and grade-separated intersections along the project road alignment.

The geometric design of junctions has been done taking in to account the site conditions, turning movement characteristics, level of services, overall economy and operational safety.

8.6.2 Details of Junctions Improvement Proposal

Existing 7 major and 8 minor junctions are proposed to be improved as a part of upgradation project. The junction improvement plan for junctions is listed in Table given below:

Table 8-11: Junction Improvement Proposal

S No.	Location	Salient Features	Road to be carried under the structure	Remarks
1	5+700 of Dwarka Expressway	Elevated Dwarka Expressway; Elevated Link road to Najafgarh; Depressed link road to Dwarka Sector 21	Service roads	Necessary improvement of the at-grade junction with the service road is also included in the scope of work
2	6+300 of Link Road to Najafgarh	Elevated Dwarka Expressway; Elevated Link road to Najafgarh; Elevated Link road from Dwarka Sector 23 to Kherki Daula 3-lane Roundabout for all at-grade service road	Service roads	Necessary improvement of the at-grade junction with the service road with a 3-lane roundabout is also included in the scope of work

S No.	Location	Salient Features	Road to be carried under the structure	Remarks
		movements		
3	8+000 of Dwarka Expressway	Elevated Dwarka Expressway	Cross-road	Necessary improvement of the at-grade junction with the service road is also included in the scope of work
4	8+600 of Dwarka Expressway	Service road on Elevated Structure Cross-road through underpass	Service roads	Necessary improvement of the at-grade junction with the service road is also included in the scope of work
5	7+600 of Link Road to Najafgarh	Elevated Link Road to Najafgarh	Golf Course road	Necessary improvement of the at-grade junction with the service road is also included in the scope of work

8.7 DESIGN OF BRIDGES

8.7.1 Existing Bridges

There are no major on the project road under Package-2.

8.7.2 Proposal of New Bridge

Only one new bridge is necessary to cross the proposed slip road across an existing drain. The proposal of this new bridge is presented below:

Table 8-12: Development Proposal of New Bridge

Sl. No	**Chainage (km)**	**Type of Structure**	**Span /Opening with span length (m)**	**Width (m)**	Remarks
1	5+340 of Dwarka Expressway	Slab	1 x 11.0m	100	Crossing of Storm water drain from Airport

8.7.3 Proposal of Elevated Structure/ Flyover

About 80% of the project road section has been proposed to be elevated. 2 x 15m wide elevated corridor has been proposed. While service road shall run beneath the elevated corridor, for cross movement service road has also been elevated at all the major junction locations.

At all the major junction locations, the cross-road has been depressed by an underpass. This would ease the at-grade turning movement at the major junctions.

The list of Elevated Structure/ Flyover is tabulated in Table 8.13 below. The list of underpasses is presented in Table 8.14.

Table 8-13: Proposal for Elevated Structure/ Flyover

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
1	Dwarka Expressway	5+460	5+812	352	Elevated Structure	33.5	As per Design Profile	Ramp on Structure
		5+812	6+480	668			5.5	
		6+680	8+338	1658			5.5	
		8+338	8+560	222			As per Design Profile	Ramp on Structure
2	Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka	5+745	5+936	191	Elevated Structure	Varying from 0 to 12.5	5.5	Merging portion
		5+936	6+349	413		12.5	5.5	
		6+349	6+575	226		12.5	As per Design Profile	Ramp on Structure
3	Ramp from ECC Dwarka merging with Right Carriageway of Dwarka Expressway	7+300	7+360	60	Elevated Structure	Varying from 0 to 12.0	5.5	Merging portion
		7+354	7+384	30		12.0	5.5	
		7+384	7+570	186		12.0	As per Design Profile	Ramp on Structure
4	Link Road to Najafgarh *(Left Carriageway)*	6+050	6+212	162	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		6+212	6+720	508			5.5	
		6+720	7+009	289			As per Design Profile	Approach from +1 level to +2 level
		7+009	7+115	106			5.5 over and above +1 level	At + 2 level
		7+115	7+458	343			As per Design Profile	Approach from +2 level to +1 level
		7+458	7+675	217			5.5	
		7+675	8+010	335			As per Design Profile	Ramp on Structure
5	Link Road to Najafgarh *(Right Carriageway)*	5+480	5+740	260	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		5+740	6+721	981			5.5	
		6+721	7+010	289			As per	Approach from +1

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
							Design Profile	level to +2 level
		7+010	7+116	106			5.5 over and above +1 level	At + 2 level
		7+116	7+459	343			As per Design Profile	Approach from +2 level to +1 level
		7+459	7+677	218			5.5	
		7+677	8+010	333			As per Design Profile	Ramp on Structure
6	Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ	5+860	6+009	149	Elevated Structure	8.5	As per Design Profile	Ramp on Structure
		6+009	6+093	84		8.5	5.5	
		6+093	6+100	7		Varying from 8.5 to 0	5.5	Merging portion
7	Ramp from Dwarka Sector 23 towards RUB/Shiv Murty	5+491	5+506	15	Elevated Structure	Varying from 7.9 to 8.5	As per Design Profile	Merging portion Ramp on Structure
		5+506	5+635	129		8.5	As per Design Profile	Ramp on Structure
		5+635	5+718	83		8.5	5.5	
		5+668	5+885	217		8.5	As per Design Profile	Ramp on Structure
8	Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka	6+430	6+425	5	Elevated Structure	0 to 10.25m	5.5	Merging portion
		6+425	6+566	141		10.25	5.5	
		6+566	6+710	144		10.25	As per Design Profile	Ramp on Structure
9	Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	6+700	6+784	84	Elevated Structure	0 to9.25m	5.5	Merging portion
		6+784	7+117	333		9.25	5.5	
		7+117	7+230	113		9.25	As per Design Profile	Ramp on Structure
10	Ramp from	7+110	7+402	292	Elevated	10.25	5.5	

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
	ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	7+402	7+520	118	Structure	10.25	As per Design Profile	Ramp on Structure
11	Ramp from ECC Bus Drop-off going towards Sector 24	7+340	7+520	180	Elevated Structure	10.25	As per Design Profile	Ramp on Structure
12	Ramp from Left Carriageway of Link Road to Najafgarh from Dwarka Sector 21 MSJ to Golf Course Road	6+910	7+050	140	Elevated Structure	0 to 10.25	On Ramp from +1 to +2 level	Merging portion
		7+050	7+120	70		10.25	5.5 over and above +1 level	
		7+120	7+455	335		10.25	As per Design Profile	Ramp on Structure
13	Link Road to Dwarka Sector 21	5+651	5+851	200	Underpass	12.5	5.5	
14	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Left Carriageway)*	5+800	6+260	460	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		6+260	6+651	391			5.5 over and above +1 level	At +2 level
		6+651	7+006	355			As per Design Profile	Approach from +2 level to +1 level
		7+006	7+010	4			5.5	
		7+010	7+186	176		Varying from 12.5m to 0	5,5	Merging portion
15	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Right*	5+800	6+260	350	Elevated Structure	12.5	As per Design Profile	Ramp on Structure
		6+260	6+309	49		12.5	5.5 over and above +1 level	At +2 level

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
	Carriageway)	6+309	6+645	336			As per Design Profile	Approach from +2 level to +1 level
		6+645	6+658	13		Varying from 12.5m to 11.9m	As per Design Profile	Approach from +2 level to +1 level
		6+658	6+660	2		11.9m to 0	5.5	Merging portion
16	Right turn beneath Dwarka Expressway from ECC Dwarka towards Kherki Daula	Crossing Dwarka Expressway at 7+470		120	Underpass	12.0	5.5	
17	U-turn beneath Dwarka Expressway from left Service road towards Sector 23ECC Dwarka	Crossing Dwarka Expressway at 8+009		440	Underpass	12.0	5.5	
18	Right Turn towards Najafgarh above Dwarka Expressway from left Service Road	Crossing Dwarka Expressway at 8+600		150	Elevated Structure	8.5	As per Design Profile	Ramp on Structure
				60		8.5	5.5	
19	Right Turn towards Shiv Murti from Elevated Cross-Road coming from Bijwasan	Crossing Dwarka Expressway at 8+600		60	Elevated Structure	8.5	5.5	
				150		8.5	As per Design Profile	Ramp on Structure
20	Najafgarh – Bijwasan Cross Road (Left Carriageway)	Crossing Dwarka Expressway at 8+600		10.5	Depressed Cross Road through Underpass structure	130	5.5	Length and width are w.r.t. Main Carriageway; Width of main carriageway on the Underpass – 33.5m; Both side approaches of the depressed cross-road through

S. No.	Road / Link	Design Chainage of Main Carriageway / Individual Link / Ramp		Length (m)	Proposed Structure	Width (m)	Vertical Clearance	Remarks
		From	To					
								underpass are included in the scope of work;
21	Najafgarh – Bijwasan Cross Road (Right Carriageway)	Crossing Dwarka Expressway at 8+600		10	Elevated Cross-Road	130	5.5	Length and width are w.r.t. Main Carriageway; Width of main carriageway on the Underpass – 33.5m; Both side approaches of the depressed cross-road through underpass are included in the scope of work;

Table 8-14: Details of Grade Separated Structures

Sl. No.	Design Chainage	Length (m)	Proposed Structure	Remarks
1	5+460 to 8+560	3100	Elevated Structure	Dwarka Expressway
2	5+745 to 6+575	830	Elevated Structure	Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka
3	7+100 to 7+570	470	Elevated Structure	Ramp from ECC Dwarka merging with Right Carriageway of Dwarka Expressway
4	6+050 to 8+010	1960	Elevated Structure at +1 and +2 level	Link Road to Najafgarh *(Left Carriageway)*
5	5+480 to 8+010	2530	Elevated Structure at +1 and +2 level	Link Road to Najafgarh *(Right Carriageway)*
6	5+860 to 6+100	240	Elevated Structure	Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ

Sl. No.	Design Chainage	Length (m)	Proposed Structure	Remarks
7	5+491 to 5+885	394	Elevated Structure	Ramp from Dwarka Sector 23 towards RUB/Shiv Murty
8	6+430to 6+710	280	Elevated Structure	Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka
9	6+700 to 7+230	530	Elevated Structure	Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ
10	7+110 to 7+520	410	Elevated Structure	Ramp from ECC Bus Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ
11	7+340 to 7+520	180	Elevated Structure	Ramp from ECC Bus Drop-off going towards Sector 24
12	6+910 to 7+455	545	Elevated Structure	Ramp from Left Carriageway of Link Road to Najafgarh from Dwarka Sector 21 MSJ to Golf Course Road
13	5+651 to 5+851	200	Underpass	Link Road to Dwarka Sector 21
14	5+800 to 7+185	1385	Elevated Structure at +2 and +1 level	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Left Carriageway)*
15	5+800 to 6+660	860	Elevated Structure at +2 and +1 level	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Right Carriageway)*
16	Crossing Dwarka Expressway at 7+470	120	Underpass	Right turn beneath Dwarka Expressway from ECC Dwarka towards Kherki Daula
17	Crossing Dwarka Expressway at 8+009	440	Underpass	U-turn beneath Dwarka Expressway from left Service road towards ECC DwarkaSector 23
18	Crossing Dwarka Expressway at 8+600	210	Elevated Structure	Right Turn towards Najafgarh above Dwarka Expressway from left Service Road
19	Crossing Dwarka Expressway at 8+600	210	Elevated Structure	Right Turn towards Shiv Murti from Elevated Cross-Road coming from Bijwasan
20	Crossing Dwarka Expressway at 8+600	9.0	Depressed Cross Road through Underpass structure	Najafgarh – Bijwasan Cross Road (Left Carriageway) Length and width are w.r.t. Main Carriageway;

Sl. No.	Design Chainage	Length (m)	Proposed Structure	Remarks
21	Crossing Dwarka Expressway at 8+600	9.0	Elevated Cross-Road	Najafgarh – Bijwasan Cross Road (Right Carriageway) Length and width are w.r.t. Main Carriageway;

8.7.4 Proposal of Pedestrian facilities and Cycle Track

Pedestrian sub-way has been proposed at all the major junction locations. The list of subway is presented below:

Table 8-15: Proposal for Subway

Sl. No.	Location	Type of Structure	Clear Size (Horizontal x Vertical)	Tentative Length	Remarks
1	Km 6+200 of Link Road to Najafgarh	Box	5m x 3m	70m	
2	Km 6+400 of Link Road to Najafgarh	Box	5m x 3m	80m	Subway shall be beneath the existing Drain coming from Airport to Najafgarh Drain
3	Km 6+200 to Link Road from Dwarka Sector 23 to Kherki Daula	Box	5m x 3m	70m	
4	Km 6+400 to Link Road from Dwarka Sector 23 to Kherki Daula	Box	5m x 3m	85m	
5	Km 6+950 of Link Road to Najafgarh	Box	5m x 3m	90m	Subway shall be beneath the existing Drain coming from Airport to Najafgarh Drain

Besides the above, 2.0m wide footpath and 2.0m wide cycle track is proposed on both sides of the entire project stretch.

8.7.5 Improvement Proposal of Culverts

All existing culverts which are newly constructed is to be used as it is. Only one new culvert has been proposed at the location given below:

Table 8-16: Proposal for New Culvert

Sl. No	Chainage (km)	Type of Culvert	Span /Opening with span length (m)	Width (m)	Remarks
1	5+950 of Link Road to Dwarka Sector 23	Slab	1 x 3.75m	75.0 (Skewed)	Oil Pipe line Crossing

8.8 RETAINING EARTH WALL

RE wall is proposed at the approaches of the elevated corridor. The stretches where RE wall is proposed is presented below:

Table 8-17: Locations of RE Wall along Main Carriageway

S. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level
1	Dwarka Expressway	5+348 to 5+517	169	Both	4.0m (Varying from 1m to 8 m)
		8+536 to 8+645	109	Both	3.0m (Varying from 1m to 6 m)
2	Ramp / Link exiting from Left Carriageway of Dwarka Expressway to ECC Dwarka	6+515 to 6+678	163	Both	3.0m (Varying from 1m to 6 m)
3	Ramp from ECC Dwarka merging with Right Carriageway of Dwarka Expressway	7+550 to 7+651	101	Both	3.5m (Varying from 1m to 7 m)
4	Link Road to Najafgarh *(Left Carriageway)*	5+990 to 6+135	145	Left	5.5 (Varying from 1m to 11 m)
		7+933 to 8+180	247	Left	3.0m (Varying from 1m to 6 m)
5	Link Road to Najafgarh *(Right Carriageway)*	5+355 to 5+523	168	Right	4.0m (Varying from 1m to 8 m)
		7+932 to 8+143	211	Right	3.5m (Varying from 1m to 7 m)
6	Ramp from Right Carriageway from Najafgarh towards Dwarka Sector 21 MSJ	5+760 to 5+860	100	Both	3.0m (Varying from 1m to 6 m)
7	Ramp from Dwarka Sector 23 towards RUB/Shiv Murty	5+360 to 5+491	131	Both	3.0m (Varying from 1m to 6 m)
		5+840 to 5+960	120	Both	4.0m (Varying from 1m to 8 m)
8	Ramp from Left Carriageway from Dwarka Sector 21 MSJ to ECC Dwarka	6+683 to 6+763	80	Both	3.5m (Varying from 1m to 7 m)
9	Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	7+210 to 7+320	110	Both	3.0m (Varying from 1m to 6 m)
10	Ramp from ECC Bus	7+465 to	80	Both	3.0m (Varying from 1m to 6

S. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level
	Drop-off merging with the Ramp from ECC Dwarka merging with Right Carriageway towards Dwarka Sector 21 MSJ	7+545			m)
11	Ramp from ECC Bus Drop-off going towards Sector 24	7+500 to 7+620	120	Both	3.5m (Varying from 1m to 7 m)
12	Ramp from Left Carriageway of Link Road to Najafgarh from Dwarka Sector 21 MSJ to Golf Course Road	7+455 to 7+550	95	Both	3.0m (Varying from 1m to 6 m)
13	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Left Carriageway)*	5+718 to 5+840	122	Left	3.5m (Varying from 1m to 6 m)
14	Link Road from Dwarka Sector 23 going towards Kherki Daula (*Right Carriageway)*	5+725 to 5+855	130	Right	4.0m (Varying from 1m to 8 m)
15	Right Turn towards Najafgarh above Dwarka Expressway from left Service Road	8+235 to 8+385 *(Chainage is w.r.t. Dwarka Expressway)*	150	Both	3.0m (Varying from 1m to 6 m)
16	Right Turn towards Shiv Murti from Elevated Cross-Road coming from Bijwasan	8+235 to 8+385 *(Chainage is w.r.t. Dwarka Expressway)*	150	Both	3.0m (Varying from 1m to 6 m)
17	Najafgarh – Bijwasan Cross Road (Right Carriageway)	Crossing Dwarka Expressway at 8+600	2 x 150	Both	3.0m (Varying from 1m to 6 m)

8.9 RETAINING WALL

Retaining wall is proposed along the approaches to the depressed cross roads to be carried under the underpass structure. The location of the retaining wall is presented in the table below:

Table 8-18: Locations of RE Wall along Service Road

Sl. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level	Remarks
1	Link Road to Dwarka Sector 21	5+397 to 5+651	254	Both	4.5m (Varying from 1m to 9 m)	
		5+851 to 6+051	200	Both	5.0m (Varying from 1m to 10 m)	
	Right turn beneath Dwarka Expressway from	Crossing Dwarka Expressway at	2 x 200m	Both	4.0m (Varying from 1m to 8 m)	On both side approaches

Sl. No.	Road / Link	Design Chainage	Length (m)	Side	Average Height from Ground Level	Remarks
	ECC Dwarka towards Kherki Daula	7+470				
	U-turn beneath Dwarka Expressway from left Service road towards ECC Dwarka	Crossing Dwarka Expressway at 8+009	2 x 200m	Both	4.0m (Varying from 1m to 8 m)	On both side approaches
	Najafgarh – Bijwasan Cross Road (Left Carriageway)	Crossing Dwarka Expressway at 8+600	2 x 200m	Both	4.0m (Varying from 1m to 8 m)	On both side approaches

8.10 DRAINS

The location of RCC Cover drains are given in ***Table 8.16 and Table 8.17***:

Table 8-19: Construction of New RCC Cover Drain

SL No.	Stretch	Length (m)	Type	Width (m)	Remarks
Along Dwarka Expressway					
1	5+300 to 9+500	4037	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain
Along Link Road to Najafgarh					
1	6+300 to 8+300	2000	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain
Along Link Road to Dwarka Sector 21					
1	5+800 to 6+150	350	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain
Along Link Road to Dwarka Sector 23					
1	5+465 to 6+300	835	Rectangular RCC covered drain	2.0m	Both sides Footpath-cum-Drain

Table 8-20**: Realignment of Existing RCC Cover Drain**

S. No.	Existing Chainage	Approx. Length (m)	Left / Right	Width	Remarks
Dwarka Expressway section between (5+300 to 6+300)					
1	Between 5+340 to 5+800	600	Left	11 m	Existing Storm water drain from Airport discharging into Najafgarh Drain needs to be realigned

8.11 RAINWATER HARVESTING SYSTEM

Rain water harvesting system shall be provided along the project highway at the following locations as per MOEF guidelines and IRC:SP:50-2013..

Table 8-21: Location of Rain Water Harvesting

Sl. No.	Details Such as Location/Interval/ Size
1	At 500m interval staggered on both sides
2	At 500 m interval beneath the elevated structure between Design Chainage 5+500 to 8+600 both along main carriageway and cross roads. The location shall be decided in consultation with AE

8.12 TOLL PLAZA

As stipulated in Manual of Specifications and Standards for Six laning of Highways through Public Private Partnership (IRC: SP: 87), Toll Plaza shall be provided at locations given below:

Table 8-22: Location of Toll Plaza

S. No.	Design Chainage (Km)	Section	No. of Lanes
1	9+045	From km 0+000 to 9+500	17 lanes on each side, including one lane for over-sized vehicles

8.13 ROAD FURNITURE AND OTHER FEATURES

8.13.1 Introduction

The road furniture, traffic safety features and other facilities included in the design are:

- Bus Bays
- Truck Lay byes
- Road Markings
- Traffic Signs
- Kilometre Stone Details
- 200m Stones and Boundary Stones
- Delineators and Object Markers
- Guard Post
- Crash Barrier
- Overhead driver feedback system

8.13.2 Bus Bays and Bus Shelters

Bus Bays are proposed as per the recommendations of IRC: 80-1981. The typical bus bay consists of deceleration and acceleration lanes of 45m length with stopping lane of 5.0 m wide, 15m long in rural areas and 10m long in urban areas. A raised footpath of 2.0m wide is proposed for the safety of waiting passengers. In urban areas, where the frequency of buses stopping is more, the length of the stopping lane

has been increased to 30m to accommodate two buses stopping at the same time. Adequate arrangements have also been made to drain off surface water. The nearby village/town sections where bus laybye with bus shelters on both sides of the 4-lane road are proposed are presented in Table 8.20.

Table 8-23: Locations of Bus Bays with Bus Shelter

S. No	Chainage (km)	Length* (m)	Left Hand Side/ Right Hand Side	Remarks
Dwarka Expressway Section between (5+300 to 9+500)				
1	5+300	30	Both Sides	Bus Bay with Shelter
2	6+100	30	Both Sides	Bus Bay with Shelter
3	6+900	30	LHS	Bus Bay with Shelter
4	8+500	30	Both Sides	Bus Bay with Shelter
Link Road to Najafgarh (6+300 to 8+200)				
1	6+900	30	RHS	Bus Bay with Shelter

8.13.3 Road Markings

Road markings perform the important function of guiding and controlling traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. The Code of Practice for Road Markings, IRC: 35 has been used in the study as the design basis.

The location and type of marking lines, material and colour is followed using IRC: 35-"Code of Practice for Road Markings".

The road markings were carefully planned on carriageways, intersections and bridge locations.

8.13.4 Cautionary, Mandatory and Informatory Signs

Traffic signs include roadside signs, overhead signs, minimum 20 numbers of Variable Message Signs (VMS) and Kerb mounted signs along the length of the Project Highway.

The Overhead traffic signs shall be provided as per numbers given below. The locations shall be finalized in consultation with Authority Engineer.

S. No.	Type	Nos	Remarks
1	Cantilever	30	Location to be decided in consultation with the Authority Engineer
2	Full Gantry	20	Location to be decided in consultation with the Authority Engineer

8.13.5 Kilometre Stone Details

The details of kilometre stones are in accordance with IRC: 8 guidelines. Kilometre stones are located on the left-hand side of the road as one proceeds from the station from which the Kilometre count starts. On divided roads with a central median, kilometre stones would be provided at the left on both sides of the road i.e., independently for each direction of travel. Kilometre stones shall be fixed at right angles to the centre line of the carriageway.

8.13.6 200m Stones and Boundary Stones

The details of 200m stones and boundary stones conform to IRC: 26 and IRC: 25. 200m stones are located on the same side of the road as the kilometre stones. The inscription on the stones shall be the numerals 2, 4, 6 and 8 marked in an ascending order in the direction of increasing kilometerage away from the starting station. The numerals shall be 80mm high. The colour of the numerals shall be black on a white background. Boundary stones shall be located on either side of the road opposite every 200m stone and kilometre stone. In addition these shall be fixed at all angular points of the boundary. Where the boundary is on a curve or the land is of significant value and likely to be encroached upon, the boundary stones, as required, shall be installed at closer intervals.

8.13.7 Delineators and Object Markers

Roadway delineators are intended to mark the edges of the roadway so as to guide drivers on the alignment ahead. Object markers are used to indicate hazards and obstructions within the vehicle flow path, for example, channelling islands close to the intersections.

Delineators and object markers are provided as per the details given in the drawings and are provided in accordance with the provisions of IRC: 79. They are basically driving aids and should not be regarded as substitutes for warning signs, road markings or barriers. Delineators are provided for all curves of radius less than 600m. They are not provided at locations where Chevron sign boards are provided.

8.13.8 Guard Post

Guard posts are proposed on embankments of height more than 1.0m, bridge approaches and horizontal curves of radius greater than 161m. The spacing of guard post shall be 2.0m c/c in these areas. Typical Guard post consists of precast (M20) post of size 200mm x 200mm and a height of 600mm above ground level. They are encased in M15 cement concrete for a depth of 450mm below ground level. Guard posts are painted with alternate black and white reflective paint of 150mm wide bands.

8.13.9 Crash Barrier

Metal Beam Crash Barrier is proposed at locations where the embankment height is more than 3.0m, at horizontal curves of radius less than 161m and also at major

bridge approaches. Metal beam rail shall be W-profile corrugated sheet steel beams complying with the following mechanical properties.

i. Tensile strength, Min = 483 MPA

ii. Elongation in 2 inches, Min = 12%

iii. Yield, Min = 345 MPA

The beam elements shall have nominal width of 483mm. Post consists of formed channel of size 150 x 75 x 5, 785mm long and space consists of formed channel of size 150 x 75 x 5, 330 mm long. All members of the system should be hot dipped galvanised to have a minimum counting of 550g/sqm, each face in compliance to relevant MOST Specification (Cl. 810). The spacing of posts should be 2.0m c/c. Crash barrier system absorbs impact of vehicle and laterally restrains a vehicle from veering off. This ensures minimum damage to the vehicle and passengers.

8.13.10 Overhead Driver Feedback System

To enhance traffic safety and increase driver awareness, overhead digital speed monitoring device along with closed circuit automatic number plate recognition (ANPR) camera is proposed to be installed at every 1km interval of the project highway including the service road stretch.

8.13.11 Road Safety Audit

Road Safety audit has the greatest potential for improving safety and is most cost–effective when it is applied to a road or traffic design before the project is built. It can be conducted on any design proposal that involves changes to the ways road users will interact, either with each other or with their physical environment. It is a formal process using a defined procedure.

As per the requirements of *TOR,* Road Safety Audit (RSA) has been carried out for project road and sufficient measures has been taken for improving detailed engineering design with respect to the road safety audit. The details of audit taken are described in Check list below:

Table 8-24: Checklist: Feasibility Stage Audit

Sl. No.	Contents	Item	Yes/No	Comment
1.	Aspects to be checked	A. Safety and operational implications of proposed alignment and junction strategy with particular references to expected road users and vehicle types likely to use the road.	Yes	The design of the proposed alignment takes care of the principal factors affecting safety and operational implications as per relevant IRC Codes.
		B. Width options considered for various sections.	Yes	As provisioned in IRC Codes.
		C. Departures from standards and action taken.	Yes	Followed relevant IRC Codes.
		D. Provision of pedestrians, cyclists and intermediate	Yes	2.0m wide footpath and 2.0m wide cycle track has been proposed along

Sl. No.	Contents	Item	Yes/No	Comment
		transport.		both sides of the project corridor. Besides, pedestrian subway is proposed at all the major intersections.
		E. Safety implications of the scheme beyond its physical limits i.e. how the scheme fits into its environs and road hierarchy.	Yes	Geometric design takes care of the safety issues of the environs. Besides provision of crash barriers, railings, lighting in the urban sections also contribute to the safety scheme. In stretches with narrow median (<4.5m) antiglare screen has been proposed to be installed on the median center atop the NJ type crash barrier.
2.	A1: General	Departures from Standards	Yes	
		Cross-sectional variation	Yes	No abrupt variation to cause concern for safety.
		Drainage	Yes	Road grades and cross fails are adequate for satisfactory drainage. Provision of proper drainage system along the road has been made.
		Climatic conditions	Yes	Design has taken care of temperature and rainfall.
		Landscaping	NA	To be taken care of at execution stage ensuring the same does not obstruct visibility.
		Services apparatus	Yes	Design is adequate in dealing with overhead services.
		Lay-byes	Yes	Bus lay-byes, truck lay-byes at identified locations have been provided.
		Footpaths	Yes	Provided for the entire project stretch.
		Pedestrian Crossings	Yes	Pedestrian subway is proposed at all major intersection.
		Access (minimize number of private accesses)	Yes	Service road on the both side has been proposed for the entire project corridor.
		Emergency vehicles	NA	Not applicable at Design Stage.
		Public Transport		
		Future Widening	Yes	
		Staging of Contracts	NA	
		Adjacent development	Yes	Access to major adjacent developments has been considered in design.
3.	A2: Local Alignment	Visibility	Yes	Horizontal and vertical alignments satisfy visibility criteria at all locations. Design is based on ISD.

Sl. No.	Contents	Item	Yes/No	Comment
		New/Existing road interface	Yes	Sufficient transition zone has been proposed. All cross roads were properly designed with main road.
		Safety Aids on steep hills.	NA	
4.	A3: Junctions	Minimise potential conflicts	Yes	All major junctions have been grade separated by Flyover and underpass.
		Layout	Yes	Followed IRC standards.
		Visibility	Yes	Horizontal and vertical alignments are consistent with visibility. Standards are appropriate for speed. Free sight line has been maintained.
5.	A4: Non-motorized road users provision	Adjacent land	Yes	Safe access to adjacent land has been designed.
		Pedestrians	Yes	2.0m wide footpath has been proposed along both sides of the project corridor. Besides, pedestrian subway is proposed at all the major intersections.
		Cyclists & Non-motorised vehicles	Yes	2.0m wide cycle track has been proposed on both sides of the project corridor.
6.	A5: Signs and lighting	Lighting	Yes	Provisions have been made.
		Signs / Markings	Yes	Provisions have been made.
7.	C6: Construction and Operation	Build ability	Yes	
		Operational	NA	
		Network Management	No	Would be taken care in the subsequent stage.

CHAPTER 9 COST ESTIMATES

9.1 GENERAL

The project cost estimates have been prepared based on various items of works required for the development of project road. The cost estimates are based on CPWD Delhi Schedule of Rates 2016 with due escalation, Market rates have also been considered for further Analysis of Rates.

In general, the work is to be executed as per the IRC and MORTH as applicable for 6-lane and Technical Specifications contained in "Specifications Road and Bridge Works" (Fifth Revision – 2013).

9.2 ESTIMATION OF QUANTITIES

The quantities of major items of works have been worked out based on following:

- Site Clearance: The area considered for Site Clearance is the area within the proposed Right of Way excluding the existing carriageway area.
- Earth Works: This item provides for roadway excavation, earthwork in embankment, sub-grade and shoulders, medians, islands including disposal of surplus earth and unsuitable material. In this stage, the construction of embankment height has been taken as per site condition. Sub-grade soil having a CBR ≥ 8 % will be taken from borrows area. It is also to be ensured that during construction the existing 500m thick embankment / existing ground below the subgrade is recompacted to MDD and have CBR value ≥ 8 %.
- The pavement quantities like GSB, WMM & Bituminous items etc. have been worked out based on the geometrics and cross sections, pavement design done based on traffic and laboratory investigations. The total earthwork in cut-and-fill has been determined from average embankment height noted during road inventory survey.
- Culverts: The estimation of quantities for culverts is based on site condition & detailed inventory. The detailed recommendations are given in proposed development scheme chapter.
- Bridges and Structures: The estimates of quantities for bridges and other structures have been worked out based on condition of structures. The detailed recommendations are given in Chapter 8. In this stage the cost for structures has been worked out based on General Arrangement Drawing.
- Drainage and Protection Works: Quantities for the surface, subsurface and roadside drains, drainage chutes in cement concrete and stone pitching at outfalls/escapes are as per actual including pre cast drain at edge of RE wall.
- Traffic Signs and Markings: Proper traffic signs were selected at required locations along the project corridor and special signs at tollgates were designed. The quantity of traffic signs and markings are calculated based on the detail

drawings for the highway and junction to ensure safety in the proposed highway facility.

Bus bays and Passenger shelters shall be allowed to stop for dropping and picking up passengers at bus bays location. In this item, the estimates of quantities are based on the standard layout given in IRC: SP: 87 as applicable.

- Junctions Improvement: This item includes quantities of kerbs, railings, median etc. at the location of junctions. The cost for junctions includes the cost for at grade junctions, which need improvement along the project roads.

9.3 COST OF UTILITY DIVERSION

Although there are not major utilities that are getting affected in this package as the road is newly laid and is a Greenfield alignment. However, there are some utilities such as HT lines which are crossing the alignment and height of the same is required to be increased for providing adequate height clearance for the highway. Since this section falls in Haryana State, HUDA is responsible to provide required utility diversion, but in order to avoid any issue later, a broad cost of INR 5 crores per Km has been considered for necessary utility diversions. Considering the cumulative total length of Package 2 is 9 Km, the total cost of Utility diversion is INR 45 Crores.

9.4 RATE ANALYSIS

Analysis of rates have been carried out using Haryana PWD Schedule of Rate, July 2014.Market rates have been adopted for the following basic materials:

- Aggregates
- Steel
- Cement
- Bitumen

While cartage rate has been adopted from SOR. Machinery rate has been adopted from the MORTH Data Book with necessary escalation. Government approved rate has been considered in the analysis. Rate analysis is being submitted as Vol-II of this report.

9.5 PRELIMINARY PROJECT COST

The project cost on above items has been worked out for the year 2017-18 based on development proposal of the project corridor. The abstract of the estimate is presented below:

Table 9-1**: Abstract Cost Estimate by Items**

S.No.	Bill no	Description	Amount (in crores)	Percent (%)
1	A	Road Works (Main Carriageway)	59,96,00,875	4.13%
2	B	Bridges & Structures		
3		Major Bridges		
4		Minor Bridges	4,95,00,000	0.34%

S.No.	Bill no	Description	Amount	Percent (%)
5		Flyover / Grade Separator	10,67,84,51,194	73.50%
6		Flyover / Grade Separator on Service Road		
7		Underpass	81,90,05,363	5.64%
8		Subway	9,87,50,000	0.68%
9		Culvert	4,14,37,500	0.29%
10	C	Other Road Appurtenances / Miscellaneous Items / Toll Plaza	2,24,26,91,039	15.44%
		TOTAL CIVIL COST (in crores)	1,453	100.00%

The Total Project Cost for Package-2 is given below:

Table 9-2**: Total Project Cost**

S No.	Description	Amount (In Crores)
I	Civil Construction Cost (Rs. In Crores)	1452.94
	Grand Total of Civil Constructions Cost	1452.94
II	Centages (Rs in Crores)	
1	Contingencies @ 2.8%	40.68
2	Construction Supervision @ 2%	29.06
3	Administrative Charges @ 1%	14.53
4	Quality Control Charges @ 1%	14.53
5	Road Safety @ 0.5%	7.26
6	Maintenance During DLP @ 5%	72.65
7	Escalation during Construction @ 5% per annum	145.30
	Total Cost (including Centages) (Rs. In crores)	1776.95
	Cost of Preconstruction Activities (Rs. In Crores)	
1	Land Acquisition	0
2	Utility Shifting (Electrical Overhead & Underground, Water supply, Sewarage,Gas pipe line & OFC)	45
	Total Capital Cost (Rs. In Crores)	1821.95