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EXECUTIVE SUMMARY

0.1 INTRODUCTION

Uttar Pradesh Expressways Industrial Development Authority (known by its acronym UPEIDA) was set up by the State Government under U.P. Industrial Areas Development Act 1976, in December 2007 for development of Expressways in Uttar Pradesh. This is a newly established Organization with lean and laborious employee base, on contract or on deputation basis from State Revenue Department/PWD, among them few are deployed on retainership basis or by service provider.

Govt. of Uttar Pradesh (GoUP) has successfully developed 165 km Noida to Agra 6 Lane Access Controlled Expressway (Yamuna Expressway). Rigid pavement has been constructed for the entire length of the expressway. The project was developed on Public Private Partnership (PPP) mode and is in operation since August 2012.

Fig. 0.1 - Yamuna Expressway

The work of linking this expressway with State Capital through another high speed six lane corridor namely "Agra to Lucknow Access Controlled Expressway (Green Field) Project" has also been successfully completed. It is India's largest 302 Km access controlled Greenfield expressway. The entire length of the project road is of flexible pavement type. This Expressway Project has been developed on EPC mode with Government funding.

Fig. 0.2 – Agra-Lucknow Expressway

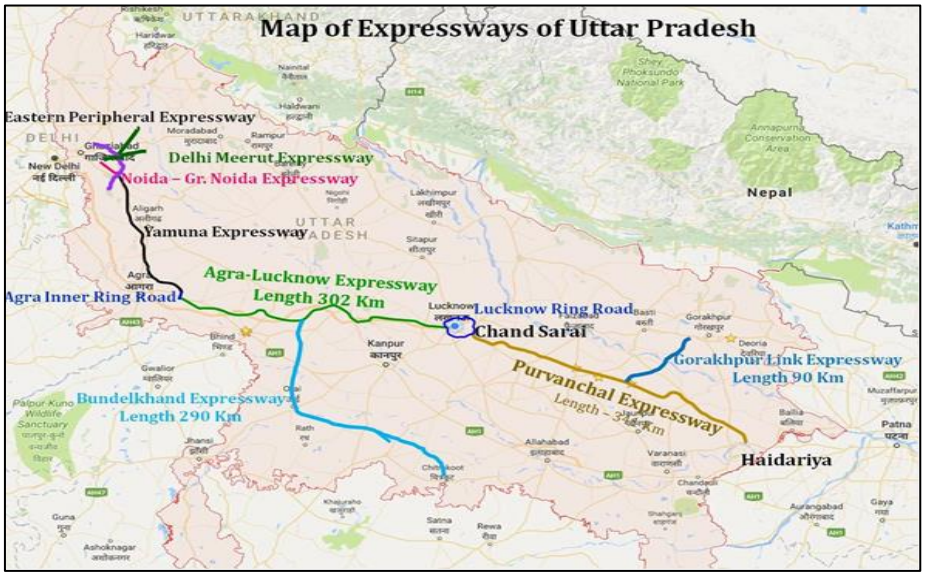
The Yamuna Expressway & Agra-Lucknow Expressway network starting from Noida area to Lucknow city provides seamless travel between State Capital and National Capital.

The Authority is developing another 6 Lane Access Controlled Green Field Expressway "The Purvanchal Expressway" in EPC Mode, which will connect to outer Ring Road in Lucknow which in turn will be connected to "Agra-Lucknow Access Controlled Expressway (Green Field) Project" at Lucknow. This Expressway project shall create immense opportunities to the people of eastern region of the State and over all development of the State by providing high speed connectivity between East & West borders of the State and with national capital.

The construction for 'Purvanchal Expressway', 'Bundelkand Expressway' & 'Gorakpur Link Expressway' projects are in progress & these Expressways are expected to be ready by 2020, 2022 & 2022 respectively.

Fig. 0.3 – Construction of Purvanchal Expressway

The Uttar Pradesh Government has decided to develop the "Ganga Expressway Project". UPEIDA is committed for the development of this expressway and has Entrusted M/s L N Malviya Infra Projects Pvt. Ltd., Highway Engineering Consultant and Intratech Civil Solutions (Consortium) to carry out the detailed project report to implement the project on EPC Mode and selection of developers through competitive bidding process.



The project will provide direct high speed connectivity from National Capital Region through proposed expressway to Meerut and then onwards to Prayagraj. It will facilitate construction of all-weather high speed access controlled expressway, which will decongest the increasing traffic on existing road network. The expressway will also decrease travel time substantially.

The Consultant has undertaken requisite surveys & studies for the project which includes costing to assess technical, environmental and social assessment studies, their analysis etc. As a part of the study to establish the viability, this Project Report has been prepared after carrying out engineering surveys and appropriate assessment of a preliminary design considering the engineering conditions, the present traffic and its growth, the environmental impact assessment as well as the social aspects along with cost assessment. This report among other aspects covers the details on finalization of alignment, grade separator interchanges and structures along the proposed Expressway, marking on the Khasra maps of ROW and marking of alignment on revenue maps, identification of Tourist spots, eco-friendly structures, water bodies etc. along the expressway.

The Project Report contains the following chapters:

- Executive Summary
- Chapter 1: Introduction
- Chapter 2: Project Description
- Chapter 3: Methodology and Design Standards
- Chapter 4: Traffic Studies
- Chapter 5: Highway Design & Proposed Typical Cross-Sections, Service Roads, Roadside Drains & Air Strip
- Chapter 6: Pavement Design & Proposals
- Chapter 7: Hydrological Studies & Drainage Design
- Chapter 8: Proposals for Structures & Interchanges
- Chapter 9: Project Facilities, Roadside Features & Road Safety
- Chapter 10: Social & Environmental Studies
- Chapter 11: Cost Estimate

0.2 APPROACH AND METHODOLOGY

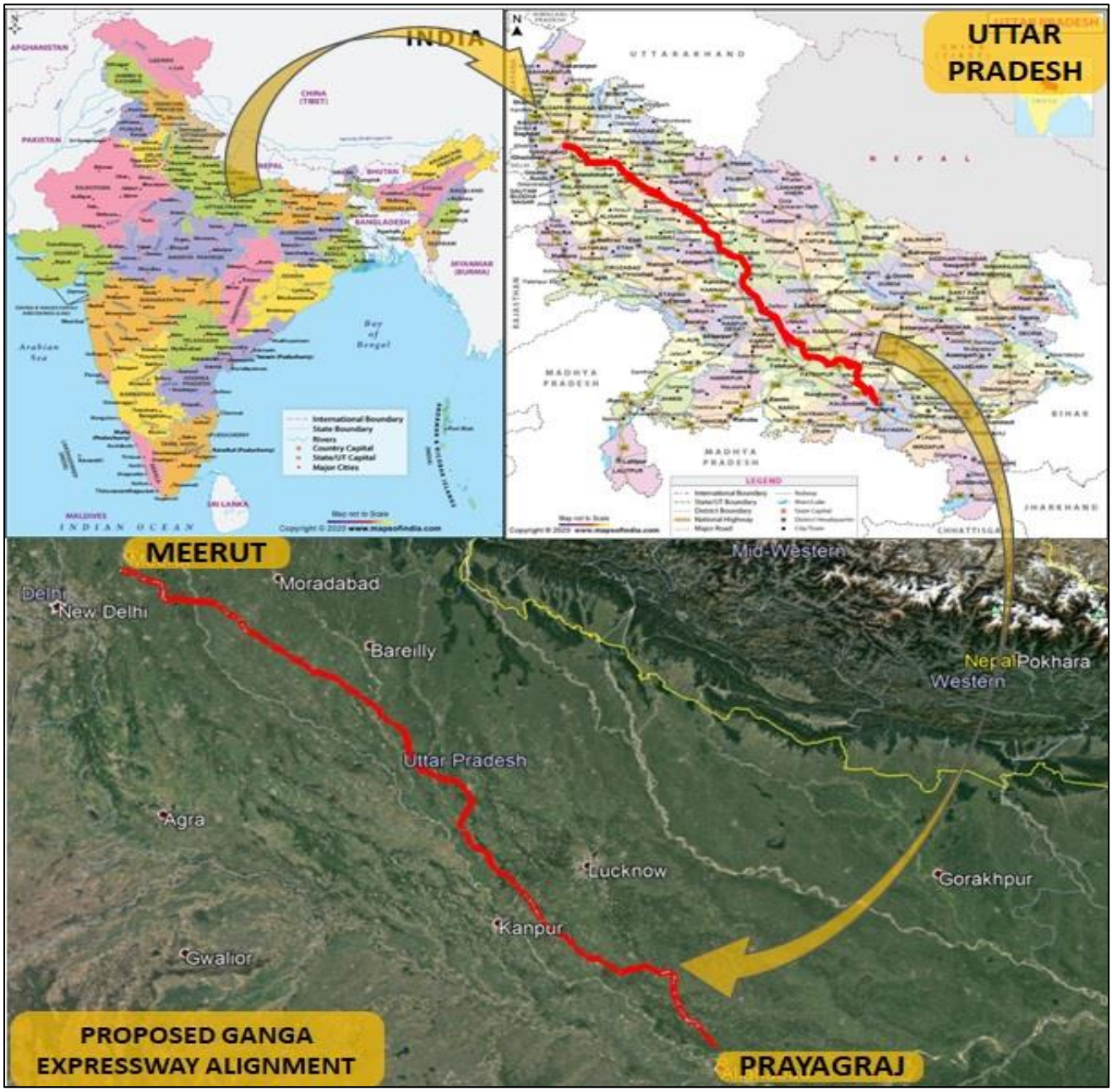
Methodology adopted for the study was initially presented in Inception Report. The methodology adopted for the project is based on initial studies, secondary data, traffic analysis, topographic survey, revenue calculations and Cost Estimates. The project area social screening/RAP and Environment Impact Assessment are also completed for the detailed Engineering stage (DPR). The government policies about Land acquisition is also covered in the detailed Engineering stage (DPR). The methodology adopted is in line with the requirements of the ToR. The methodology adopted to arrive at detailed Engineering stage is covered in chapter 3. Detailed Engineering and field studies such as soil investigations, Environment Impact Analysis and design works are completed for the most preferred alignment Option-1.

0.3 PROJECT ALIGNMENT DESCRIPTION

The proposed Ganga Expressway starts from **km 16+000** of Meerut-Bulandshahar (NH-334) near village Bijoli (Dist. Meerut) **(CH 7+900)** & terminates at Prayagraj Bypass on NH-19 near village Judapur Dando (Dist. Prayagraj) **(CH 601+847)**.

The length of the proposed expressway alignment is **593.947 km**.

The project Index Map is Shown below:



The proposed expressway has been divided into 12 packages. The chainage wise detail of the packages has been given in Table-0.1 below: The Project under consideration is Package-9.

Table-0.1

Package No.	Section Details	Chainage (km)		Length
		From	To	
I	From Village Bijoli (Dist. Meerut) to Village-Chandner (Dist. Hapur)	7.900	56.900	49.000
II	From Village-Chandner (Dist. Hapur) to Village-Mirzapur Dugar (Dist. Amroha)	56.900	86.900	30.000
III	From Mirzapur Dugar (Dist. Amroha) to Village-Nagla Barah (Dist. Budaun)	86.900	137.600	50.700
IV	From Village-Nagla Barah (Dist. Budaun) to Village-Binawar (Dist. Budaun)	137.600	189.700	52.100
V	From Binawar (Dist.Budaun) to Girdharpur (Dist. Shahjahanpur)	189.700	236.400	46.700
VI	From Village- Girdharpur (Dist. Shahjahanpur) to Village-Ubariya Khurd (Dist. Hardoi)	236.400	289.300	52.900
VII	From Village-Ubariya Khurd (Dist. Hardoi) to Village- Pandra Lakhanpur (Dist. Hardoi)	289.300	341.700	52.400
VIII	From Village- Pandra Lakhanpur (Dist. Hardoi) to Village-Raiyamau(Dist. Unnao)	341.700	391.900	50.200
IX	From Village- Raiyamau (Dist. Unnao) to Village-Sarso (Dist. Unnao)	391.900	445.000	53.100
X	From Village- Sarso (Dist. Unnao) to Village-Terukha (Dist. Raebareli)	445.000	496.800	51.800
XI	From Village-Terukha (Dist. Raebareli) to Village-Arro (Dist. Pratapgarh)	496.800	548.800	52.000
XII	From Village- Arro (Dist. Pratapgarh) to Village-Judapur Dando (Dist. Prayagraj)	548.800	601.847	53.047
Total				**593.947**

The Expressway is access controlled with only entry/exit at Nodes (intersecting points of National Highway or State Highways or Major District Roads – crossing with the proposed Expressway Alignment), details of which has been described in Table-0.3.

0.3.1 Alignment & Structures

The expressway alignment is having 6 Lanes with Paved Shoulders Configuration with Service Roads, which is further expandable up to 8 Lanes. The alignment has been designed with the design speed of 120 km/h.

The key features of the project alignment are given in Table 0.2 below:

Table-0.2

S. No.	Particulars	Nos. / Length
1	Length (km)	53.100
2	Major Bridges	1
3	Minor Bridges	14
4	Culverts	79

S. No.	Particulars	Nos. / Length
5	ROB	1
6	VUP	7
7	LVUP	12
8	SVUP	8
9	Flyovers	1
10	Trumpet	0
11	Double Trumpet	0
12	Diamond Interchange	1
13	Way Side Amenities	1
14	Proposed Node Development	1

0.3.2 Node Development

The Expressway is access controlled with only entry/exit at Nodes (intersecting points of National Highway or State Highways or Major District Roads – crossing with the proposed Expressway Alignment). In view of the background and detailed discussions held with UPEIDA and other stake holders such as the Revenue Authorities, Eighteen locations were selected along the project corridor where Nodes would be developed and are lettered "A" to "R", out of which Node 'N' falls under Package-9 as listed in Table-0.3 below:

Table-0.3

Toll Nodes	Chainage	Details of the Intersecting Roads	Road No.	Type of Interchange
A	0+100	Delhi - Meerut Expressway	Expressway	Dummy Node
B	8+920	Meerut – Hapur	NH-334	Trumpet
C	35+270	Hapur - Garhmukteshwar	NH-24	Diamond
D	54+640	Bulandshahr - Garhmukteshwar	SH-65	Diamond
E	74+181	Hasanpur-Anupshahar	MDR-162W	Diamond
F	102+427	Anupshahr - Moradabad	ODR	Diamond
G	123+288	Babrala - Chandausi	NH-509	Double Trumpet
H	173+454	Chandausi - Budaun	SH-125	Diamond
I	189+394	Budaun - Bareilly	SH-33	Double Trumpet
J	255+167	Farukkhabad - Shahjahanpur	SH-29	Double Trumpet
K	282+845	Farukkhabad - Shahbad	SH-138	Diamond
L	329+945	Kannauj– Hardoi	SH-21	Double Trumpet
M	378+136	Agra - Lucknow Expressway	Agra Lucknow Exp	Double Trumpet
N	420+932	Kanpur - Lucknow	NH-27	Diamond
O	487+285	Lalganj - Raebareli	NH-31	Double Trumpet
P	517+708	Raebareli–Unchahar	NH-30	Double Trumpet
Q	554+951	Manikpur - Bela Pratapgarh	MDR-102E	Diamond
R	600+457	Prayagraj Bypass	NH-19	Trumpet

Node A is revised and treated as Dummy Node in this Report, as the Start Point of the Ganga Expressway has been changed from Node A to Node B due to Engineering Design Constraints, with prior approval of UPEIDA.

0.4 RIGHT OF WAY

ROW has been taken as total 120 m for the proposed expressway except at Interchange Locations, Way Side Amenities (including Toilet Block), Toll Plaza locations and at locations for training on the course of nallah/drain and at airstrip, where the ROW varies.

0.5 ABUTTING LAND USE PATTERN

The land use pattern on the both sides of the expressway in maximum section is agricultural.

0.6 TERRAIN

The terrain of this stretch can be termed as plain and flat throughout.

0.7 FOREST

No forest land observed along the road. However, the alignment passes some stretches of Social Forestry.

0.8 ARCHEOLOGICAL/ANCIENT STRUCTURE

No such type of structure found along the project corridor.

0.9 TRAFFIC SURVEYS, ANALYSIS AND PROJECTIONS

The traffic surveys were mainly:

(a) Origin and destination surveys (which included willingness-to-pay "stated-preference" questions and, in one instance where this type of survey was possible, a "revealed-preference" survey – see below); and

(b) Classified Volume Count Surveys;

(c) Axle Load Surveys

All survey types were conducted in accordance with the guidelines specified in IRC 9-1972, IRC 102-1988 and IRC SP19-2001.

The surveys were conducted at points close to where the proposed Expressway would intersect with the National, State and other highways/district roads and other locations from which, traffic that may eventually use the Expressway either partly or entirely.

Table-0.5 Locations for Road-Side Origin and Destination (O-D) Surveys

OD. No.	Survey Location	Stretch & Road Name	Day & Date of O-D Survey
1	Siwaya Toll Booth	Muzaffarnagar - Meerut	Wednesday, 12thFebruary 2020
2	Nizampur	Meerut - Garhmukteshwar	Friday, 6th December 2019
3	Kurkawali	Hasanpur - Chandausi	Monday, 4th November 2019
5	Nagariya	Aligarh - Etah	Wednesday, 27th November 2019
6	Khankah e Niyaziya	Aliganj - Farrukhabad	Monday, 9th December 2019

OD. No.	Survey Location	Stretch & Road Name	Day & Date of O-D Survey
7	Samdhan	Farrukhabad - Kannauj	Wednesday, 27th November 2019
8	Bilhaur	Kannauj - Kanpur	Monday, 2nd December 2019
9	Katohan Toll Booth	Fatehpur - Prayagraj	Monday, 16th February 2020
10	Agwanpur	Bijnor - Moradabad	Friday, 29th November 2019
11	Faridpur Toll Booth	Bareilly - Shahjahanpur	Monday, 2nd December 2019
12	Nawada	Chandausi - Budaun	Thursday, 28th November 2019
13	Usawan	Budaun - Farrukhabad	Thursday, 5th December 2019
14	Shahabad	Shahjahanpur - Hardoi	Friday, 29th November 2019
15	Safipur	Bangarmau - Unnao	Wednesday, 4th December 2019
16	Semari	Unnao - Lalganj	Friday, 6th December 2019
17	Andiyari	Unchahar - Prayagraj	Tuesday, 10th December 2019

Seven-day count using video coverage was undertaken on National Highways/State Highways/Major District Roads where Road Side Origin-Destination Surveys were carried out – results **(Average Daily Traffic - ADT**) are shown on Tables 4.6 and detailed counts at each location are provided in Appendix.

Table-0.6 Average Daily Traffic (ADT) on Existing Alternate Roads

Vehicle Classification			PCU Factor	Muzaffarnagar – Meerut	Aligarh - Etah	Aliganj - Farrukhabad	Farrukhabad – Kannauj	Kannauj - Kanpur	Budaun – Farrukhabad	Meerut – Garhmukteshwar	Hasanpur - Chandausi	Chandausi - Budaun	Bijnor - Moradabad	Bareilly – Shahjahanpur	Shahjahanpur - Hardoi	Bangarmau - Unnao	Unnao - Lalganj	Unchahar - Prayagraj	Fatehpur - Prayagraj
Passenger Vehicles	Two Wheeler		0.5	5380	1750	2813	3569	2723	1776	3683	2285	3453	7080	9565	3514	6026	2838	6245	3162
	Three Wheeler		1.5	877	605	124	658	415	87	695	254	212	934	1749	347	362	74	586	300
	Car/Van/ Jeep		1.0	12525	736	679	1921	2444	964	4879	855	2027	5179	5976	2476	2163	1282	4632	3094
	Mini Bus		1.5	21	4	18	9	35	7	11	8	7	39	21	19	31	3	52	32
	Bus		3.0	1253	541	37	75	249	244	430	202	278	581	578	197	191	210	490	469
Govt. & Other Vehicles	Tempo/ LCV		1.5	1048	346	226	344	795	315	842	510	707	745	1794	783	742	618	956	1274
	Commercial Vehicles	2 Axle	3.0	484	1061	73	85	853	430	599	164	456	263	1509	231	280	493	448	1033
		3 Axle	3.0	325	1066	50	90	877	438	561	176	447	283	1453	392	491	501	656	1062
		M-Axle	4.5	665	826	138	146	972	454	481	152	509	143	2375	467	606	778	1171	2464
Agricultural Vehicles	Tractor		1.5	20	26	17	17	20	31	48	26	50	43	26	28	38	20	34	13
	Tractor with Trailer		4.5	71	82	139	99	103	151	250	250	282	325	206	243	111	37	356	89
Passenger Vehicles	Cycle		0.5	42	152	950	357	239	286	385	82	500	125	527	835	500	570	501	151
	Cycle Rickshaw		2.0	11	2	0	0	0	9	23	3	7	26	0	0	0	0	0	11
Goods Vehicles	Animal Drawn	Bullock Cart	8.0	0	2	13	10	1	24	50	0	6	14	84	30	16	17	47	0
		Horse	8.0	0	3	0	0	0	35	0	0	24	11	0	0	0	0	0	0
	Hand Cart		3.0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	Other (Pl. Specify)		2.0	24	10	0	3	6	17	28	7	14	42	29	31	1	9	3	16
Total Vehicles (Nos.)				**22749**	**7212**	**5277**	**7383**	**9733**	**5269**	**12966**	**4974**	**8980**	**15833**	**25892**	**9594**	**11558**	**7449**	**16178**	**13170**
Total Vehicles (PCUs)				**27761**	**15313**	**4975**	**7364**	**16617**	**9240**	**17867**	**6692**	**12859**	**17245**	**39371**	**12376**	**13428**	**11487**	**22484**	**26414**

0.10 PAVEMENT DESIGN

Flexible pavement has been adopted for new carriageways throughout the project length except at toll plaza/booth & Air strip locations. In the toll plaza/booth area & Air strip, rigid pavement has been adopted.

(a) New Flexible Pavement Design

The pavement design basically aims at determining the total thickness of the pavement structure as well as thickness of individual structural components. The following assumptions are considered for the preliminary pavement design. The basic assumptions considered while designing are as follows:

- Design life of 20 (after construction period) years has been considered for flexible pavement design.
- Sub grade CBR (for design) has been taken as 8%.
- Design life for Cement Concrete pavement has been assumed as 30 years.

Proposed Crust Composition for New Construction

Proposed Crust For Main Carriageway										
Package No.	Section		Length (m)	Adopted MSA (20 Years)	Design CBR	Crust Composition (in mm)				
	From	To				Subgrade	GSB	WMM	DBM	BC
IX	391.90	445.00	53.10	98	8%	500	200	150	155	40

(b) Service roads have been designed for 5 MSA with design CBR of 8%. The crust composition of service roads is given in Table below:

Proposed Crust For Service Road							
Package No.	Design MSA	Design CBR	Crust Composition (in mm)				
			BC	DBM	WMM	GSB	Subgrade
IX	5	8%	30	50	150	150	500

0.11 ROAD SIDE DRAINS

Lengths and types of Drains are given in table below:

Package No.	Length of Drain					Remarks
	Unlined Drain (LHS+RHS)	Lined Drain (LHS+RHS)	Median Drain	Covered Drain (LHS+RHS)	Chute Drain	
IX	42200	63188	51030	-	41920	
Total Length (km)	**42.200**	**63.188**	**51.030**	**-**	**41.920**	

0.12 SERVICE ROADS

Details of proposed Service Roads are as follows:

Package No.	3.75 m Service Road (Km)		7.0 m Service Road (Km)		10.0 m Service Road (Km)	
	LHS	RHS	LHS	RHS	LHS	RHS
IX	33.79	25.12	3.08	2.01	0	0

0.13 AIR STRIPS

Air Strip has not been proposed in Package-9.

0.14 GRADE SEPARATED STRUCTURES

Package wise count & details of Grade Separated structures are given in table below:

Package No.	ROB (Nos.)	VUP (Nos.)	LVUP (Nos.)	SVUP (Nos.)	Flyover (Nos.)	Trumpet (Nos.)	Double Trumpet (Nos.)	Diamond Interchange (Nos.)
Package-9	1	7	12	8	1	0	0	1

Table 0.12 (a) List of Road Over-bridge (ROB)

S. No.	Chainage	Type of Structure			Span Arrangement	Width of Structure (m)	Skew Angle, if any	Remarks
		Foundation	Sub Structure	Super Structure				
1	420+100	Pile	R.C.C.	Bowstring	1X15+1X64.09+1X15	4X12.5	0	Package-9

Table 0.12 (b) List of Vehicular Underpass (VUP)

S. No.	Chainage	Type of Crossing	Structure Type	Span Arrangement		Width of Structure (m)	Skew Angle, if any	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)			
1	395+440	ODR	Box	2X10	5.5	2x21.25	10	Package-9
2	398+662	ODR	Box	2X10	5.5	2x21.25	15	Package-9
3	401+755	ODR	Box	2X10	5.5	2x21.25	20	Package-9
4	423+352	ODR	Box	2X10	5.5	2x21.25	15	Package-9
5	424+000	WSA	Box	2X10	5.5	2x21.25	0	Package-9
6	432+750	MDR	Box	2X10	5.5	2x21.25	48	Package-9
7	438+821	ODR	Box	2X10	5.5	2x21.25	45	Package-9

Table 0.12 (c) List of Light Vehicular Underpass (LVUP)

S. No.	Chainage	Type of	Structure	Span Arrangement	Width of	Remarks

		Crossing	Type	Lateral Clearance (m)	Vertical Clearance (m)	Structure (m)	
1	393+700	VR	Box	12	4.5	2X21.25	Package-9
2	406+260	VR	Box	12	4.5	2X21.25	Package-9
3	407+810	VR	Box	12	4.5	2X21.25	Package-9
4	409+650	VR	Box	12	4.5	2X21.25	Package-9
5	417+790	VR	Box	12	4.5	2X21.25	Package-9
6	418+925	VR	Box	12	4.5	2X21.25	Package-9
7	424+832	Road	Box	12	4.5	2X21.25	Package-9
8	427+763	VR	Box	12	4.5	2X21.25	Package-9
9	429+990	VR	Box	12	4.5	2X21.25	Package-9
10	431+017	VR	Box	12	4.5	2X21.25	Package-9
11	440+340	VR	Box	12	4.5	2X21.25	Package-9
12	443+785	VR	Box	12	4.5	2X21.25	Package-9

Table 0.12 (d) List of Smaller Vehicular Underpass (SVUP)

S. No.	Chainage	Type of Crossing	Type of Structure	Span Arrangement		Width of Structure	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
1	392+840	VR	Box	7	4.0	2X21.25	Package-9
2	396+302	VR	Box	7	4.0	2X21.25	Package-9
3	400+300	VR	Box	7	4.0	2X21.25	Package-9
4	404+741	VR	Box	7	4.0	2X21.25	Package-9
5	411+800	VR	Box	7	4.0	2X21.25	Package-9
6	413+212	VR	Box	7	4.0	2X21.25	Package-9
7	415+400	VR	Box	7	4.0	2X21.25	Package-9
8	442+785	VR	Box	7	4.0	2X21.25	Package-9

Table 0.12 (e) List of Flyovers

S. No.	Chainage	Type of Crossing	Structure Type			Span Arrangement	Width of Structure	Remarks
			Foundation	Sub Structure	Super Structure			
1	420+932	NH-27	Pile	R.C.C.	PSC I Girder	2x30	2x21.25	Package-9

Table 0.12 (f) List of Trumpets

S. No.	Chainage	Type of Crossing	Remarks

NIL

Table 0.12 (g) List of Double Trumpets

S. No.	Chainage	Type of Crossing	Remarks
1	123+288	NH-509	Package-3
2	189+394	SH-33	Package- 4
3	255+167	SH-29	Package-6
4	329+945	SH-21	Package-7
5	378+136	Agra-Lucknow Expressway	Package-8
6	487+285	NH-31	Package-10
7	517+708	NH-30	Package-11

Table 0.12 (h) List of Diamond Interchanges

S. No.	Chainage	Type of Crossing	Remarks
1	420+932	NH-27	Package-9

0.15 CROSS DRAINAGE STRUCTURES

Package wise count of Major Bridges, Minor Bridges & culverts is given in table below:

Package No.	Major Bridges (Nos.)	Minor Bridges (Nos.)	Culverts (Nos.)
Package-9	1	14	79

Table-0.13 (a) List of Major Bridges

S. No.	Chainage	Type of Crossing	Type of Structure			Span Arrangement	Width of Structure	Skew Angle, if any	Remarks
			Found-ation	Sub Structure	Super Structure				
1	422+002	Canal+Road	Well	R.C.C.	PSC Box Girder	3 X 20.033	2x21.25	45	Package-9

Table-0.13 (b) List of Minor Bridges

S. No.	Chainage	Type of	Type of Structure	Span	Width of	Skew	Remarks

		Crossing	Found-ation	Sub Structure	Super Structure	Arrangement	Structure	Angle, if any	
1	392+612	Canal	Raft	Box MNB	Box MNB	1X8	2x21.25	44	Package-9
2	394+132	Stream/ Nallah	Raft	Box MNB	Box MNB	1X10X5	2x21.25	9	Package-9
3	397+182	Canal+Road	Raft	Box MNB	Box MNB	2 x 7.5 x 7.5	2x21.25	49	Package-9
4	401+175	Stream/ Nallah	Raft	Box MNB	Box MNB	1X8X5	2x21.25	0	Package-9
5	402+750	Stream/ Nallah	Raft	MNB	MNB	1X25	2x21.25	0	Package-9
6	407+037	Stream/ Nallah	Raft	Box MNB	Box MNB	1X10X5	2x21.25	0	Package-9
7	408+332	Stream/ Nallah	Raft	MNB	MNB	1 X 20	2x21.25	45	Package-9
8	414+612	Canal+Road	Raft	Box MNB	Box MNB	1x13	2x21.25	24	Package-9
9	420+322	Stream/ Nallah	Raft	Box MNB	Box MNB	2X8X5	2x21.25	0	Package-9
10	428+544	Canal	Raft	Box MNB	Box MNB	1X8	2x21.25	0	Package-9
11	431+336	Stream/ Nallah	Raft	MNB	MNB	1X30	2x21.25	24	Package-9
12	433+605	Canal+Road	Raft	Box MNB	Box MNB	1x13	2x21.25	0	Package-9
13	436+039	Canal+Road	Raft	Box MNB	Box MNB	1X10	2x21.25	29	Package-9
14	440+437	Gas Pipe Line	Raft	MNB (Portal Frame)	MNB (Portal Frame)	1X9	2x21.25	56	Package-9

Table-0.13 (c) List of Culverts

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
1	392+180	Culvert	2	2	2X21.25	Package-9
2	393+093	Culvert	2	2	2X21.25	Package-9
3	394+717	Culvert	2	2	2X21.25	Package-9
4	395+170	Culvert	2	2	2X21.25	Package-9
5	396+761	Culvert	2	2	2X21.25	Package-9
6	397+550	Culvert	2	2	2X21.25	Package-9
7	398+245	Culvert	3	3	2X21.25	Package-9
8	399+192	Culvert	3	3	2X21.25	Package-9
9	399+630	Culvert	2	2	2X21.25	Package-9
10	400+002	Culvert	3	3	2X21.25	Package-9
11	400+670	Culvert	2	2	2X21.25	Package-9
12	401+580	Culvert	2	2	2X21.25	Package-9
13	402+530	Culvert	2	2	2X21.25	Package-9
14	403+413	Culvert	2	2	2X21.25	Package-9
15	403+850	Culvert	3	3	2X21.25	Package-9
16	404+176	Culvert	3	3	2X21.25	Package-9
17	405+500	Culvert	2	2	2X21.25	Package-9
18	406+430	Culvert	2	2	2X21.25	Package-9

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
19	407+470	Culvert	3	3	2X21.25	Package-9
20	408+675	Culvert	2	2	2X21.25	Package-9
21	409+270	Culvert	3	3	2X21.25	Package-9
22	410+240	Culvert	2	2	2X21.25	Package-9
23	410+819	Culvert	2	2	2X21.25	Package-9
24	410+856	Culvert	2	2	2X21.25	Package-9
25	411+263	Culvert	2	2	2X21.25	Package-9
26	411+531	Culvert	2	2	2X21.25	Package-9
27	412+095	Culvert	2	2	2X21.25	Package-9
28	412+890	Culvert	2	2	2X21.25	Package-9
29	413+700	Culvert	2	2	2X21.25	Package-9
30	414+572	Culvert	2	2	2X21.25	Package-9
31	415+550	Culvert	2	2	2X21.25	Package-9
32	416+134	Culvert	2	2	2X21.25	Package-9
33	416+820	Culvert	2	2	2X21.25	Package-9
34	417+110	Culvert	3	3	2X21.25	Package-9
35	417+302	Culvert	4	3	2X21.25	Package-9
36	418+410	Culvert	3	3	2X21.25	Package-9
37	419+280	Culvert	2	2	2X21.25	Package-9
38	419+590	Culvert	3	3	2X21.25	Package-9
39	421+060	Culvert	5	3	2X21.25	Package-9
40	421+590	Culvert	3	3	2X21.25	Package-9
41	422+720	Culvert	3	3	2X21.25	Package-9
42	423+610	Culvert	2	2	2X21.25	Package-9
43	424+561	Culvert	2	2	2X21.25	Package-9
44	425+468	Culvert	2	2	2X21.25	Package-9
45	426+100	Culvert	3	3	2X21.25	Package-9
46	426+202	Culvert	3	3	2X21.25	Package-9
47	426+835	Culvert	3	2	2X21.25	Package-9
48	427+130	Culvert	2	2	2X21.25	Package-9
49	428+369	Culvert	3	3	2X21.25	Package-9
50	429+300	Culvert	2	2	2X21.25	Package-9
51	430+428	Culvert	3	3	2X21.25	Package-9
52	431+664	Culvert	2	2	2X21.25	Package-9
53	432+060	Culvert	3	3	2X21.25	Package-9

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
54	433+170	Culvert	2	2	2X21.25	Package-9
55	434+260	Culvert	2	2	2X21.25	Package-9
56	434+650	Culvert	2	2	2X21.25	Package-9
57	435+032	Culvert	2	2	2X21.25	Package-9
58	435+480	Culvert	2	2	2X21.25	Package-9
59	436+263	Culvert	3	3	2X21.25	Package-9
60	436+790	Culvert	2	2	2X21.25	Package-9
61	437+430	Culvert	2	2	2X21.25	Package-9
62	438+268	Culvert	3	3	2X21.25	Package-9
63	438+600	Culvert	6	3	2X21.25	Package-9
64	439+265	Culvert	3	3	2X21.25	Package-9
65	439+623	Culvert	3	2	2X21.25	Package-9
66	440+140	Culvert	2	2	2X21.25	Package-9
67	440+870	Culvert	2	2	2X21.25	Package-9
68	441+430	Culvert	3	3	2X21.25	Package-9
69	442+000	Culvert	2	2	2X21.25	Package-9
70	442+485	Culvert	2	2	2X21.25	Package-9
71	442+840	Culvert	2	2	2X21.25	Package-9
72	443+499	Culvert	2	2	2X21.25	Package-9
73	444+463	Culvert	2	2	2X21.25	Package-9
74-75	420+932	Culverts @ Diamond Interchange	2	2	2 Culverts	Package-9
76	420+932	Culverts @ Diamond Interchange	5	3	1 Culvert	Package-9
77	420+932	Culverts @ Diamond Interchange	5	3	1 Culvert	Package-9
78	423+844	HPC @ Way Side Amenities	1X1200		1 Culvert	Package-9
79	424+140	HPC @ Way Side Amenities	1X1200		1 Culvert	Package-9

0.16 RAILWAY TRACKS/CROSSINGS

There is 1location where expressway corridor crosses railway lines. 1 No. of Rail over Bridge (ROB) has been proposed at this location, list of which has already been attached above in in Table-0.12 (a).

0.17 TOLL PLAZAS & RAMP PLAZAS

4 Ramp Plazas (2 lanes on each leg) on Diamond Interchange have been proposed along the project corridor. List of the Toll Plazas & Toll Booths is attached below:

S. No.	Location	Remarks

S. No.	Location		Remarks
1	420+932	Kanpur - Lucknow	Ramp Plaza

0.18 WAY SIDE AMENITIES

Way Side Amenities have been proposed on 1 location along the project corridor. WSA will be approachable from both side of MCW.

S. No.	Chainage	LHS/RHS
1	424+000	LHS

0.19 SOCIAL IMPACT ASSESSMENT (SIA) AND R&R POLICY

Social Impact Assessment will involve:

(i) Agricultural/Homestead/Commercial Land Impacts;

(ii) Loss of Structures (Residential/Commercial/Other);

(iii) Loss of livelihood due to loss of primary source of income;

(iv) Loss of community infrastructure/common property resources;

(v) Temporary Impacts on agricultural land due to plant site for contractor etc.;

(vi) Any unanticipated impacts due to the project will be documented and mitigated based on the spirit of the principle agreed upon in this policy framework.

R&R Policies:

The project being greenfield alignment will require acquisition of large area of agriculture/ private/ government land. However, it is kept in mind while finalizing the alignment that the impact to the structures is minimum.

The R&R policies for the impacts to the Land (agricultural/Private/Government), Structures, Persons, Livelihood & others will involve various kind of compensations involving financial assistance, compensation for land, land for land (if feasible), compensation for crops, rental accommodation etc., whichever applicable based on the policy norms.

0.20 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The major objective of EIA study is to establish present environmental condition along the project corridor through available data / information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. An Environmental Impact Assessment (EIA) study basically includes:

- Establishment of the present environmental scenario

- Study of the specific activities related to the project
- Evaluation of the probable environmental impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan

0.21 TCS SCHEDULE FOR THE PROJECT

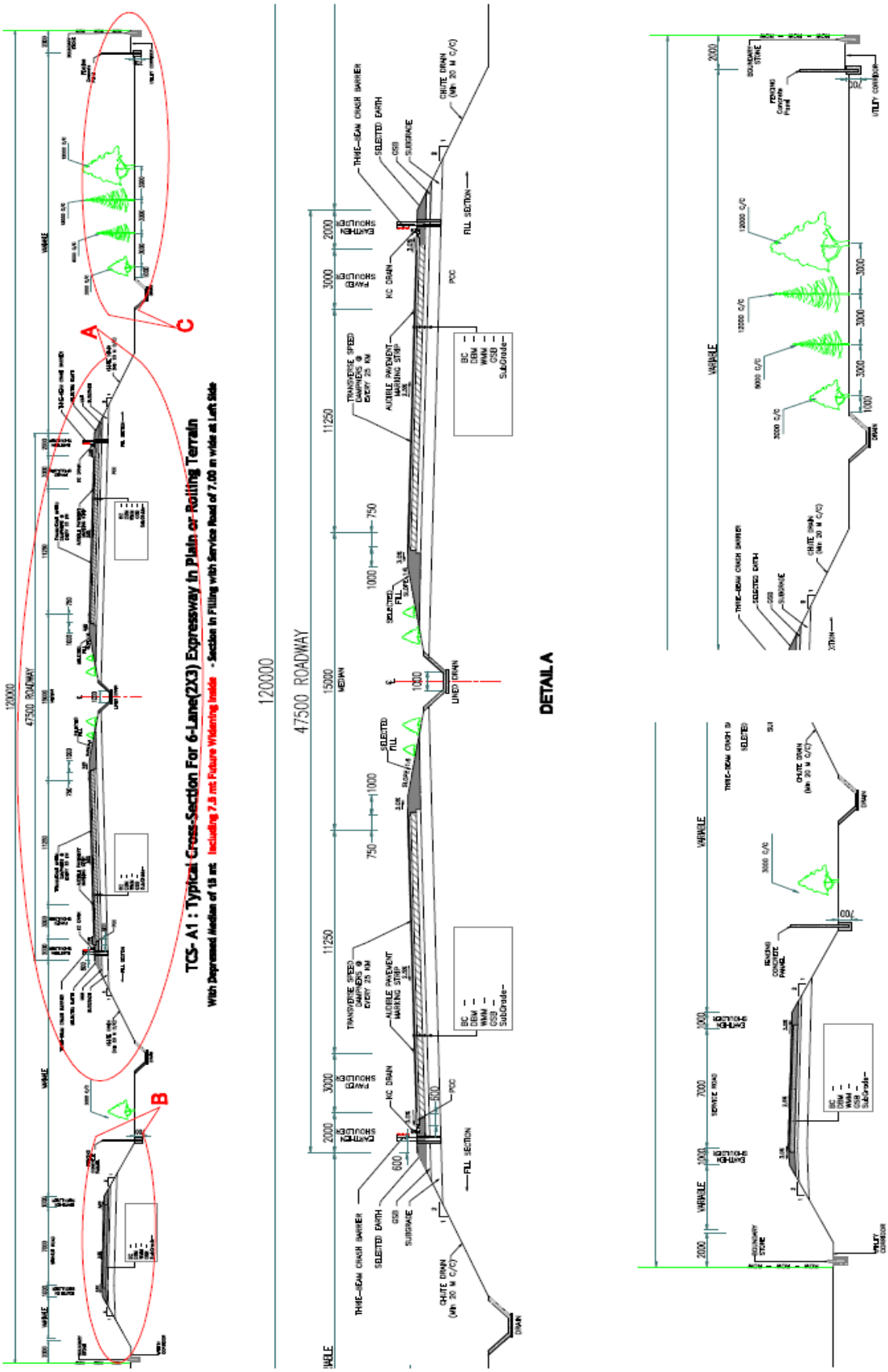
The chainage wise list of Typical Cross-sections applicable along the project is attached below:

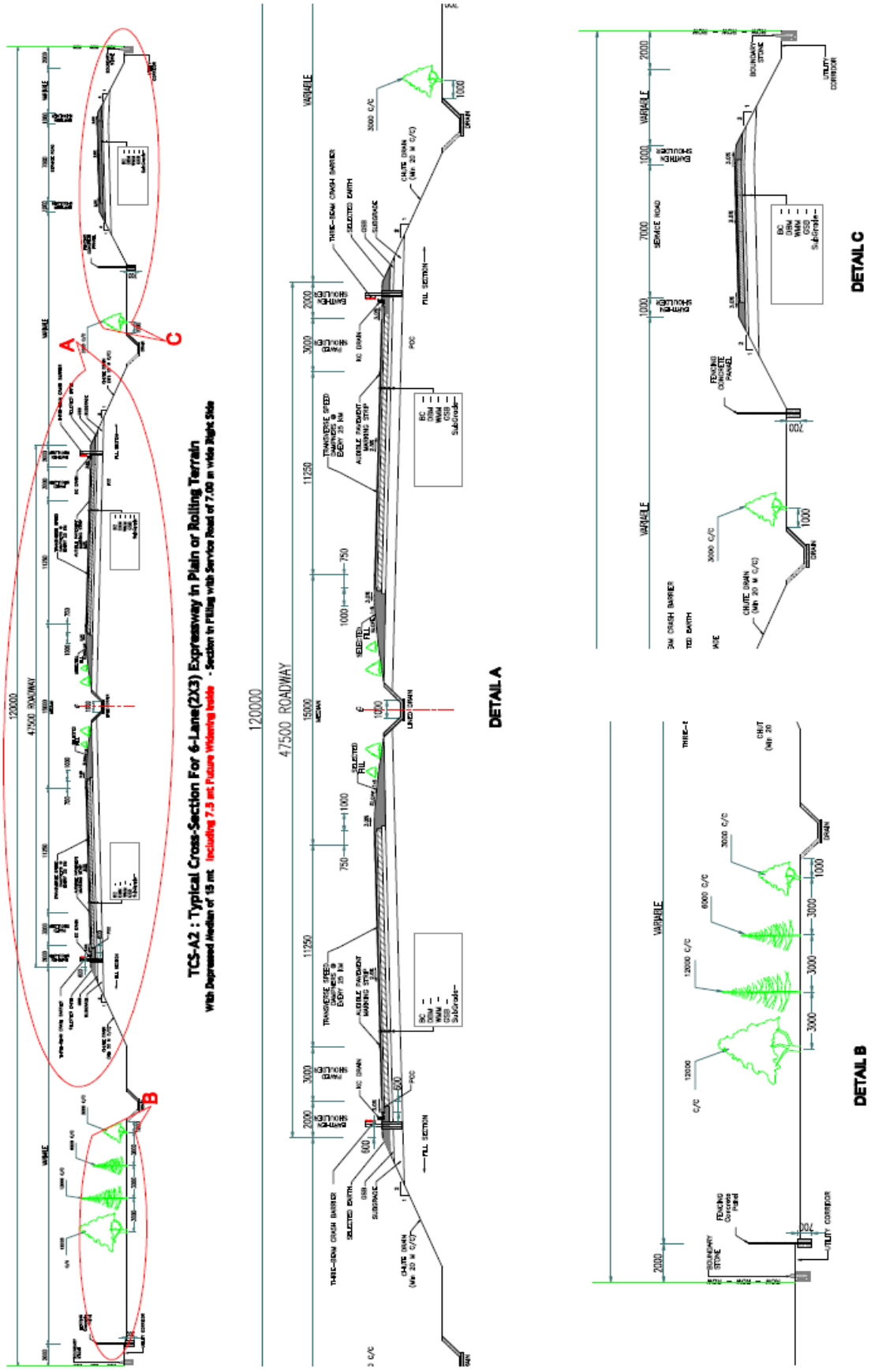
Chainage		Length (Km)	Service Road Width (Km)		Type of C/S	Package No.
From	To		LHS	RHS		
391.900	392.410	0.510	3.75	Nil	B1	Package-9
392.410	392.810	0.400	7.00	Nil	A1	Package-9
392.810	393.240	0.430	3.75	Nil	B1	Package-9
393.240	393.700	0.460	3.75	3.75	B3	Package-9
393.700	393.940	0.240	3.75	Nil	B1	Package-9
393.940	394.340	0.400	7.00	Nil	A1	Package-9
394.340	396.990	2.650	3.75	Nil	B1	Package-9
396.990	397.050	0.060	7.00	Nil	A1	Package-9
397.050	397.120	0.070	7.00	3.75	D	Package-9
397.120	397.390	0.270	7.00	Nil	A1	Package-9
397.390	398.640	1.250	3.75	Nil	B1	Package-9
398.640	399.180	0.540	3.75	3.75	B3	Package-9
399.180	400.950	1.770	Nil	3.75	B2	Package-9
400.950	401.280	0.330	Nil	7.00	A2	Package-9
401.280	401.360	0.080	7.00	7.00	A3	Package-9
401.360	401.750	0.390	3.75	3.75	B3	Package-9
401.750	402.550	0.800	Nil	3.75	B2	Package-9
402.550	402.950	0.400	Nil	7.00	A2	Package-9
402.950	403.850	0.900	Nil	3.75	B2	Package-9
403.850	404.950	1.100	3.75	3.75	B3	Package-9
404.950	406.260	1.310	Nil	3.75	B2	Package-9
406.260	406.840	0.580	3.75	3.75	B3	Package-9
406.840	407.240	0.400	Nil	7.00	A2	Package-9
407.240	408.130	0.890	Nil	3.75	B2	Package-9
408.130	408.530	0.400	Nil	7.00	A2	Package-9
408.530	409.270	0.740	Nil	3.75	B2	Package-9

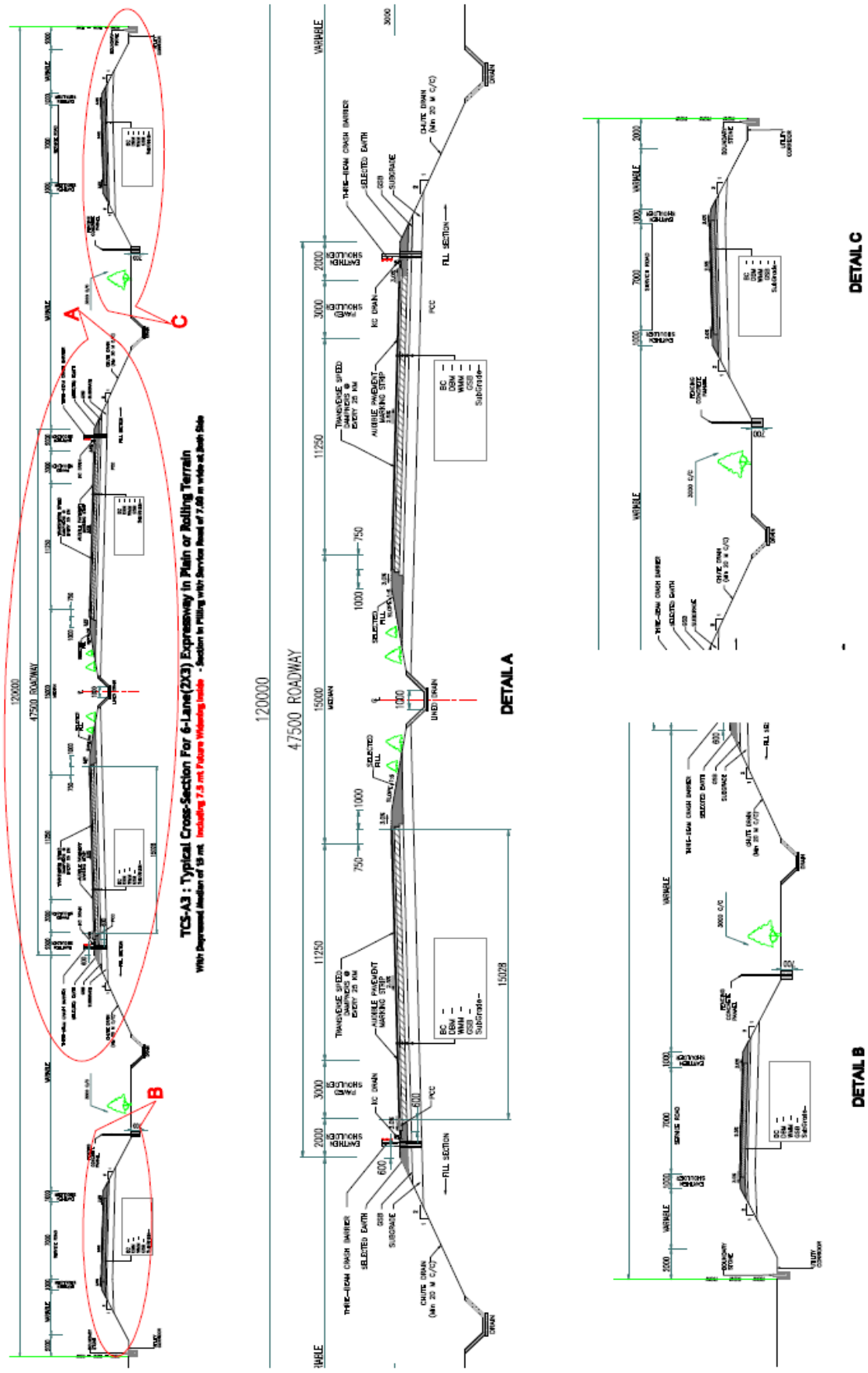
Chainage		Length (Km)	Service Road Width (Km)		Type of C/S	Package No.
From	To		LHS	RHS		
409.270	409.650	0.380	3.75	3.75	B3	Package-9
409.650	411.530	1.880	Nil	3.75	B2	Package-9
411.530	411.830	0.300	3.75	3.75	B3	Package-9
411.830	413.210	1.380	3.75	Nil	B1	Package-9
413.210	413.620	0.410	3.75	3.75	B3	Package-9
413.620	414.410	0.790	Nil	3.75	B2	Package-9
414.410	414.610	0.200	Nil	7.00	A2	Package-9
414.610	414.810	0.200	7.00	7.00	A3	Package-9
414.810	415.390	0.580	3.75	3.75	B3	Package-9
415.390	417.100	1.710	Nil	3.75	B2	Package-9
417.100	417.790	0.690	3.75	3.75	B3	Package-9
417.790	418.920	1.130	Nil	3.75	B2	Package-9
418.920	419.600	0.680	3.75	3.75	B3	Package-9
419.600	419.710	0.110	3.75	Nil	B1	Package-9
419.710	420.950	1.240	Nil	Nil	C	Package-9
420.950	422.032	1.082	3.75	Nil	A1	Package-9
422.032	422.640	0.608	Nil	Nil	C	Package-9
422.640	423.350	0.710	Nil	3.75	B2	Package-9
423.350	423.370	0.020	Nil	Nil	C	Package-9
423.370	428.350	4.980	3.75	Nil	B1	Package-9
428.350	428.750	0.400	7.00	Nil	A1	Package-9
428.750	429.120	0.370	3.75	Nil	B1	Package-9
429.120	430.000	0.880	3.75	3.75	B3	Package-9
430.000	431.017	1.017	3.75	Nil	B1	Package-9
431.017	431.140	0.123	3.75	3.75	B3	Package-9
431.140	431.540	0.400	7.00	3.75	D	Package-9
431.540	432.750	1.210	3.75	3.75	B3	Package-9
432.750	433.410	0.660	3.75	Nil	B1	Package-9
433.410	433.810	0.400	7.00	Nil	A1	Package-9
433.810	435.840	2.030	3.75	Nil	B1	Package-9
435.840	436.240	0.400	7.00	Nil	A1	Package-9
436.240	438.770	2.530	3.75	Nil	B1	Package-9
438.770	439.280	0.510	3.75	3.75	B3	Package-9
439.280	440.360	1.080	3.75	Nil	B1	Package-9
440.360	442.785	2.425	3.75	3.75	B3	Package-9

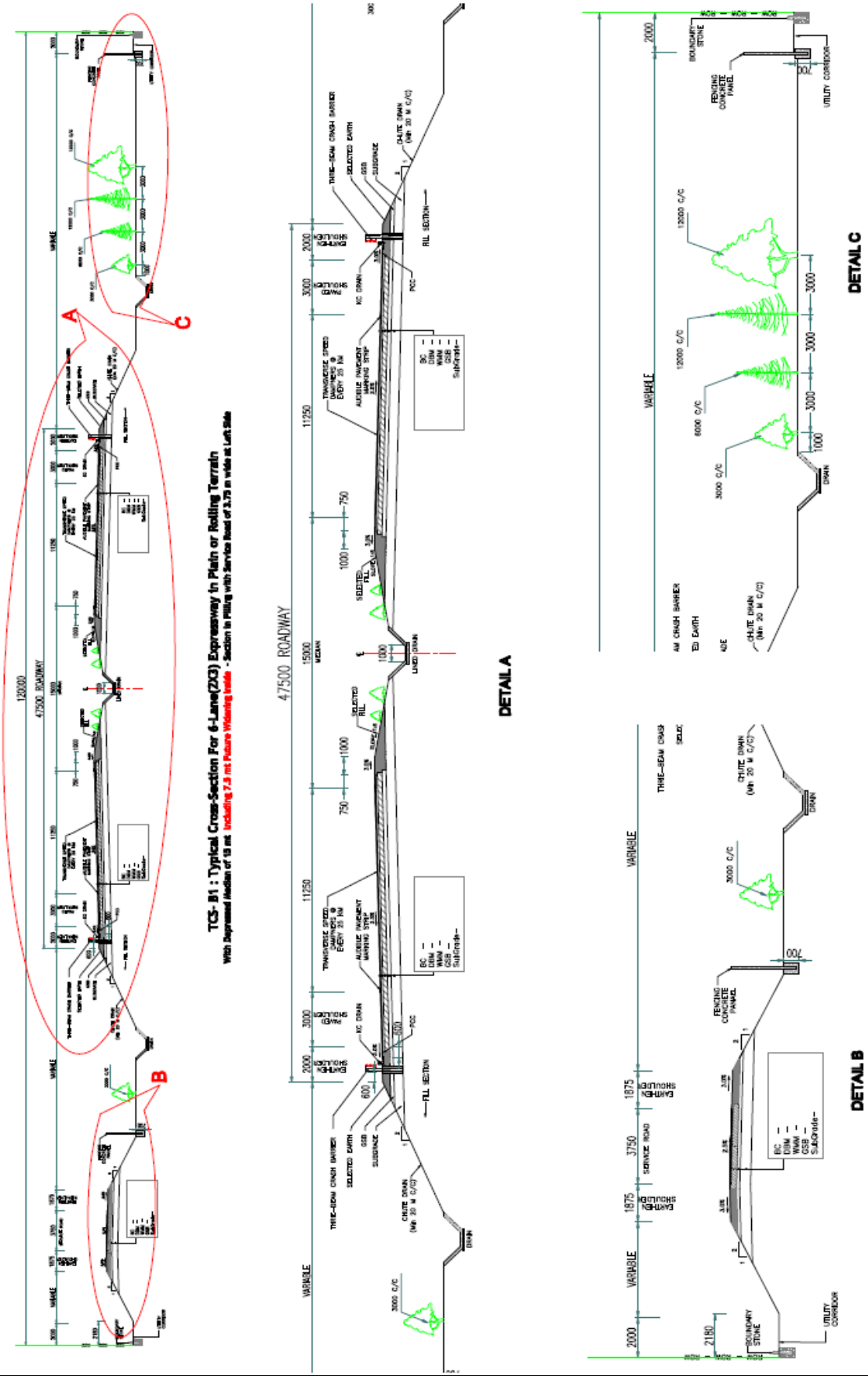
Chainage		Length (Km)	Service Road Width (Km)		Type of C/S	Package No.
From	To		LHS	RHS		
442.785	443.760	0.975	3.75	Nil	B1	Package-9
443.760	444.520	0.760	3.75	3.75	B3	Package-9
444.520	445.000	0.480	3.75	Nil	B1	Package-9

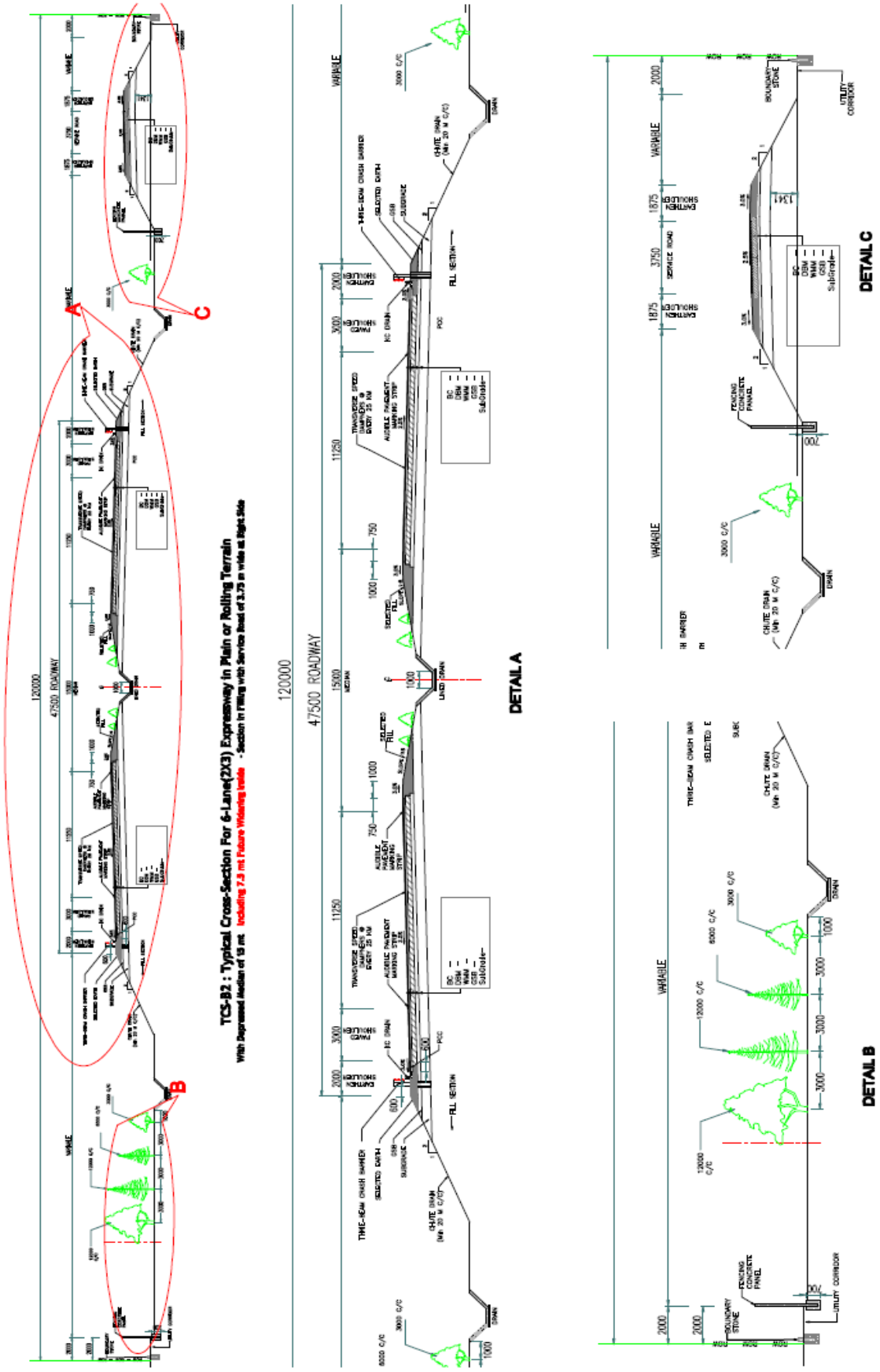
Typical cross-sections mentioned in the above table have been attached below:

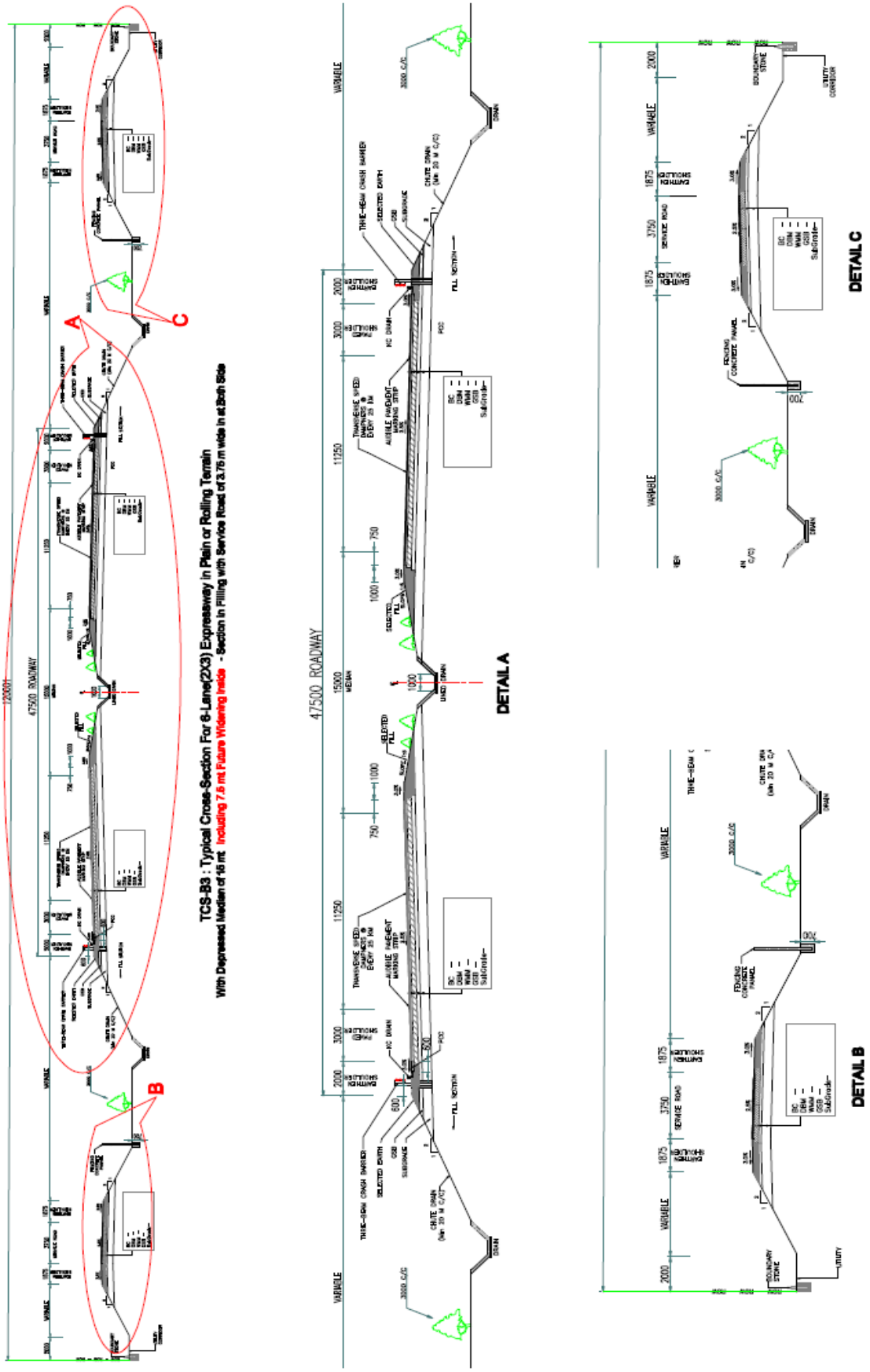

TCS- A1 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt. Future Widening Inside - Section in Filling with Service Road of 7.00 m wide at Left Side
47500 ROADWAY
120000
DETAIL A
A
B
C

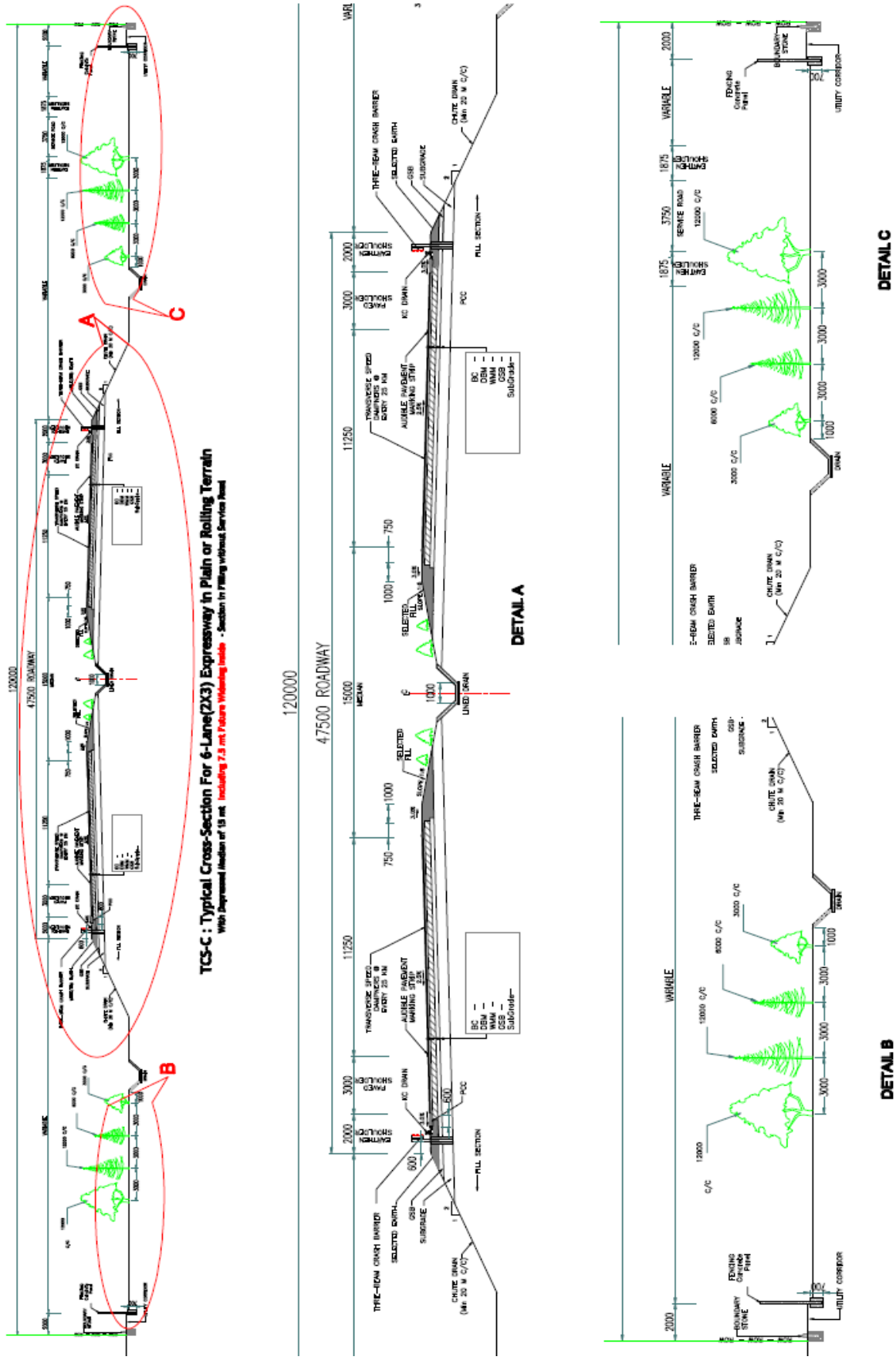

TCS-A2 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt. Future Widening Inside - Section in Filling with Service Road of 7.00 m wide Right Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
A
B
C

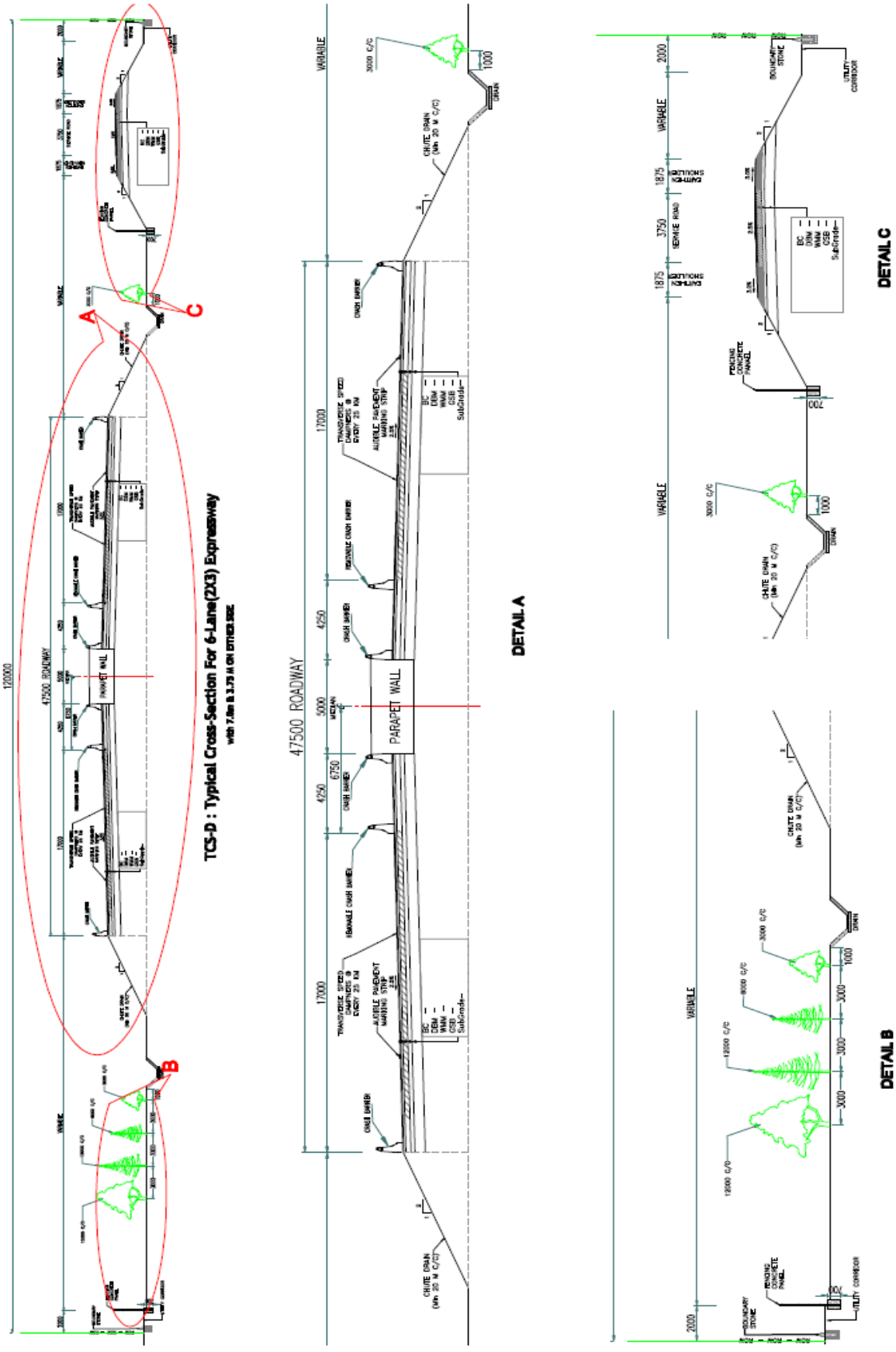

TCS-A3 : Typical Cross-Section For 6-Lane(2X3) Expressway In Plain or Rolling Terrain
47500 ROADWAY
120000
DETAIL A
DETAIL B
DETAIL C
A
B
C

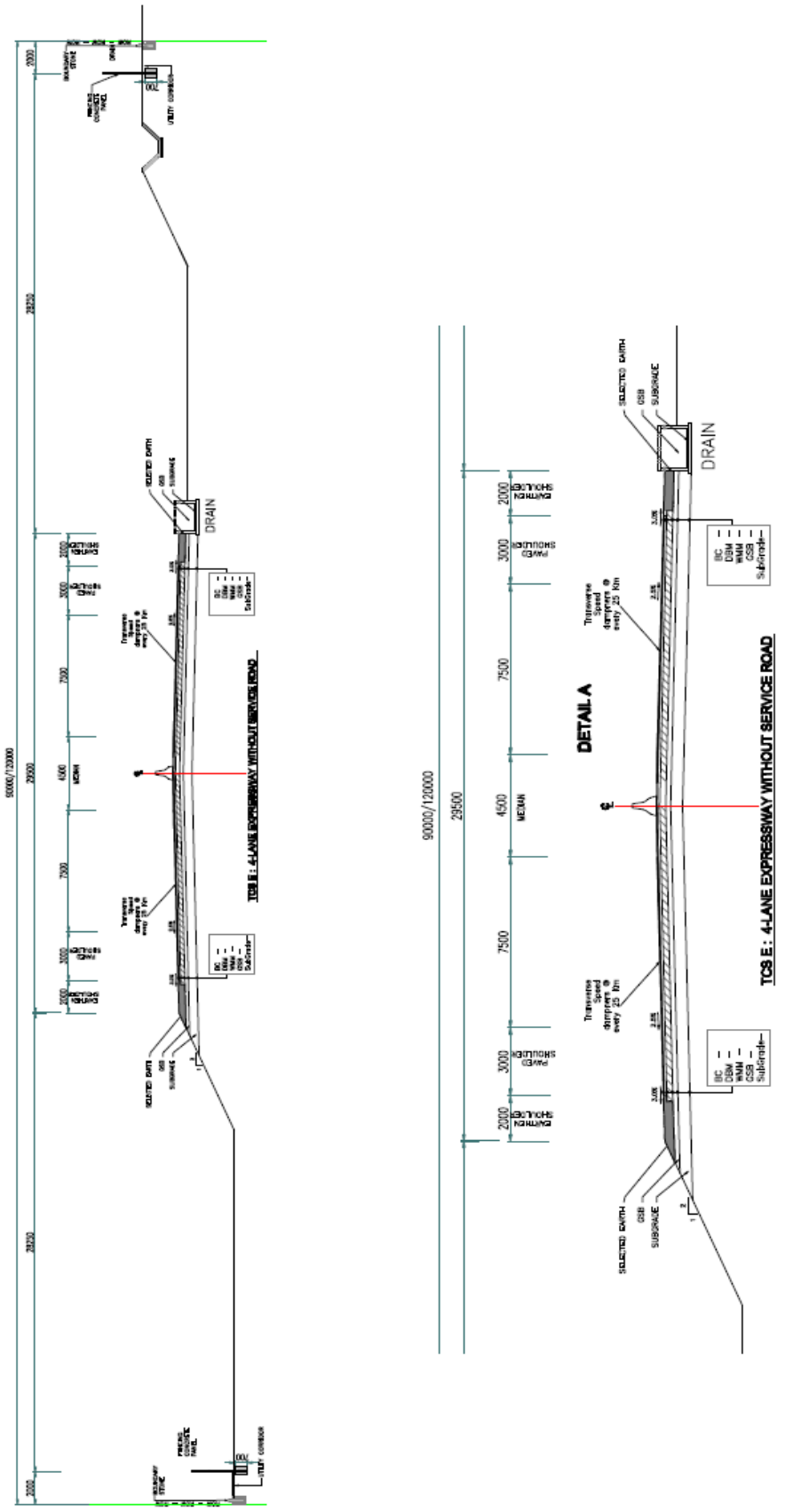

TCS- B1 : Typical Cross-Section For 6-Lane(203) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide on Left Side
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
A
B
C

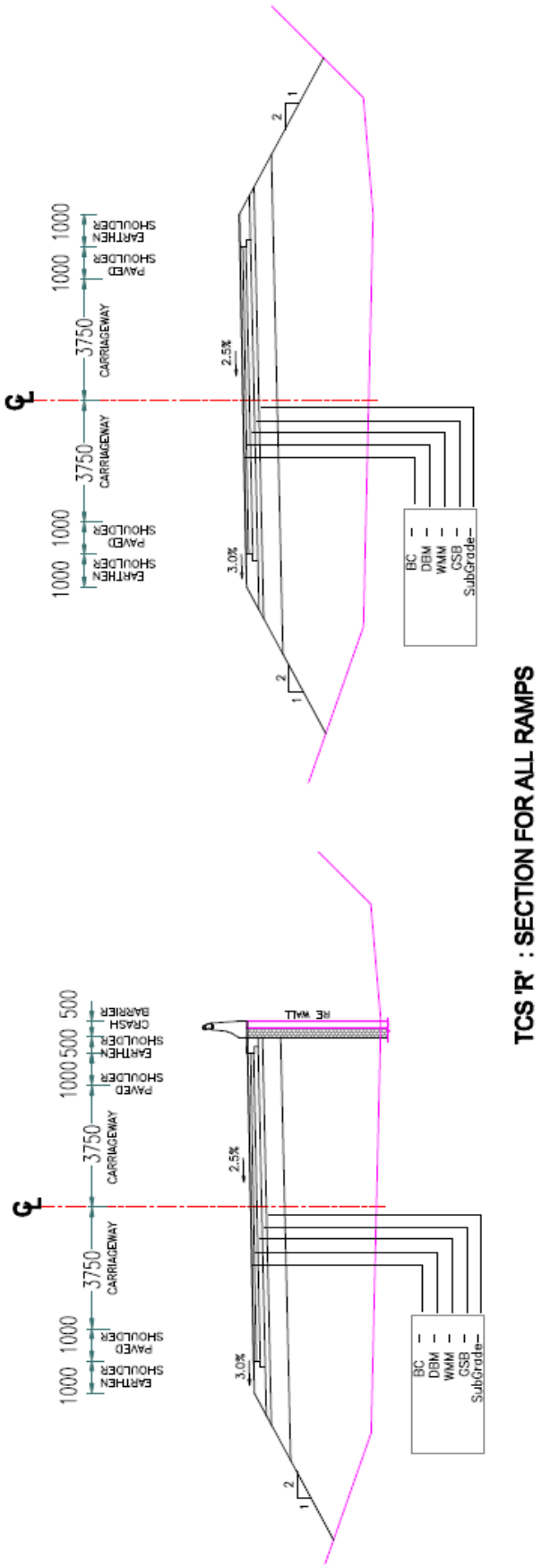

TCS-B2 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide at Right Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
VARIABLE
A
B
C


TCS-B3 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide in at Both Side
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
A
B
C

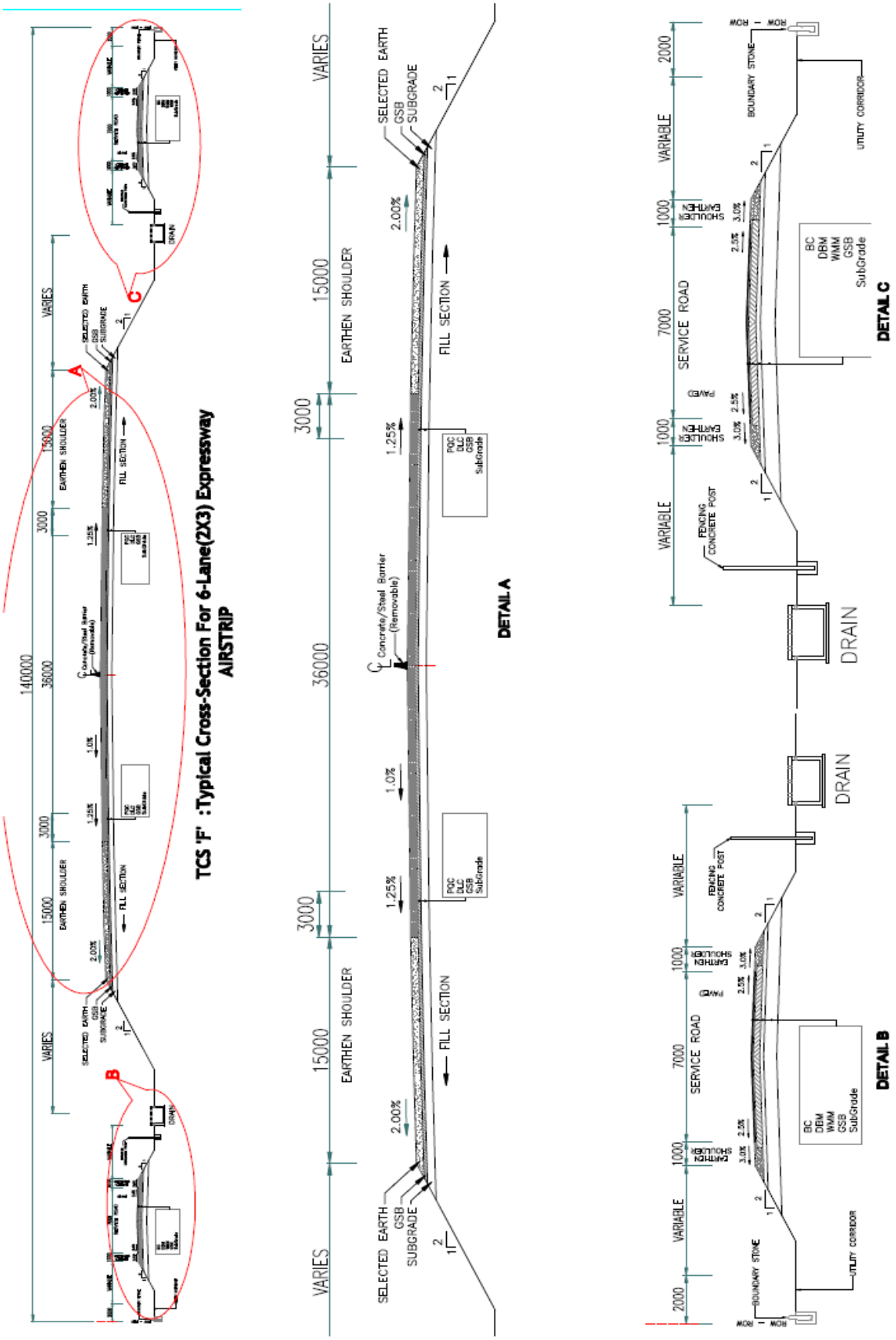

TCS-C : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 19 mt Including 7.3 mt Future Widening Inside - Section in Filling without Service Road
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
A
B
C


TCS-D : Typical Cross-Section For 6-Lane(2X3) Expressway
DETAIL A
DETAIL B
DETAIL C
47500 ROADWAY
PARAPET WALL
VARIABLE
120000
17000
4250
5000
6750
3000 C/C
1000
2000
1875
3750
700
A
B
C


DRAIN
DETAIL A
TCS E : 4-LANE EXPRESSWAY WITHOUT SERVICE ROAD
90000/120000
29500
7500
4500
MEDIAN
3000
PAVED SHOULDER
2000
PAVEMENT SHOULDER
SELECTED EARTH
GSB
SUBGRADE



TCS 'R' : SECTION FOR ALL RAMPS


TCS 'F' :Typical Cross-Section For 6-Lane(2X3) Expressway
AIRSTRIP
DETAIL A
DETAIL B
DETAIL C
VARIES
EARTHEN SHOULDER
FILL SECTION
SELECTED EARTH
GSB
SUBGRADE
Concrete/Steel Barrier (Removable)
SERVICE ROAD
VARIABLE
DRAIN
BOUNDARY STONE
UTILITY CORRIDOR
FENCING CONCRETE POST
BC
DBM
WMM
GSB
SubGrade
PQC
DLC
GSB
Subgrade

0.22 TOLLING STRATEGY

- The closed tolling system needs to be adopted and implemented for the primary reason of amassing the maximum toll fee from the maximum number of commuters in order to adequately recover the project costs.
- Further, closed tolling system is also a transparent and authentic way of tolling as the commuter pays toll fee based on the distance travelled.
- Moreover, in a closed tolling system, the commuter has an advantage of commuting with minimum halts at only two locations namely, ingress and egress; whereas in the open tolling system, the commuter might have to stop at multiple locations.
- Additionally, a closed tolling system will reduce the fuel consumption of the vehicles by eliminating conventional deceleration and acceleration and cost of travel.

0.23 COST ESTIMATES & RATE ANALYSIS

This being a Project Report, cost estimate is carried out based on preliminary design. The project cost estimates have been prepared considering various items of works associated with the identified proposals. Package-9 cost summary is given below:

Package No.	Chainage (km)		Length	Cost		
	From	To		Civil Cost	Civil Cost (Including 12% GST)	Capital Cost
IX	391.9	445	53.1	₹ 15,445,750,470	₹ 17,299,240,526	₹ 27,551,565,374.40

0.24 ECONOMIC & FINANCIAL ANALYSIS

Financial Viability Report & Economic Viability Report is attached separately as Volume-VII.

1. INTRODUCTION

1.1 GENERAL

During the last two decades India has witnessed significant improvements in road infrastructure. Highways can now facilitate higher speed and volume of transportation due to their increased capacity. Today road transport in India carries 65 per cent of freight and it has more than doubled over the last 20 years. This is despite about 45% lower freight cost of rail on per ton per km basis. In addition to freight, it also caters to 80% of passenger traffic.

Thus considering the trend of massive dependence of trade and commerce on roads, and the catalytic growth expected from the recent policies to boost manufacturing in India, the creation of increased high quality and efficient transport infrastructure system is extremely mandatory. Good roads bring about overall development in the region as it helps in the success of all developmental activities, be it in the sphere of movement of people or goods, development of agriculture, commerce, education, health and social welfare, or even maintenance of law and order and security.

The State of Uttar Pradesh (UP) is the most populous state in the country accounting for 16 per cent of the country's population. It is also the fourth largest state in geographical area covering 9.0 per cent of the country's geographical area, encompassing about 243 lakhs hectare land. Garlanded by the river Ganga and Yamuna, Uttar Pradesh is surrounded by Bihar in the East, Madhya Pradesh in the South, Rajasthan, Delhi, Himachal Pradesh and Haryana in the West and Uttarakhand in the North and Nepal touches the northern borders of Uttar Pradesh.

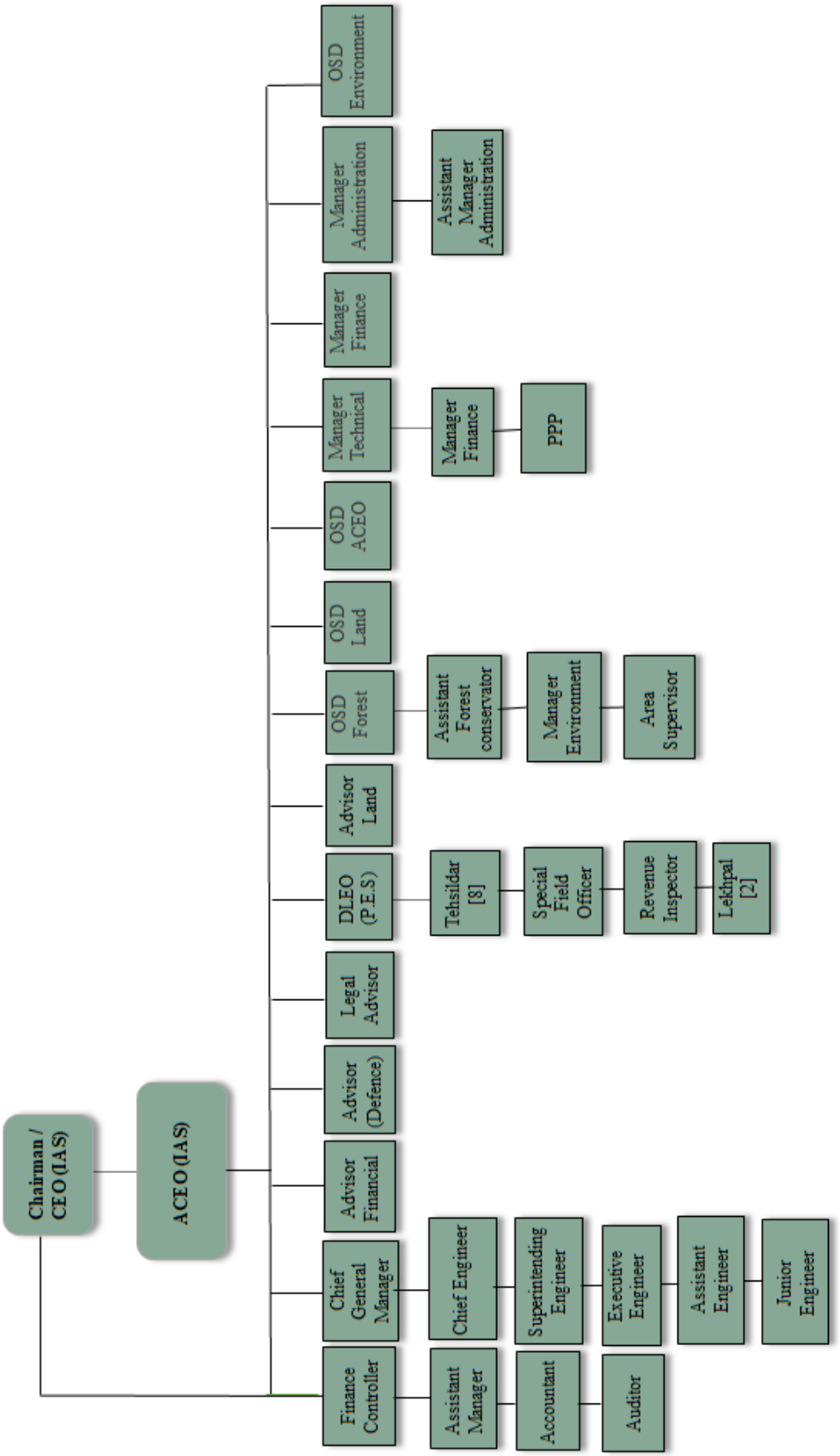
The Government of Uttar Pradesh has set up an Authority named "Uttar Pradesh Expressways Industrial Development Authority" (UPEIDA), under UP Industrial Area Development Act 1976, vide Notification Number 4246/77-4-07-94 Bha/07TC, dated December 27, 2007 issued by Industrial Area Development Department-4, Government of Uttar Pradesh.

1.2 ABOUT UPEIDA

Uttar Pradesh Expressways Industrial Development Authority (known by its acronym UPEIDA) was set up by the State Government under U.P. Industrial Areas Development Act 1976, in December 2007 for development of Expressways in Uttar Pradesh. This is a newly established Organisation with lean and laborious employee base, on contract or on deputation basis from State Revenue Department/PWD, among them few are deployed on retainership basis or by service provider.

1.2.1 UPEIDA Organisational Structure

An organizational structure is a system that outlines how certain activities are directed in order to achieve the goals of an organization. These activities can include rules, roles, and responsibilities. The organisational structure of UPEIDA is given below:


UPIEDA ORGANISATIONAL STRUCTURE
Chairman / CEO (IAS)
ACEO (IAS)
OSD Environment
Manager Administration
Assistant Manager Administration
Manager Finance
Manager Technical
Manager Finance
PPP
OSD ACEO
OSD Land
OSD Forest
Assistant Forest conservator
Manager Environment
Area Supervisor
Advisor Land
DLEO (P.E.S)
Tehsildar [8]
Special Field Officer
Revenue Inspector
Lekhpal [2]
Legal Advisor
Advisor (Defence)
Advisor Financial
Chief General Manager
Chief Engineer
Superintending Engineer
Executive Engineer
Assistant Engineer
Junior Engineer
Finance Controller
Assistant Manager
Accountant
Auditor

1.2.2 Expressway Projects by UPEIDA

Expressway Projects executed/ under execution by UPEIDA so far are as under:

(a) Agra-Lucknow Expressway

This Greenfield Expressway project is 302.22 km long, starts from Agra passes through Firozabad, Mainpuri, Etawah, Auraiya, Kannauj, Kanpur Nagar, Unnao, Hardoi and ends at Lucknow districts. The expected travel time from Agra to Lucknow shall be reduced to 4 hours. The width of the Expressway is 6 lanes (expandable up to 8 lanes with all structured as 8 lanes) with a design speed of 120 km per hour. Inauguration of this expressway has been done on 21.11.2016 and at present this Expressways is operational.

(b) Purvanchal Expressway

This Greenfield Expressway project is 340.824 KM long, starts from Lucknow passes through districts Barabanki, Ayodhya. Amethi, Sultanpur, Ambedkarnagar, Azamgarh, Mau and ends at Ghazipur. Purvanchal Expressway 6 lane (expandable to 8 lane with all structures as 8 lane) Access Controlled expressway project with design speed of 120 km/h. This Expressway is under construction and expected to be operational at the end of year 2020.

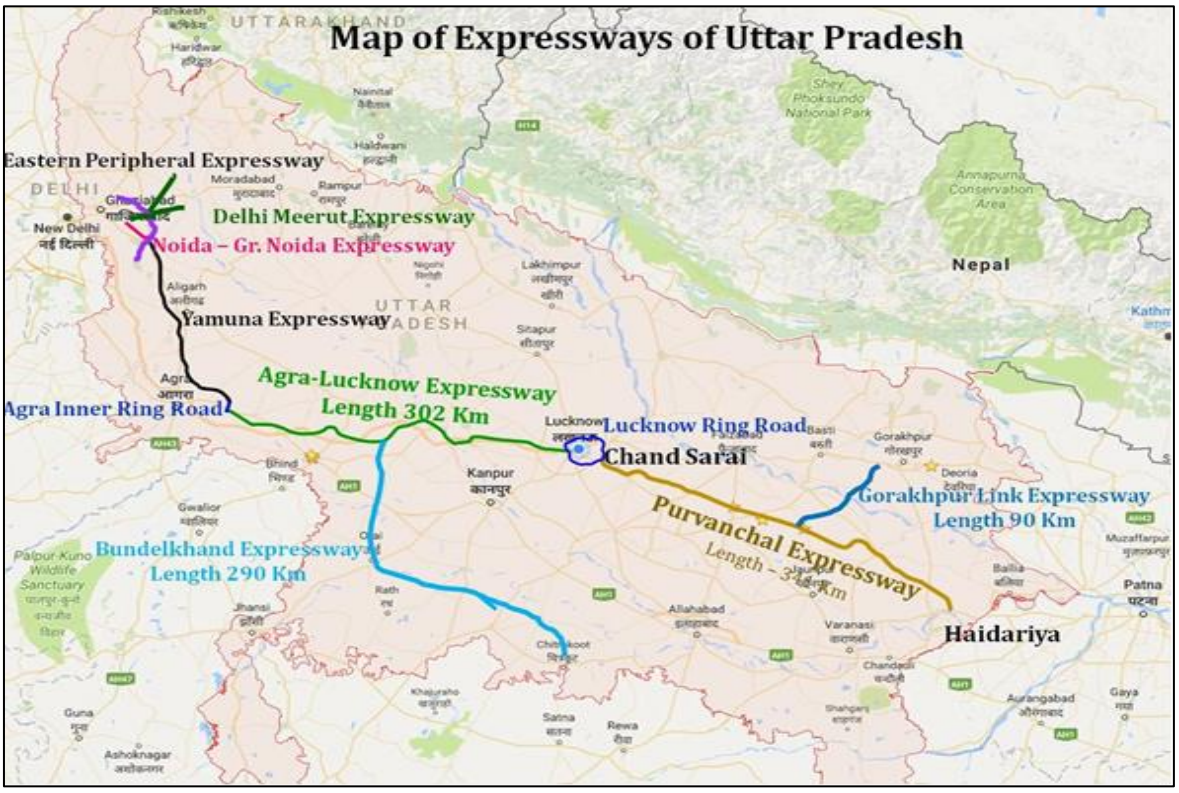
(c) Bundelkhand Expressway

This Greenfield Expressway project is 296.07 KM long, starts from Chitrakoot passes through districts Banda, Mahoba, Hamirpur, Jalaun, Auraiya and ends at Agra-Lucknow Expressway in

district Etawah. Bundelkhand Expressway is 4 lane (expandable to 6 lane with all structures as 6 lane) Access Controlled expressway project with design speed of 120 km/h. This Expressway is under construction and expected to be operational by the year 2022.

(d) Gorakhpur Link Expressway

This Greenfield Expressway project is 91.352 KM long, starts from Gorakhpur passes through districts Ambedkar nagar, Sant Kabir nagar and ends at Purvanchal Expressway in district Azamgarh. Gorakhpur Link Expressway is 4 lane (expandable to 6 lane with all structures as 6 lane) Access Controlled expressway project with design speed of 120 km/h. This Expressway is under construction and expected to be operational in the year 2022.

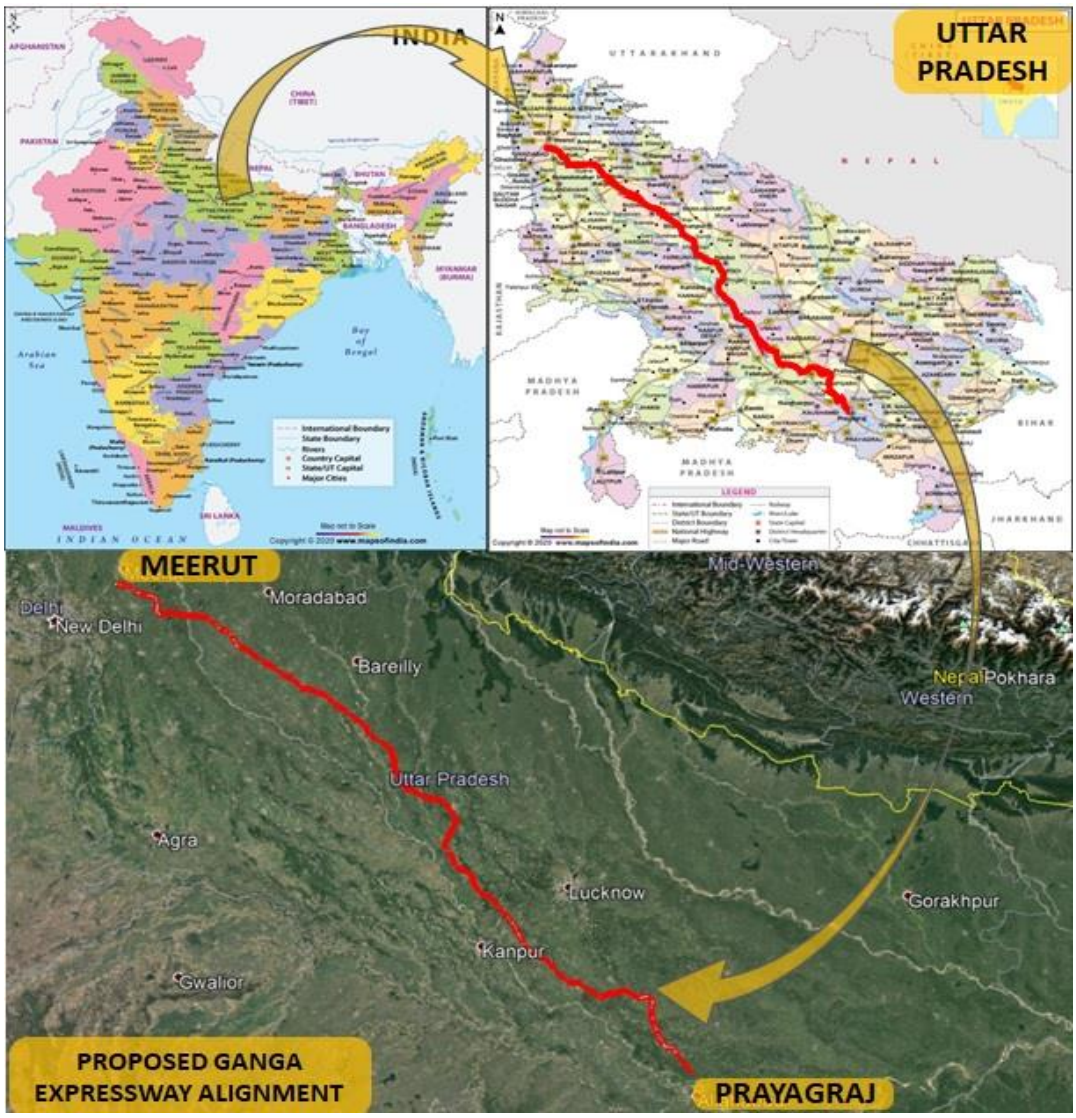


1.3 NEWLY PROPOSED GANGA EXPRESSWAY (THE PROJECT)

The proposed "Ganga Expressway" is Access Controlled Expressway (Green Field) Project which will connect Meerut to Prayagraj. This proposed Expressway project shall create immense opportunities to the people of Western & Central region of the State and over all development of the State by providing safer & faster connectivity from East to West borders of the State and with National Capital and NCR Region.

The project will provide direct high speed connectivity from National Capital Region through proposed expressway to Meerut and then onwards to Prayagraj. It will facilitate construction of all-weather high speed access controlled expressway, which will decongest the increasing traffic on existing road network. The expressway will also decrease travel time substantially.

Index Map showing proposed Ganga Expressway alignment is presented below:



Index map of Ganga Expressway

The Uttar Pradesh Government has decided to develop the "Ganga Expressway Project". UPEIDA is committed for the development of this expressway and has Entrusted M/s L N Malviya Infra Projects Pvt. Ltd., Highway Engineering Consultant and Intratech Civil Solutions (Consortium) to carry out the detailed project report to implement the project on EPC Mode and selection of developers through competitive bidding process.

The Consultant has undertaken requisite surveys & studies for the project which includes costing to assess technical, environmental and social assessment studies, their analysis etc. As a part of the study to establish the viability, this Project Report has been prepared after carrying out engineering surveys and appropriate assessment of a preliminary design considering the engineering conditions, the present traffic and its growth, the environmental impact assessment as well as the social aspects along with cost assessment. This report among other aspects covers the details on finalization of alignment, grade separator interchanges and structures along the proposed Expressway, marking on the Khasra maps of ROW and marking of alignment on

revenue maps, identification of Tourist spots, eco-friendly structures, water bodies etc. along the expressway.

1.4 OBJECTIVE

The objective of this consultancy (the "Objective") is to undertake feasibility study and prepare a 'Detailed Project Report' of the Project Expressway.

1.5 SCOPE OF CONSULTANCY SERVICES

(a) Preparation of feasibility report having different alignment options conforming to expressway Geometric Standards and also showing their merits & demerits so that most appropriate Alignment can be selected.

(b) Traffic surveys and demand assessment.

(c) Engineering surveys and investigations.

(d) Location and layout of toll plazas, truck lay byes, bus bays and bus shelters, public utilities, restaurant, workshops, PCO etc.

(e) Social and Environmental impact assessment including providing all assistance in obtaining necessary clearances including Forest, Wild-Life & Environment Clearance from GoUP/GoI.

(f) Designs of Road/Bridges/Structures/interchanges etc.

(g) Preparation of detailed cost estimates on the basis of designs & Bill of Quantities.

(h) Detailed cost of shifting and relocation of utilities (duly authenticated by the competent authority in the department owning the Utilities), land acquisition, removal of encroachments and rehabilitation etc.

(i) Evaluating the financial viability/economic analysis of the project.

(j) For SELECTED mode the consultant shall have to suggest the possible modes of financing of the project and help the Authority/ Government to arrange funds from external resources, if required. For PPP mode, the consultant shall have to assist the Authority in getting the VGF. For other modes, necessary assistance for the funding of the project shall have to be provided by the consultant.

(k) Preparation of bid documents for selection of prospective "Developer(s)/Contractor(s)" including all schedules of the Agreement.

(l) Finalization of Expressway Packages and evaluating their detailed costs separately and including measurements of different items, analysis of rates based on prevalent PWD rates, BOQ including Costing of Structures, Toll Plaza, utility areas etc. and for evaluation of the Financial viability of Project separately for each distinct package as well as the complete Project as a whole.

(m) The Project is to be bidded out in a way so that the Bidders may have an option of bidding for individual packages/ combination of packages/ Complete Project.

(n) Preparation of supporting information to assist bidders in preparation of their bids, and where relevant, creation of a data base and management access to the data base.

(o) Support to communication with the prospective bidders and interaction with them, including managing and responding to requests for clarification.

(p) Preparation of a bid evaluation plan, assistance in evaluation and preparation of evaluation reports.

(q) Assistance in negotiation with one or more parties prior to contract award, if required.

(r) Monitoring and advice on bidder performance against any conditions precedent to financial close; and

(s) Providing assistance in obtaining necessary clearances from the Forest Department which includes preparation of proposal for clearance under Forest Conservation Act., counting & marking of trees, joint inspection with Forest Department officials etc.

(t) Preparation of TOR, Bid Documents, Contract Agreement for selection of Authority's Engineer, Project Management Consultant (PMC) and Safety Engineer etc. as per requirement and facilitation of Authority in their selection and appointment.

1.6 CONSULTANT'S APPROACH

The Consultant's approach to the project is in accordance with the "Description of Services" given in the Contract Document, understanding of the project objectives and further discussions with the Client during progress of the project study. The main approach of this consultancy service comprise of the following:

(a) The Greenfield alignment is within the proposed Right of Way (ROW);

(b) The most economical but sound proposal is arrived at for the required roadwork and related bridge works;

(c) Engineering, economic, environmental and social feasibility studies of the proposed road improvements are carried out keeping in view of several important aspects of project execution.

(d) International "best practices" including use of "State of the art" and computer based survey and design techniques (e.g. GPS, Total Station Survey, LiDAR, Computer Aided Designs (MX/MOSS/Equivalent etc.) is incorporated for preparation of the technical proposal, development of designs, cost estimates, bid documents etc.;

(e) Preliminary designs of the agreed road and related bridge works is prepared, as a basis for completing Environmental Impact Assessment (EIA) shall be prepared;

(f) Reports and analysis shall be provided, suitable for meeting the standards and specifications laid down according to Ministry of Road Transport and Highways (MORTH), Government of India requirements on environmental and social assessment.

1.7 STRUCTURE OF DETAILED PROJECT REPORT

The Detailed Project Report has been divided in following volumes:

Volume-I: Main Report

Volume-II: Cost Estimates

Volume-III: Rate Analysis

Volume-IV: Design Report

Volume-V: Technical Specifications

Volume-VI: Investigation Reports

(a) Report on traffic survey and demand assessment

(b) Soil, geotechnical and drainage report

(c) Social Impact Assessment Report

(d) EIA Report and Environmental Management Plan

Volume-VII: Financial Analysis & Economic Analysis

Volume-VIII: Drawings (Highways, Structures & Miscellaneous)

Volume-IX: Land Acquisition Reports & LA Plans

Volume-X: Report on Project Clearances

2. PROJECT DESCRIPTION

2.1 GENERAL

Uttar Pradesh is a state in northern part of India. It was formed on 1 April 1937 as It was created on 1 April 1937 as the United Provinces of Agra and Oudh during British rule, and was renamed Uttar Pradesh (UP) in 1950. The state is divided into 18 divisions and 75 districts with the capital being Lucknow. On 9 November 2000, a new state, Uttarakhand, was carved out from the state's Himalayan hill region.

The two major rivers of the state, the Ganges and Yamuna, join at Allahabad and flow further east as Ganges. Other prominent rivers are Gomti and Varuna. Hindi is the most widely spoken language and is also the official language of the state, along with Urdu.

From population, political awareness, historical and cultural heritage and freedom movement points of view, Uttar Pradesh is a very important state of the country. As much as 16.17% of India's population lives in the state. Geographically, it acquires 5th position after Rajasthan, Madhya Pradesh, Maharashtra and Andhra Pradesh and covers 7.3% land area of India. Area wise it covers 240.928 square Kilo meters. For administrative convenience, it has 18 divisions, 75 districts, 915 urban bodies, 8135 Nyaya Panchayats. 13 Municipal corporations, 226 municipal boards, 59163 gram sabhas, 822 development blocks, 97941 populated villages 180000 post offices and 2885 telephone exchanges.

Uttar Pradesh sends 80 members to Lok Sabha, 31 members to Rajya Sabha and 404 members to its Legislative Assembly and 100 members to its Legislative council.

It is pertinent to mention that the strength of work force in the state is 23.7%, out of which 65.9% are farmers and 5.6% are industrial workers. Its per capita income is Rs. 13,262 as per existing rate.

Area	240928 square K.M.
No. of districts	75
Total population (year 2011)	199812341
Male	104480510
Female	95331831
Population growth during 2001-2011	33614420
Decline in population rate during 2001-2011	20.29%
Density of population (per sq. km)	829
Sex ratio	912:1000
percentage of children population in the age group of 0-6 years	
Total children	18.35%
Boys	18.18%
Girls	18.54%
Literacy among in the age group of 7 years and above (2011)	
Total	69.72%
Male	79.24%
Female	59.26%

2.2 PROJECT BACKGROUND

After Successful Preparation/ Execution of various Expressway Projects viz. Yamuna Expressway, Agra-Lucknow Expressway, Purvanchal Expressway & Bundelkhand Expressway, the Uttar Pradesh Government has decided to develop the "Ganga Expressway Project".

The project will provide direct high speed connectivity from National Capital Region through proposed expressway to Meerut and then onwards to Prayagraj. It will facilitate construction of all-weather high speed access controlled expressway, which will decongest the increasing traffic on existing road network. The expressway will also decrease travel time substantially.

UPEIDA is committed for the development of this expressway and has entrusted M/s L N Malviya Infra Projects Pvt. Ltd., Highway Engineering Consultant and Intratech Civil Solutions (Consortium) to carry out the detailed project report to implement the project on EPC Mode and selection of developers through competitive bidding process.

The Consultant has undertaken requisite surveys & studies for the project which includes costing to assess technical, environmental and social assessment studies, their analysis etc. As a part of the study to establish the viability, this Project Report has been prepared after carrying out engineering surveys and appropriate assessment of a preliminary design considering the engineering conditions, the present traffic and its growth, the environmental impact assessment as well as the social aspects along with cost assessment. This report among other aspects covers the details on finalization of alignment, grade separator interchanges and structures along the proposed Expressway, marking on the Khasra maps of ROW and marking of alignment on revenue maps, identification of Tourist spots, eco-friendly structures, water bodies etc. along the expressway.

2.3 PROJECT DESCRIPTION

The The proposed Ganga Expressway **(CH 7+900)** starts from km 16+000 of Meerut-Bulandshahar (NH-334) near village Bijoli in District Meerut & terminates at Prayagraj Bypass on NH-19 near village Judapur Dando (Dist. Prayagraj) **(CH 601+847)**.

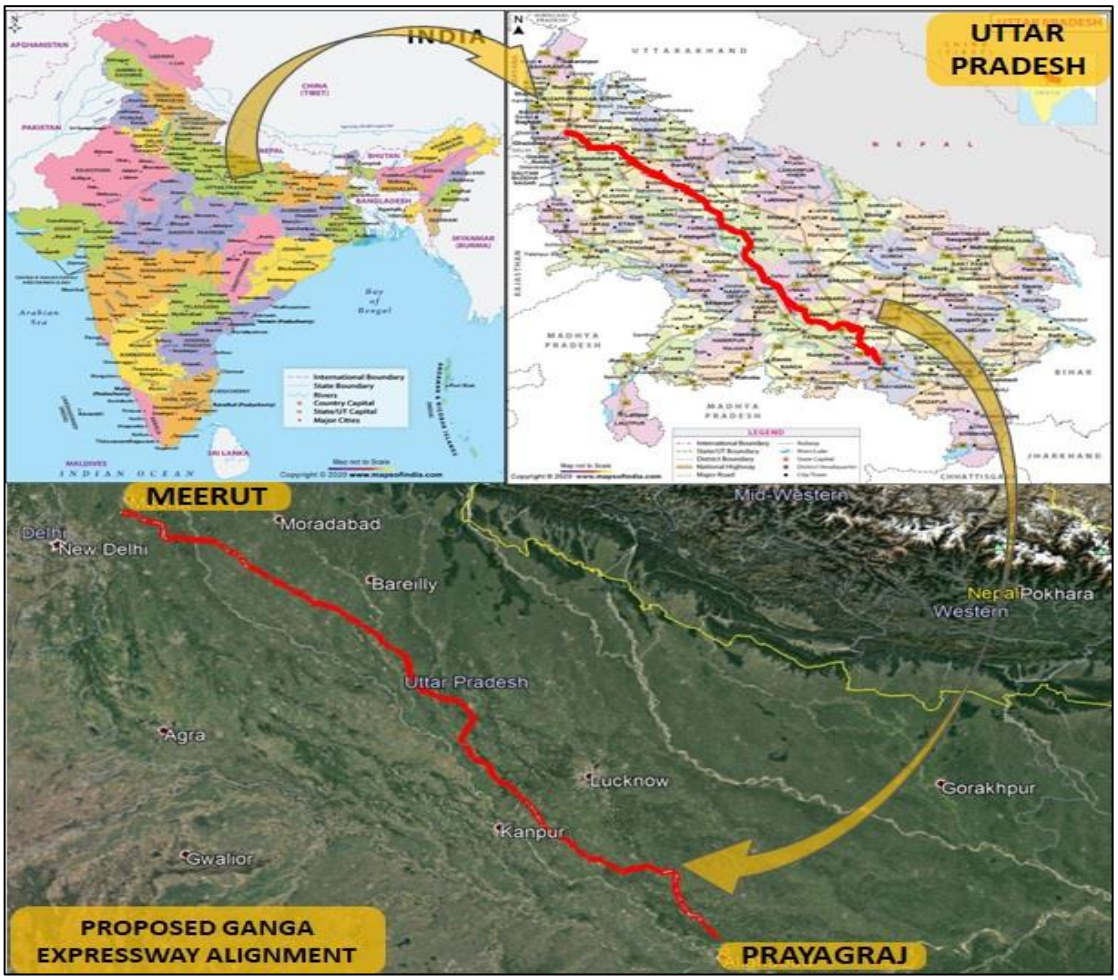
The length of the proposed expressway alignment is **593.947 km**.

The proposed expressway has been divided into 12 packages. The chainage wise details of the packages have been given below. The project under consideration is Package-9.

Package No.	Section Details	Chainage (km)		Length
		From	To	
I	From Village Bijoli (Dist. Meerut) to Village-Chandner (Dist. Hapur)	7.900	56.900	49.000
II	From Village-Chandner (Dist. Hapur) to Village-Mirzapur Dugar (Dist. Amroha)	56.900	86.900	30.000
III	From Mirzapur Dugar (Dist. Amroha) to Village-Nagla Barah (Dist. Budaun)	86.900	137.600	50.700
IV	From Village-Nagla Barah (Dist. Budaun) to Village-Binawar (Dist. Budaun)	137.600	189.700	52.100
V	From Binawar (Dist.Budaun) to Girdharpur (Dist. Shahjahanpur)	189.700	236.400	46.700

Package No.	Section Details	Chainage (km)		Length
		From	To	
VI	From Village- Girdharpur (Dist. Shahjahanpur) to Village-Ubariya Khurd (Dist. Hardoi)	236.400	289.300	52.900
VII	From Village-Ubariya Khurd (Dist. Hardoi) to Village- Pandra Lakhanpur (Dist. Hardoi)	289.300	341.700	52.400
VIII	From Village- Pandra Lakhanpur (Dist. Hardoi) to Village-Raiyamau(Dist. Unnao)	341.700	391.900	50.200
IX	From Village- Raiyamau (Dist. Unnao) to Village-Sarso (Dist. Unnao)	391.900	445.000	53.100
X	From Village- Sarso (Dist. Unnao) to Village-Terukha (Dist. Raebareli)	445.000	496.800	51.800
XI	From Village-Terukha (Dist. Raebareli) to Village-Arro (Dist. Pratapgarh)	496.800	548.800	52.000
XII	From Village- Arro (Dist. Pratapgarh) to Village-Judapur Dando (Dist. Prayagraj)	548.800	601.847	53.047
Total				**593.947**

The project Index Map is Shown below:



3. METHODOLOGY & DESIGN STANDARDS

3 General

All the services are carried out strictly as per ToR. The Guidelines for Expressway published by Ministry of Road Trans-port and Highways (MoRT&H) have been followed for preparing this Project Report. Specific Codes and Guidelines of the IRC and publications of the MoRT&H including circulars & general/special publications, technical Specifications & Standards have also been considered. All the field activities have been completed as discussed in detail with Authority.

For Topographic survey latest electronic instruments like Differential Global Positioning System (DGPS), RTK GPS and Total Station were used. Data was collected as per formats and procedures approved by the MoRT&H and analyzed using in-house developed software. MX Roads software for the highway designs and STADD-proV8i for the structure designs are used. For the pavement designs standard software/programs developed in-house have been used.

In depth consultation process with UPEIDA was held on a regular basis to enhance the progress of the work. As time and quality are the essence of the project, before any analysis and designs, all the parameters to be used were got approved by the Client during preparation of draft reports so there is minimum changes later on, i.e. minimum time requirement in the finalization of final reports without compromising quality.

The idea is to seek prior approval from client through meeting/discussion on Inception, alignment finalization, bid evaluation, pre-bid conference etc. Similarly, various traffic scenarios will be developed and presented to client for discussion and approval.

3.1 Design Basis

The broad methodology has been developed keeping standard practices / IRC guidelines, with certain additions and modifications as felt necessary.

3.2 Review of Earlier Reports

The Consultants have collected and reviewed the relative study reports to have a better understanding of the project & also for getting some inputs as a part of the services. The study reports thus considered for review are:

1. Concept Report for Development of Purvanchal Express-way (Green Field) Project.
2. Road development plan in the region by UPEIDA.
3. Any useful details relevant for the project available with the Client/ Other agencies have been collected. Other details are also collected and collated to form recommendations by considering the following inputs:
    - Material details
    - Soil Test results
    - Geo-technical investigation reports
    - Topographic survey details / Bench mark details and other survey information
    - Utility Services/Utility Relocation Plans
    - Traffic Studies

- Tree plantation records
- Hydrological and Hydraulic details
- Development Plans for major towns and areas along the project road
- Availability of construction materials and unit rates for work items
- Recent acquisition rates for different types of land/immovable properties
- Right of Way Details from Revenue maps

3.3 Socio-Economic Profile

Socio-economic profile of the influence area is prepared, after study of data on growth of population and density, human settlement pattern, land use, sub-profiles of agriculture and industries, economic base, trends in socio-economic indicators, development scenarios for various sectors, transport infrastructure and its uses such as use of waterways & rail transport etc.

The relevant data is collected from the following sources:

- State Statistical Abstracts
- State Year Books

Census Publications – Districts and State

- Hand Books of Statistics of Districts in the area of influence
- Economic Surveys of the State constituting the zone of influence
- The Bureau of Economics & Statistics of Uttar Pradesh

3.4 Traffic Survey, Analysis and Projections

Traffic surveys include (only those surveys would be carried out which are required for correctly forecasting the traffic along the proposed road):

- Classified Traffic Volume Counts
- Origin – Destination and commodity Movement Surveys

Standard procedures given in IRC Codes have been followed for carrying out Traffic Surveys. The data arrived from the Surveys has been analyzed to determine ADT of surrounding roads of the proposed project road and travel characteristics.

Growth of traffic in project road influence area and also on the project road is regarded as the most important aspect since the whole project design is based on this. To establish the realistic growth rates, road transport data, population growth rates and socio-economic parameters have been studied and analyzed. The growth rates for passenger vehicles have been worked out on the basis of annual growth rate of population and per capita income while the growth rates of freight vehicles have been based on the rate of growth in agricultural, industrial and tourism sectors and historical traffic data. These growth rates have been used to arrive at the traffic projections for the design period. After the development of project corridor to six lane standard configuration, greater amount of traffic is expected to be diverted from the peripheral road network. Appropriate traffic diversion models have been used for assessment of diverted traffic to this road. Details on traffic data & projections have been discussed in Chapter 5 of this Report.

3.5 Engineering Surveys and Investigations

3.5.1 Reconnaissance Survey of the Project Road

Reconnaissance survey has been carried out immediately before the kick off meeting to examine the general characteristics of the Project Corridor. Consultants have undertaken a site visit along with the experts in the field of Highway, Pavement and Bridge Engineering. This has helped in the detailed appreciation of the project corridor in terms of traffic and other engineering measures and judicious assessment of the following salient factors have generally been made:

- Topography of the area
- Terrain and soil conditions
- Climate and Rainfall
- Drainage Characteristics
- Traffic patterns and preliminary identification of traffic homogeneous sections of road.
- Railway lines and other critical utilities/services having impact on road alignment
- Land use (agricultural, build-up, forest land, etc.,)
- Environmental factors
- Availability of materials
- Any other useful information

The findings are described in the following paragraphs;

3.5.2 Topographic Surveys

Topographic survey has been carried out along the proposed alignment to know the topography, natural and manmade features present within the proposed ROW and to assess the existing geometric deficiencies along with land use plan. The survey has been carried out only after establishing horizontal and vertical control grids. Horizontal grid has been established through DGPS points and been erected at every 5 km interval. For vertical grid, bench mark has been erected at every 250m interval and connecting these to the nearest BM of Survey of India.

Selection of primary Control Points and Observations is as detailed below:

- These are located on the edge of the proposed right of way (ROW) at inter-visible locations at every 5 km.
- These are, as far as possible, on either side of 5 km stone so that it can be identified easily in the field and an arrow has been painted on the existing road indicating their location. They are recorded in separate field with their three dimensional locations.
- The stations selected are free from obstruction towards sky at an angle of 15° with horizontal plane.
- The horizontal control station is established on nail fixed in centre of RCC (M15) pillar of size 15 cm x 15 cm x 45 cm embedded in concrete M10 (5 cm all around) up to a depth of 30 cm and the balance 15 cm above the ground painted yellow.

- The Primary Control Stations are fixed using DGPS Trimble make instrument. The time of observations at Base Stations is observed for a minimum of 30 minutes and at Reference Stations for 20 minutes or longer if instrument signal is not indicating sufficient data received, to eliminate the possible projection and time errors in the signals received from various satellites being observed at respective locations in order to ensure high accuracy in the positioning of control stations within + 20 mm.
- Minimum of 6 satellites are available during observation to ensure high accuracy Secondary control stations are established at 2 km intervals using Total Station and through closed traverse distributed linearly running between two nearest Primary Control Stations ensuring accuracy in the order of $12\sqrt{K}$ in mm, where 'K' is the distance in kilometers between two primary control stations. Any errors within permissible limits are distributed in rational manner to establish the accurate and effective horizontal control grid. These are established on reference pillars having configuration similar to primary control station with an arrow painted on the surface of existing road indicating their location.

3.5.2.1 Pillar Construction

Benchmark pillars at every 1000m along the route within the ROW have been constructed. All these pillars will have to be furnished with X, Y, Z co-ordinates. The pillars are of size 150 x 150 x 600mm long. The pillar is concreted and embedded in a manner that 150mm is remain above ground. A steel rod has been fixed in the centre for punching the point and finally these are to be painted yellow.

3.5.2.2 Total Station Traverse

A closed traverse is run for a loop length of 5 km. While traversing, station is established 200 to 250mts apart. The pillars constructed along the route are connected. These points are further used for detailed survey. The minimum accuracy of this survey is 1:10,000.

3.5.2.3 Bench mark

These are located, as far as possible, along the proposed right of way (ROW) boundaries at an interval of 250 m with BM No. marked on it with red paint.

- Bench Mark pillar is of size 15 cm x 15 cm x 45 cm cast in RCC M15 with a nail fixed in the centre of the top surface and embedded in concrete M10 (5cm all around) up to a depth of 30 cm. The balance 15 cm above the ground is painted yellow.
- An arrow indicating the location of the BM is painted on the road with the permanent yellow paint and recorded in separate field books with its three dimensional location.

The Bench Mark is established using high accuracy Digital Level and Bar coded staff by way of double run leveling in small circuits of 3 km length ensuring an accuracy in the order of $12\sqrt{k}$ mm, where 'K' is the distance in Kilometers between two Bench Marks avail-able in the project area, and error, if any, within permissible limits is distributed in rational manner to establish the accurate and effective vertical control grid.

The topographic survey has been extending up to the proposed Right of Way (ROW). Wherever necessary, the survey corridor width is further increased to accommodate situations arising out of encroachments and any other contingencies. The survey areas at the locations of intersections cover up to a minimum of 500m on the either side of the centre-line and have sufficient width to accommodate improvement measures. Necessary surveys are

also carried out for determining the requirements of service roads for local traffic, where appropriate.

3.5.2.4 Detailed Survey

Using the horizontal and vertical control points established accurate data in the digital format in terms of Northing (Y). Easting (X) and Elevation (Z) co-ordinates for all breaks in terrain such as ridges and ditches are collected perpendicular to the centre line at 50m intervals in tangent sections and 20-25m in curve sections using Total Stations. Cross sections are taken for the specified corridor width of 110m; however this corridor width is increased to 150m on the inside of sharp curves to account for minor adjustments.

All natural and man-made features such as buildings, irrigation channels, drainage structures, temples, mosques, trees and utility installations etc. are captured during the survey. Spot level on the existing carriageway are captured at five points namely at centerline, mid points of both lanes of traffic movement and pavement edges at both ends to calculate the profile corrective courses more realistically. Trees with girth wise are captured with areas of plantation. Wherever there are groups of trees/plantations, they are picked with the areas of plantation. Boundaries of Agricultural Land area have been surveyed to demarcate the cultivation land limit.

Where existing major roads cross the alignment, the survey has been extended to a maximum of 500m on either side of the road centerline to allow improvements including grade separated intersections to be designed. Apart from this, the survey has covered a maxi-mum of 1000m and 500m on either side of centerline in cases of major and minor bridges respectively.

3.5.2.5 Data Processing

The field survey data are processed in the office to provide a digital output file for the de-sign engineers. The data is structured so that the existing vertical profile along the pro-posed alignment can be produced automatically. The format of the resulting data readily promotes the calculations of earthworks and other quantities required for the evaluation of cost estimates.

Roadway plans have been produced from the survey data, which identify the available Right of Way (ROW) along the existing road corridors. In addition, the plans identify all existing utilities /installations within the corridor/ROW that require re-location by the new road design. Action Plans for covering the relocation of these obstructing installations and public utilities are to be prepared on a km to km basis.

3.5.2.6 Material Investigations

The Material Investigation for road construction has been carried out to identify the potential sources of construction materials and to assess their general availability, mechanical properties and quantities. This is one of the most important factors for stable, economic and successful implementation of the road program within the stipulated time for improvement work as well as for new carriageway, the list of materials includes the following:

a) Granular material for lower sub-base works.

b) Crushed stone aggregates for upper sub-base, base, surfacing and cement concrete works.

c) Sand for filter material and cement, concrete works, sub-base and filling material.

d) Borrow material for embankment, sub-grade and filling.

e) Manufactured material like cement, steel, bitumen, geo-textiles etc. for other related works. The Information on material sources has been carried out with the following basic objectives:

Source location, indicating places, kilometer age, availability and the status whether in operation or new source.

- Access to source, indicating the direction and nature of the access road i.e. left / right of project road, approximate lead distance from the gravity centre and type of access road.
- Ownership of land / quarries, either government or private.
- Probable uses indicating the likely use of materials at various stages of construction work i.e. fill materials, sub-grade, sub-base, base and wearing course and cross drainage structures.

During the process of investigation, due consideration has been given to the locally available materials for reducing the cost of construction.

The samples have been collected as described below:

- From quarry sites for aggregate characteristics like, aggregate impact value, gradation, soundness, flakiness index and elongation, stripping value and water absorption etc.
- From random pits (farmland) along the proposed alignment for availability of suitable embankment and sub grade material, and identification of the borrow areas and tested in line with relevant IRC code.

3.5.2.7 Geotechnical Investigations

Sufficient information about the arrangement & behavior of the underlying materials and their physical properties for adopting and designing the structural foundation is essential. Soil exploration through field investigation and laboratory testing of the substrata are helpful in arriving at required parameters for designing of safe and economical foundations. The data obtained from these investigations has been analyzed for safe design of the foundation. In the geotechnical report's recommendations has been made for type of foundations and its safe bearing capacity/load carrying capacity required for the structure design.

3.5.2.8 Hydrological Investigations

Hydrological investigations have been carried out for the entire project. It has been ensured that majority of the cross drainage structures are hierologically adequate to carry the discharge of the river / streams.

3.6 Traffic Design

3.6.1 General

The capacity standards for expressway have been adopted as per the "Guidelines for Expressways". Capacity analysis is fundamental to the planning, design and operation of roads and provides, among other things, the basis for determining the carriageway width to be provided at any point in a road network with respect to the volume and composition of traffic. Moreover, it is a valuable tool for evaluation of the investments needed for future road constructions and improvements.

3.6.1.1 Equivalency Factors

The need of expressing capacity in passenger car units has triggered off many studies for establishing appropriate passenger car equivalency (PCE) values for different types of vehicles. Notable among the studies carried out in India are the road user cost studies (RUCS) by CRRI and the MoRT&H. It has been recognized that the PCE values vary under different traffic, roadway conditions and composition for any given type of vehicle.

Equivalency Factor is a factor to convert the mixed flow of traffic in to single unit to express the capacity of road. The unit generally employed is the passenger car unit (PCU). The equivalency factors for conversion of different types of vehicles in to equivalent passenger car units based on their relative interference value are given in Table 2.1 (as per IRC: 64 – 1990).

Table 2.1: PCU Factor for Various types of Vehicles on Rural Roads

S. No.	Vehicle Type	Equivalency Factors
Fast moving vehicles		
1	Motor cycle or scooter	0.50
2	Passenger car, pick up van or auto-rickshaw	1.00
3	Agricultural tractor, light commercial vehicle	1.50
4	Truck or bus	3.00
5	Truck – trailer, agricultural tractor – trailer	4.50
Slow moving vehicles		
1	Cycle	0.50
2	Cycle rickshaw	2.00
3	Hand cart	3.00
4	Horse drawn vehicle	4.00
5	Bullock cart	8.00

3.6.2 Capacity Analysis for 6-Lane Expressway

As per the Guidelines for Expressways Volume-I: Planning, the capacity of an expressway is sensitive to the traffic flow characteristics on divided highways.

3.6.2.1 Free Flow Speed

An important element of the speed – flow curves of the project roads is the free flow speed. It is the speed at which driver feel comfortable travelling under the physical, environmental and traffic control conditions on a non-congested section of a multi lane highway, - HCM (2000). All recent studies suggest that speed on project road is insensitive to flow over a broad range of flows. Thus free-flow speed can be established on an existing facility by measuring in the field, the average speed of vehicles when flow rates do not exceed 1300 passenger car per hour per lane (PCPHPL) (HCM 1994). In the absence of traffic flow speed data on highway in India, the free flow speed is required to be assumed.

3.6.2.2 Factors affecting the Free Flow Speed (FFS):

The FFS of an expressway depends on the traffic and roadway conditions described below:

- Lane width
- Lateral Clearance
- Number of Lanes
- Interchange Density
- Geometric design

The basic equation used to calculate the FFS is as given below:

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID} \quad \text{----Eq(1)}$$

Where,

BFFS=base free flow speed, kmph

f_{LW} = adjustment factor for lane width

f_{LC} = adjustment factor for right shoulder lateral clearance

f_N = adjustment factor for number of lanes

f_{ID} = adjustment factor for interchange density

Base Free Flow Speed BFFS is set at 120 kmph for rural facilities.

Adjustment factor for Lane width (f_{LW}) is given in Table 2.2.

Table 2.2: Adjustment Factor for Lane Width

Lane Width (m)	Reduction in FFS (kmph)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

For the project road, the lane width considered is 3.75, hence, the reduction in FFS =0.0

Adjustment factor for left shoulder clearance (f_{LC}) is given in Table 2.3.

Table 2.3: Adjustment Factors for Left Shoulder Clearance.

Left Shoulder width(m)	Reduction in FFS (Kmph; fLC)			
	Number of Lanes in One Direction			
	2	3	4	>=5
>=1.8	0.0	0.0	0.0	0.0
1.5	1.0	0.6	0.3	0.2

1.2	2.0	1.3	0.6	0.3

For the project road, the left shoulder width is greater than 1.8, hence adjustment factor is 0.0.

Adjustment factor for Number of Lanes (fN):

For rural facilities f***N*** is set as 0.

Adjustment factor for Interchange density (fID)

Since the minimum interchange spacing more than 4 kms, the adjustment factor for interchange density is set as 0.

The using Equation (1) we get

FFS=120-0-0-0-0

FFS = 120kmph

Calculation of Base Capacity (Base Cap)

The base capacity (pcphpl) of an expressway facility is given by

Base Capacity = 1700+10FFS; for FFS<=112 ----------Eq(2)

Base Capacity = 2400; for FFS>112 ----------Eq(3)

Since, the FFS is (120kmph)>112kmph, base capacity =2400pcphpl

Determination of Peak Capacity (Peak Cap)

The peak capacity is given by,

Peak Cap = Base Cap*PHF*N*f_{HV}*f_P

Where,

Peak Capacity = Peak capacity, vehicles per hour (all lanes, one direction)

PHF = Peak Hour Factor; *0 .88 so as to maintain LOS B always on Expressway*

N = Number of lanes in one direction (3 for 6-lane); *3 for one direction flow on Expressway*

f_{HV} = Adjustment factor for heavy vehicles; *0.8253 for expressway as calculated below*

f_P = Adjustment factor for driver population; *0.975 for rural expressways*

Assign a final PHF is given in **Table 2.4.:**

Table 2.4: Peak Hour Factor

Area Type	V/C Ratio	PHF
Rural	<0.7744 0.7744<=v/c<=0.9025 >0.9025	0.88 Equation (4.04) 0.95
Urban	<0.8100 0.8100<=v/c<=0.9025 >0.9025	0.90 Equation (4.04) 0.95

For the project road the PHF of 0.88 has been considered.

Adjustment factor for Heavy Vehicles (fHV)

The adjustment factor for heavy vehicles is based on calculating passenger car equivalents for trucks and buses.

$f_{HV} = 1/(1+PT(ET-1))$

Where,

PT= Proportion of trucks and buses in the traffic stream; 42% as per traffic projections

ET=Passenger car Equivalents; 1.5 for rural expressways in level terrain.

The f_{HV} factor for the expressway using the above equation is 0.8253

Adjustment factor for Driver Population (f_P)

On rural expressways, the factor is set to 0.975 but has been considered as 1.0 for the project road.

Thus, the peak capacity for the 6-lane expressway

Peak Capacity = 2400*0.88*3*0.8253*.975

= 5089 pcphpl *(for 3-lane in one direction)*

= 5089*2/0.08 = 127225 PCUs per day *(for 6-lane carriageway with depressed median)*

The peak capacity of the Ganga Expressway shall be 127225 PCUs per day

3.6.2.3 Recommended Design Service Volume for Six Lane Expressway

Assuming a V/C ratio of 0.77 lesser than 0.7744 corresponding to PHF of 0.88 to maintain a Level of Service B, the Design Service Volume for 6-Lane Expressway with depressed median shall be 98000 PCU per day for peak hour flow of 8%

= 127225 * 0.77 = 97963, say 98000 PCUs per day

3.7 Engineering Design

3.7.1 Geometric Design of the Alignment

The Preliminary Design has been carried out on the selected alignment so as to have optimum Construction, Operation & maintenance cost and Vehicle Operation Cost; minimum Social Impacts and Social Costs and Environmental Impacts and Environmental Mitigation Costs.

The preferred alignment would definitely have minimum Rehabilitation and Resettlement i.e. it would utilize to the maximum possible barren / agriculture / government land to minimize Land Acquisition in villages / habited areas. A thorough consultation with stakeholders including industries, relevant government agencies, NGOs, project affected persons (including farmers & people having property) and other consultants working in the region will be made.

Geometric Design Control

The detailed design for geometric elements covers, but is not limited to the following major aspects:

- Horizontal alignment
- Longitudinal profile

- Cross-sectional elements
- Junctions, intersections and Interchanges
- Service road along the alignment

Different options for providing grade separated interchanges were examined and the geometric design of interchanges has taken into account the site conditions, turning movement characteristics, level of service, overall economy and operational safety.

Indicative Design Standards

The indicative design standards for geometric design of road are illustrated in Table 2.5 for main carriageway, geometric standards for Interchange elements and Length of speed change lanes. Ruling design speed is adopted for designing the Project Highway in conformity with the provisions of the Guidelines for Expressway Manual.

Table 2.5: Indicative Design Standards

S.No.	Descriptipn		Details of Project Road
1	Design speed		120 Kmph
2	Lane width		3.75 m
3	Depressed Median (including shyness)		15.0 m
4	Median side paved strip (Shy distance)		0.75 m
5	3-Lane carriageway		11.25m
6	Paved Shoulder		3.00m
7	Earthen Shoulder		2.00m
8	Camber/Cross-fall	C/W & PS	2.50%
		Earthen shoulder	3.00%
9	Width of Service Road		3.75 m/7.00m/10.00m
10	Utility Corridor		2.00m
11	Maximum	For below 1000m radius	7.00%
	Super-elevation	For above 1000m radius	5.00%
12	Safe Stopping Sight Distance (SSD)		250 m
13	Desirable Minimum Sight Distance (ISD)		500 m
14	K-Value for Sag-curve (minimum)		132
	K-Value for Hog-curve (minimum)		261
15	Desirable Minimum radius of horizontal curve		1000 m
16	Minimum radius of Horizontal curve without transition		4000 m
17	Minimum vertical Gradient		0.30%

S.No.	Descriptipn		Details of Project Road
18	Min. Longitudinal slope for Drain	Unlined	1%
		Lined	0.50%
19	Ruling/Limiting gradients		2.5% / 3%
20	Minimum grade change requiring vertical curve		0.50%
21	Minimum length of vertical curve		100m
21	Minimum Height of Embankment		Bottom of Sub-grade is at least 1.5 m above the High Flood Level/Water Table/Pond Level.
22	Vertical clearance for SVUP		4.0 m
	Vertical clearance for LVUP		4.5 m
	Vertical clearance for VUP		5.5 m
	Vertical clearance for Interchanges/Flyovers		6.5 m
	Vertical clearance for ROB		7.3 m
23	K-Value for Sag-curve (minimum)		132
24	K-Value for Hog-curve (minimum)		261

Design Speed

Design speed 120 Km/h is the basic parameter, which determines the geometric features of the road. The proposed design speeds for different terrain categories are as per "Guidelines for Expressway".

In general, the ruling design speed is adopted for geometric design of the highway. Only in exceptional circumstances, minimum design speed may be adopted where site conditions are extremely restrictive and adequate land width is not available.

3.7.2 Cross Sectional Elements

Right of Way (ROW)

As per Guidelines for Expressway the minimum right of way (ROW) for up to 6 lanes expressways is 90m for plain and rolling terrain in case of without service road. The minimum ROW of 120 m has been adopted for the proposed expressway in rural section (open areas i.e. green field section). The ROW at toll plaza locations, ROBs and flyovers/interchange sections may vary depending on their respective layout and requirement. A 2m wide utility corridor outside the boundary fencing has been taken into account within the proposed ROW width.

Table 2.6: Right of Way in Plain/Rolling Terrain

Section	Right Of Way Width* (ROW)
Rural Section	90 m – 120 m

Rural Section passing through semi-urban areas	120 m#

* The ROW width includes 2 m wide strip on either side reserved for placement of utilities outside fencing.

In case an elevated expressway on viaduct is proposed, the width of ROW may be reduced as per site conditions and availability of land

Lane Width

As per Guidelines for Expressway the width of a lane in Plain and Rolling terrains has been taken as 3.75 m. The kerb shyness of 0.75 m shyness on median side has been provided.

Median width of Carriageway

The median shall be depressed or flush. As a rule, depressed median shall be provided except in situations where the availability of ROW is a constraint. The width of median is the distance between inside edges of carriageways. The recommended width of median is given in Table 2.7 below:

Table 2.7: Median Width

Type of Median	Recommended Median Width (m)	
	Minimum	Desirable
Depressed	12	15
Flushed	4.5	4.5
Flush (to accommodate structure/pier on median)	8	8

The depressed median shall have suitably designed drainage system so that water does not stagnate in the median.

An edge strip of 0.75 m width of depressed median adjacent to carriageway in either direction shall be paved with same specifications as of the adjoining carriageway.

As far as possible, the median shall be of uniform width in a particular section of the Project Expressway. However, where changes are unavoidable, a transition of 1 in 50 shall be provided.

Paved Shoulder

Paved shoulders shall be designed as an integral part of the pavement for the main carriageway. Width of these shoulders has been taken as 3 m. This will provide for better traffic operation conditions, lower maintenance and facility of directly using these as part of carriageway when the road is subsequently widened on these sides.

The Composition and specification of the paved shoulder shall be as that of the main carriageway.

Earthen Shoulder

The earthen shoulder has been proposed with good borrowed earth having a width of 2m on the outer side.

Sight Distance

The Safe stopping sight distance and desirable minimum sight distance for divided carriageway for various design speed given in Table 2.8. The desirable values of the sight distance shall be adopted unless there are sight constraints. A minimum of Safe stopping sight distance shall be available throughout.

Table 2.8: Safe Sight Distance

Design Speed (km/h)	Safe Stopping Sight Distance (m)	Desirable minimum Sight Distance (m) (Intermediate Sight Distance)
120	250	500
100	180	360

At critical locations decision or decision points where changes in cross sections occurs such as Toll Plazas and Interchanges, the sight distance shall not be less than decision sight distance given in Table 2.9. The criteria for measuring sight distance are same as for the stopping sight distance.

Table 2.9: Decision of Sight Distance

Design Speed (km/h)	Decision Sight Distance (m)
120	360
100	315

Horizontal Alignment

The horizontal curves on the project road are designed for maximum radii (where feasible) as per Guidelines of Expressway manual and IRC:SP:99-2013, absolute minimum radius has been used at couple of locations.

The Alignment shall be fluent and blend with the topography. The horizontal curve shall be designed to have largest practical radius and shall consist of circular portion flanked by spiral transitions at both the ends.

Super – Elevation

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 or equal to desirable minimum. Super elevation shall not be less than the minimum specified Cross fall.

The super elevation at curves is arrived at as per the following equation:

$(e + f) = v2/127R$

Where,

v = Vehicle speed in Km/h.

e = Super elevation ratio in meter per meter

f = Coefficient of side friction between vehicle tyre and pavement (0.1)

R = Radius in meters.

The super elevation is calculated keeping in view the horizontal radii and gradient at curves at different locations.

3.7.3 Method for attaining super-elevation

Dual – inner edge pivot of both carriageways at different chainage is used for attaining super-elevation. This method pivots the dual carriageway about the inner edge strings of both carriageways using different chainage, so that the central reservation levels are not changed. The application of super-elevation to the left and the right carriageways will start (or end) at different chainage, to ensure that the rate of change remains the same for both. The method is explained in Figure 2.1:

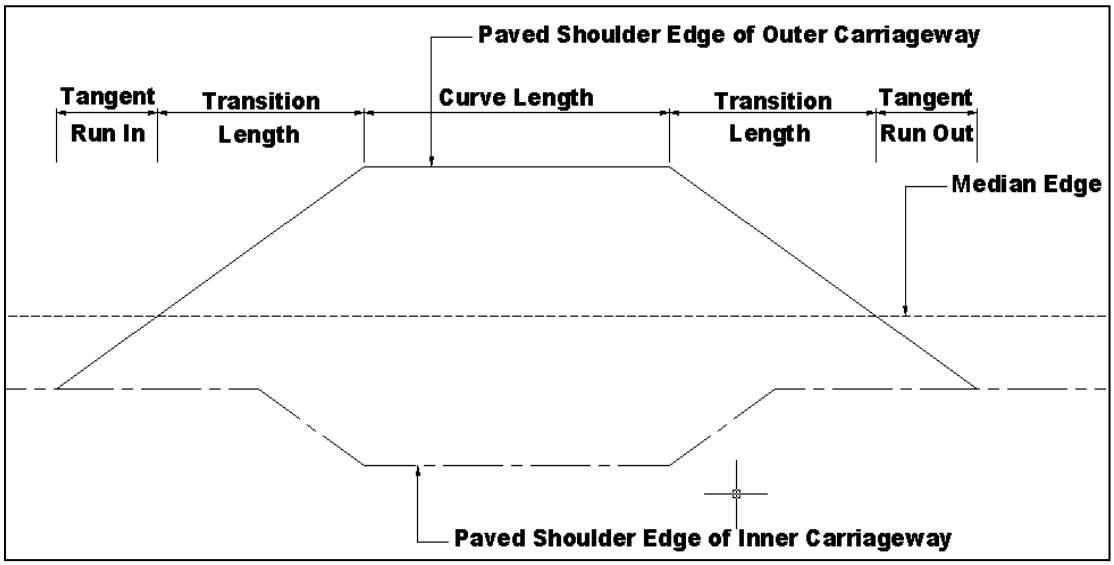


Figure 2.1: Method for attaining Super-Elevation

3.7.4 Transition Curves

The following three formulae are used for calculating the transition lengths and the maximum value is being adopted for design:

a) Rate of change of centrifugal acceleration

Ls = 0.0215 V3/ CR

Where,
R – Radius of curve in meters
V – Vehicle speed in Km / hour
Ls – Length of transition in meters
C – Rate of change of acceleration.
C = 80/(75+V)

Subject to maximum of 0.6 & minimum of 0.4

b) Rate of change of super elevation or runoff.

The rate of change of super elevation is being considered not steeper than 1 in 200 for roads in plain and rolling terrain and 1 in 150 for roads in Mountainous terrain.

c) Three seconds time for manipulating the steering. The minimum length of transition curves for this criterion is as in Table 2.10.

Table 2.10: Minimum Length of Transition Curve

Design Speed (km/h)	Minimum length of transition curve (m)
120	100
100	85

3.7.5 Vertical Alignment

General

The vertical alignment of the carriageway is generally compatible with the guidelines given in the Guidelines of Expressway manual as well as IRC: SP: 99-2013.

At locations of grade break of 0.5%, vertical curves are being provided.

- There shall be no change in grade within a distance of 150m
- The length of vertical curve will not be less than 0.6V (kmph)
- Number of vertical intersection point shall not be more than 4 per km.
- At locations of sight deficiency, at least stopping sight distance (SSD) is being provided.

The aspect of efficient drainage shall be kept into consideration while designing the vertical profile and cross sections of the Project Expressway as stipulated in IRC:SP:42 and IRC:SP:50.

The vertical alignment shall be coordinated with the horizontal alignment

Gradients

The ruling and limiting gradients are given in Table 2.11.

Table 2.11: Gradients

Terrain	Ruling Gradient	Limiting Gradient
Plain	2.5%	3.0%
Rolling	3.0%	4.0%

The ruling gradient shall be adopted as far as possible. Limiting gradient shall be adopted only in very difficult situation and for short lengths.

In cut sections, minimum gradient for drainage considerations is 0.5% (1 in 200) if the side drains are lined; and 1.0% (1 in 100) if these are unlined.

Vertical Curves

Long sweeping vertical curves shall be provided at all grade changes. Summit curves and valley curves shall be designed as square parabolas. The length of the vertical curves is controlled by sight distance requirements, but desirably curves with the longer length shall be provided from aesthetic considerations. The minimum grade changes requiring vertical curve and the minimum length of vertical curve shall be as given in Table 2.12. More liberal

values are adopted wherever this is economically feasible. Valley curves are designed for headlight sight distance.

Table 2.12: Minimum Length of Transition Curve

Design Speed (km/h)	Minimum Grade Change requiring Vertical curve	Minimum length of Vertical Curve(m)
120	0.5%	100
100	0.5%	85

Lateral and Vertical Clearance at Underpasses

Lateral Clearance

Minimum clearance at under passes shall be as follows:

i) For Vehicular Underpass, the lateral clearance shall not be less than 20 m

ii) For Light Vehicular Underpass, the lateral clearance shall not be less than 12 m including 1.5 m wide raised footpaths on either side.

iii) For Smaller Vehicular Underpass, the lateral clearance shall not be less than 7m.

iv) Crash barrier shall be provided for protection of vehicles from colliding with abutments and piers and the deck of the super structures.

Vertical Clearance

The vertical clearances at underpasses shall not be less than the values given in Table 2.13.

Table 2.13: Vertical Clearance

Rail Over Bridges	7.3 m
Interchange/Flyover	6.5 m
Vehicular Underpass	5.5 m
Light Vehicular Underpass	4.5 m
Smaller Vehicular Underpass	4.0 m

Lateral and Vertical Clearance at Overpasses

Lateral Clearance

Shall be provided as a full roadway width as specified in Schedule of Contract Agreement.

Vertical Clearance

A minimum of 5.5m Vertical Clearance shall be provided from all points of the Carriageway of the Project Expressway.

3.7.6 Cross-Fall

The cross-fall on each sections of the expressway carriageway shall be as given in Table 2.14. Each carriageway shall have unidirectional cross fall.

Table 2.14: Cross-fall on different surfaces

Cross-Sectional Element	Annual Rainfall	
Carriageway, Paved shoulders, Edge Strip, Flush Median.	**1000mm or more**	**Less than 1000mm**
	2.5 %	2.0 %

The cross-fall for earthen/granular shoulders on straight portions shall be at least 0.5% steeper than the values given in Table above. On Super Elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse crossfall so that the earth does not drain on the carriageway and the storm water drains out with minimum travel path.

3.8 Design OF Horizontal and Vertical Alignment

The general principles and design criteria laid down in MoRTH Guidelines for Expressways shall be followed except as otherwise indicated in this Manual.

Culverts

The culverts are proposed to be built to the full formation width of the road and have been designed accordingly.

Highway Signs and Marking

The road signs conforming to latest IRC: 67 have been proposed. Location of route marker signs are as per the latest IRC: 2; the provision for hectometer stones, 5th kilometer stone, Kilometer and 200 m stones are as per latest IRC: 8 and latest IRC: 26 respectively. The boundary stones are as per latest IRC: 25. Road Delineators are as per latest IRC: 79.

All road signs are considered as retro-reflective sheet of high intensity grade with encapsulated lens fixed over aluminium substratum and conforming to MoRT&H Specifications for road and bridge works. Provisions for Road markings have been considered as latest IRC: 35.

3.9 Access Control

Project Expressway shall be designed for fast motorized traffic with full control of access. Access to the Expressway shall be provided with grade separators at location of intersections. Parking/standing, loading/unloading of goods and passengers and pedestrians/animals shall not be permitted on the Expressway.

Location of interchange – The locations of individual interchanges are determined primarily to reduce detour considering regional network and nearness to places of importance. Location of interchange is guided by the following situations:

i) At crossing or nearest points of other Expressways, National Highways, State Highways and important arterial roads.
ii) At crossing or nearest points of major roads to important ports, airports, material transport facilities, commercial and industrial areas, and places of tourist interest.

The interchanges shall be provided at the locations specified in Schedule-B of the Concession Agreement.

3.10 Connecting roads

Connecting roads where required to maintain proper circulation of local traffic, continuity of travel and to facilitate crossing over to the other side of the Project Expressway through an under/overpass shall be constructed on the land acquired within the ROW of the Project Expressway. These shall be provided outside the fencing. The location, length, other details and specifications of connecting roads to be constructed shall be specified in Schedule-B of the Concession Agreement. The width of the connecting road shall be 7.0 m. The construction and maintenance of connecting roads shall be part of the Project Expressway

3.11 Pavement Design

Type of Pavement – The Authority may require provision of specific type (flexible/rigid) of pavement depending upon specific site conditions. Such requirements shall be as specified in Schedule-B of the Contract Agreement. Unless otherwise specified in Schedule-B, the may adopt any type (flexible/rigid) of pavement structure for new construction.

Flexible pavement is designed by using IRC: 37-2012 and rigid pavement is designed as per the provisions contained in latest IRC: 58. Besides the above, designs for service roads, toll plaza, parking bays have been carried out.

Design of flexible pavement – The pavement shall be designed to ensure the specified performance for the projected traffic needs, climate and type of soils in the given area. The Contractor is expected to use a design procedure that is appropriate to produce a cost-effective structure meeting the performance requirements and long term durability. The Contractor may use IRC:37 "Tentative Guidelines for the Design of Flexible Pavements" or it may use any internationally accepted design procedure that is based on past performance and research. It will be the Contractor's responsibility to provide a pavement structure that fully meets the prescribed performance requirements throughout the operation period.

Design of rigid pavement – Jointed rigid pavement shall be designed in accordance with the method prescribed in IRC:58 "Guidelines for the Design of Plain Jointed Rigid Pavements for Highways". Continuously Reinforced Concrete Pavements (CRCP) shall be designed as per any recognized international guidelines which shall be subject to approval by the Independent Engineer.

Design Life

The bituminous pavement with design life of 20 years has been considered for the flexible pavement design. For rigid pavement a design life of 30 years has been considered.

Design Traffic

The Design traffic has been estimated in terms of cumulative number of standard axles (8160kgs) to be carried by the Pavement during the design period.

Any likely change in traffic due to proposed improvement of the facility and/or future development plans, land use, shall be duly considered in estimating the Design Traffic. The Growth rates mentioned in the Traffic Studies chapter has been considered while calculating the Million Standard Axle loads. The project road is a green field highway and there is no existing carriageway, therefore, the VDF has been calculated based on the Axle Load Surveys

conducted on alternate roads and the values of VDF has been presented in Section 3.3.3 of this report.

Rigid Pavement Design

Design of Concrete Slab

Once the parameters are decided, actual stresses developed in the concrete slab due to design wheel load is computed by the Westergaard's Equation modified by Teller and Sutherland. The maximum stress occurs in the corner and the minimum in the interior. The edge load condition gives an intermediate value.

Temperature stresses at the edge are calculated by using Bradbury's formula. The temperature stresses in the corner region is negligible as the corners are relatively free to wrap and may be ignored.

The design wheel load stress and the temperature stress at the edge are then added up together and this summation shall be less than 28 days flexural strength of concrete for the assumed thickness to be adequate from design point of view.

Once the assumed slab thickness is found adequate for the combined stresses developed due to temperature and design wheel load, its adequacy needs to be checked from the view point of its consumption of fatigue resistance. In this case also, edge stresses are computed as discussed earlier for various axle load classes. Then stress ratio (SR) is calculated as ratio of stress due to wheel load and the 28 days flexural strength of concrete for all axle load class. Consumption of fatigue resistance is computed for this stress ratio for each axle load class. Summation of this consumption of fatigue resistance should not exceed the allowable limit for the assumed thickness to be adequate from the view point of fatigue consideration.

Design of Joints

Once the concrete slab thickness is designed based on particular spacing and location of joints, the remaining job is the design of dowel bars and tie bars with the provision of adequate sealants.

Dowel Bars

The design of dowel bar at joints is carried out on the basis of its load transfer capacity. It is recommended that 40% of wheel load can be transferred through dowel bar system. It is observed that failure of dowel bar occurs due to the crushing of concrete below the dowel bar and hence bearing stress shall be considered for its design.

Generally, 500 mm long 32 mm diameter M.S. bar at a spacing of 250 – 300 mm is used as dowel bar for concrete slab of 200 -350 mm thick. No dowel bar is required for slab thickness less than 150 mm. However separate calculation has been made for present situation for dowel bar design.

Tie Bar

Tie bars are provided to prevent the adjoining slabs from separating. Longitudinal joints are provided with tie bars. It does not increase the structural capacity of the slab and are not designed as load transferred devices.

3.12 Hydrological Design

Design Standards

The hydrological & hydraulic design for cross drainage structure shall conform to the following codes and reports:

IRC: SP-13 – Guidelines for the design of small bridges and culverts

IRC: 5 – Code of practice for Road Bridges, Section I (General features of Design)

IRC: 78 – Code of Practice for Road Bridges, Section VII (Design of Foundation and Substructure)

IRC: SP-87 – Manual of Specifications and Standards for Six-Laning of Highways through Public Private Partnership

Design Approach

The hydrological & hydraulic design of bridges is an important aspect to determine the minimum required waterway; design highest flood level (HFL) and minimum scour levels of piers & abutments of the bridges proposed on the new alignments. The various design standards (latest) which have been adopted for the hydrological & hydraulic design of bridges are given below. Approach slabs shall be provided for all bridges and grade separated structures as per Clause 217 of IRC:6 and Section 2700 of MORTH Specifications.

Design Parameters –

Area of catchment & length of longest stream have been obtained from topographical sheets of Survey of India (SOI).

The Cross Section of stream at 500 m U/S and 500 m D/S depending upon catchment area along with longitudinal gradient has been obtained to evaluate design discharge .The various method such as area velocity , unit hydrograph Rankins method has been considered for obtaining of design discharge .

Scour Depth

Scour depth can be calculated as per Clause 703.2 of latest IRC: 78 and as explained in latest IRC: SP 13. The mean depth of scour, dsm below the highest flood level is given by the following equation:

dsm = 1.34 (Db2/Ksf)1/3

Where, Db = the design discharge for foundation in cumec per meter width. The value of Db shall be the total design discharge divided by the effective linear waterway width be-tween abutments.

"Silt Factor" (Ksf) have been assumed based on the silt factor values of the Agra to Etawah project. As per latest IRC: 78, for the design of piers and abutments located in a straight reach and having individual foundations without any floor protection works, the maximum depth of scour from the highest flood level is given by:

For piers: dmax = 2 x dsm

For abutments: dmax = 1.27 x dsm (having retained approach)

Minimum Founding Level: The foundation has been taken to a level to safeguard against scour. In case of bridges, where the mean scour depth dsm is calculated by using the equation given in Clause 703.2 of latest IRC-78, the depth of foundation has not been taken less than that of existing structures in the vicinity.

3.12.1

3.12.2 Drainage and Protection Works

The drainage requirements for the project road and adjoining areas are assessed through the DTM prepared from topographical survey data. Pavement internal and external drain-age is ensured by providing drainage layer and camber respectively. Longitudinal slopes in roadside ditches and central drain are generally equal to generate self-cleaning velocity at the time of storm.

Small catchment analysis with project specific unit hydrograph is undertaken for the hydraulic design of the drain channel. The shape of the channels is fixed to facilitate easy and economical construction and easy maintenance. Suitable drainage system is planned for the high embankment, super-elevated carriageway and other key areas, with a view to en sure easy collection and disposal of storm water. A network has been conceptualized from runoff till final disposal and its continuity is ensured at each critical point.

3.13 Structural Design

3.13.1 General

This section deals with the standards to be adopted in design of vis-à-vis ROBs, flyovers, bridges, underpasses and culverts. It also provides for the type of materials and their specifications that had been adopted for the above structures, the loads and forces to be considered. The project road is 6 lane and the structures are also designed for 6 lanes.

3.13.2 Cross-sectional Elements

a) Structural width for bridges / flyovers / road over rail bridges

The overall deck width for all bridges, underpasses has been kept as 21.25 m (including 0.5m crash barrier on either side) & 2X12.5 m for ROBs in each direction of traffic. Please refer for structure drawing and GADs of each major/minor structures.

b) Median width

A median width of 12.5 m is maintained between two outer faces of RCC crash barriers.

c) Reinforced Earth Retaining Structures –

The design and construction of reinforced earth structures shall conform to section 3100 of MORTH Specifications. Reinforced earth retaining structures shall not be provided near water bodies. Such structures should be given special attention in design, construction, ground improvement where necessary, maintenance and selection of System/System design. Local and global stability of the structure shall be ensured.

d) Road over bridge (road over railway line)

i) If the alignment of road at the existing railway crossing has skew angle more than 45°, the alignment of road or of pier/abutment shall be suitably designed to reduce skew angle up to 45°.

ii) Railways normally do not allow construction of solid embankment in their right of way. The horizontal and vertical clearances to be provided on the railway land shall be as per requirement of the Railway authorities.

iii) In case the Authority has obtained approval of General Arrangement Drawings, the same shall be appended with the Request for Proposal. The Contractor shall have option of adopting the same span arrangement or have his revised proposal for GAD approved from the Railways. In case the total length of stilt portion is not reduced, it will not be considered as change of scope. However, before submitting the revised proposal to the Railways, prior consent of the Authority shall be required.

iv) The Contractor shall be required to obtain approvals of all designs and drawings from the concerned Railway authorities.

v) The construction of ROB within the railway boundary shall be under the supervision of the Railway authorities.

vi) The approach gradient shall not be steeper than 1 in 40.

vii) Outside the railway boundary, one span of 12 m conforming to the requirements of Vehicular Underpass shall be provided on either side of ROB to cater for the local traffic, inspection, and pedestrian movement.

3.13.3 Specification for Material

a) **Concrete:** The grades of concrete are either equal to or higher than those pre-scribed in latest IRC: 112. Grade of concrete in various structural elements is for moderate conditions of exposure.

Superstructure

PSC Members : M 45

RCC T-Girder and Deck Slab : M 35

RCC Solid Slab : M 35

RCC Box cell : M 35

RCC Crash Barriers: M 40

Substructure

RCC substructures and foundations: M 35

All PCC structural members: M 20

All PCC non structural members: M 15

Pedestals for bearings

Pot/PTFE : M 40

Elastomeric: M 40

b) **Steel:** This conforms to the provisions given in IS: 1786, IS: 432 (Part I).

Reinforcement steel:

- High yield strength deformed bars conforming to Fe 500 / TMT.
- Mild steel not to be used.
- Pre-stressing steel

These conform to IS: 14268-1995

System : 19 K13 or 12 T13 low relaxation multiple strands system

Cables :19 K13 or 12 T13 systems with strands of 12.7 mm nominal diameters.

Sheathing : 90 mm / 75mm Corrugated HDPE sheathing duct.

c) Bearings

All bearings shall be easily accessible for inspection, maintenance and replacement. Suitable permanent arrangements shall be made for inspection of bearings from bridge deck. Design and specifications of bearings shall be as per IRC: 83 (Part I, II and III). Spherical bearings shall conform to the requirements of BS:5400 and materials of such bearings may conform to the relevant BIS codes nearest to the specifications given in BS:5400. The drawing of bearings shall include the layout plan showing exact location on top of pier and abutment cap and the type of bearings i.e. fixed/free/rotational at each location along with notes for proper installation. The bearing should cater for rotation and movement in both longitudinal and lateral direction. Elastomeric bearing has been provided under RCC T-beams and RCC solid slabs type superstructures as per latest IRC: 83 (Part II) and shall conform to clause 2005 of MoRT&H specification for Road and Bridge Works.

POT cum PTFE bearing has been provided for span more than 25m where we have to cater for large loads and conforming to latest IRC: 83 (Part III) and clause 2006 of MoRT&H specifications for Road & Bridge works.

d) Expansion Joints

All Structures shall have minimum number of expansion joints. This may be achieved by adopting longer spans, making the superstructure continuous or by adopting integrated structures. Expansion joints shall conform to IRC:SP:69. In any case, the number of expansion joints shall not be more than 1 for each 100 m length of the bridge or part thereof. For avoidance of doubt, the structures upto 100 m length shall have only one joint at one side abutment, the structures over 100 m and upto 200 m length may have two joints and structures over 200 m and upto 300 m length may have maximum 3 expansion joints. Elastomeric strip seal type expansion joints are provided on all the bridges and ROBs as per Clause No. 2607 of MoRT&H specification for road and bridge works and interim specifications for expansion joints issued subsequently vide MoRT&H letter no. RW/NH-34059/1/96-S&R dated 25.01.2001 and addendum there to circulated vide letter of even no; dated 30.11.2001. In case of bridges with smaller spans slab seal type expansion joints are provided.

3.13.4 Loads and Forces to be considered in Design

Vertical Loads

a) Dead Loads

Following unit weights are assumed in the design as per latest IRC Codes.

Pre-stressed Concrete: 2.5 t / m3

Reinforced Concrete: 2.5 t / m3

Plain Cement Concrete: 2.2 t / m3

Structural steel: 7.85 t / m3

Dry Density of Backfill Soil: 2.0 t / m3

Saturated Density of Backfill Soil: 2.0 t / m3

b) Superimposed Dead Loads

Wearing Coat: 65mm thick with 40mm bituminous concrete overlaid + 25mm thick bituminous mastic layer

Crash barriers: 1.0 t / m / side

c) Live Loads

Carriageway live loads: The following load combinations are considered in the analysis and whichever produces the worst effect is considered.

Five Lanes of IRC Class A

One Lane of 70R (wheeled) with Three lanes of IRC Class A.

Resultant live load stresses are reduced by 20% in case all the five lanes are loaded. Impact factor is as per latest IRC: 6 for the relevant load combinations. For simplicity in design, Impact factor for continuous structures is calculated for the smallest span of each module and used for all the spans of that module.

d) Horizontal Forces

(i) Longitudinal Forces due to live load

Following effects are considered in the design

- Braking forces as per the provision of latest IRC: 6
- Distribution of longitudinal forces due to horizontal deformation of bearings/frictional resistance offered to the movement of free bearings as per latest IRC: 6

(ii) Horizontal forces due to water currents

The portion of bridge, which may be submerged in running water, is designed to sustain safely the horizontal pressure due to force of water current as per the stipulations of latest IRC:6

(iii) Earth load

Earth forces are calculated as per the provisions of latest IRC:6 assuming the following soil properties:

a. Type of soil assumed for backfilling: As per latest IRC: 112

Angle of Internal Friction: Φ= 30O

Angle of Wall Friction: δ = 20O

Coefficient of Friction 'μ'at base : tan (2/3 Φ), while Φ is the angle of internal friction of substrata immediately under the foundations.

b. Live load surcharge is considered as per the provisions of latest IRC: 6.

e) Centrifugal forces

Centrifugal forces are calculated as per the provisions of latest IRC: 6 for a design speed applicable at horizontal curves.

f) Wind effect

Structures are designed for wind effects as stipulated in latest IRC: 6. The wind forces are considered in the following two ways and the one producing the worst effect shall govern design.

g) Seismic Effect

The road stretch is located in Seismic Zone-III as per the revised seismic map of India (IS: 1893-2002). The seismic forces will be coefficient method as suggested by the modified clause for the interim measures for seismic provisions in latest IRC: 6.

h) Other Forces / Effects

Temperature effects: The bridge structure / components i.e. bearings and expansion joints, are designed for a temperature variation of + 250 C considering extreme cli-mate. The superstructures are also designed for effects of distribution of temperature across the deck depth as given in latest IRC: 6, suitably modified for the surfacing thickness.

Temperature effects considered are as follows:

- Effects of non-linear profile of temperature combined with 50% live load and full value of 'E' is considered.
- Effects of global rise and fall of temperature combined with 100% live load and full value of 'E' is considered.

Differential shrinkage effects: A minimum reinforcement of 0.2% of cross sectional area in the longitudinal direction of the cast-in-situ slab is provided to cater for differential shrinkage stresses in superstructures with cast-in-situ slab over precast Girders as per Clause 605.2 of latest IRC: 22.

However, effects due to differential shrinkage and / or differential creep are duly accounted for in the design.

Construction stage loadings / effects: A uniformly distributed load of 3.6 KN /m2 of the form area is considered to account for construction stage loadings in the design of superstructure elements, wherever applicable, as per Cl. 4.2.2.2.2 of IRC: 87 – 1984.

Buoyancy: 100% buoyancy is considered while checking stability of foundations 78um-spective of their resting on soil/weathered rock / or hard rock.

i) Load Combinations to be considered in Design

All members are designed to sustain safely 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 are as per latest IRC: 6.

In addition, the stability of bridge supporting two superstructures (with an expansion joint) is checked under one span dislodged condition also.

j) Exposure Condition

Moderate exposure conditions are considered while designing various components of the bridge.

k) Design Codes

The main design criteria adopted is to evolve design of a safe structure having good durability conforming to the various technical specifications and sound engineering practices.

l) Load combinations

The various load combinations considered are as per provisions of latest IRC: 6

ROB

The design of ROB will be based on the guidelines of Ministry of Railways. As per the latest Railways Guidelines, a vertical clearance of 7.3 m is being imposed for electrified track.

CD structures & HO/Grade separators

The GAD of CD structures is based on hydraulic and hydrological studies.

The GAD of flyovers/Grade separator is based on the traffic surveys and guidelines as contained in relevant IRC codes.

Codes and Publications

The following codes and publications (latest editions) shall be used for the design of approach road and bridge components:

- Specifications For Road and Bridge Works (4th Revision, 2000)
- IRC: 5-1998 For General Features of Design
- IRC: 6-2000 For Loads and Stresses
- IRC: 18-2000 For Pre-stressed Concrete Road Bridges
- IRC: 21-2000 For Reinforced Concrete Design
- IRC: 78-2000 For Substructure and Foundations
- IRC: 83-1999 (Part I) For Metallic Bearings
- IRC: 83-1987 (Part II) For Elastomeric Bearings
- IRC: 83-1987 (Part III) For Pot cum PTFE Bearings

3.14 Environmental and Social Screening

3.14.1 Environmental Screening

An Environmental screening study has been undertaken. The preliminary environmental study focused on identifying the key areas, the need for assessment of key impacts, issues, including information necessary for proposed development. The following issues were identified:

- The important environmental issues and concerns;
- The significant effects and factors; and
- The appropriate content and boundaries of an EIA study.

The programme included:

- Field surveys;
- Consultation exercises; identifying existing relevant baseline data;
- Identifying the scope of baseline surveys required;
- Identifying key issues to be addressed within the EIA; and
- Providing a technical brief for the EIA.

To identify any potential environmental conflicts arising out from the construction of the road, information was collected to arrive at the environmental constraints for the proposed scheme. The main issues included as appropriate, local settlements and communities, traffic, agriculture, ecology, land-use and soils, water, archaeological heritage, cultural and religious sites and planning issues.

This part of the study was undertaken in parallel with the economic and engineering analyses in order to determine any significant social or environmental issues, which require further detailed study. The approach and methodology to be adopted for environmental assessment conforms to the requirement of the Environmental Impact Assessment Notification, MoEF, 2006 & its amendment.

3.14.1.1 Secondary data collection

Secondary data collection including relevant maps for all the corridors was made available from various government agencies regarding:

(i) Flora and fauna

(ii) Critical natural habitats

(iii) Built-up areas

(iv) Water bodies

(v) Other critical environmental indicators

(vi) Policy, legal and administrative framework etc.

The available data has been used for environmental screening. The results of the preliminary screening lead to identification of the nature and extent of environmental issues needing more detailed examination, which may be dealt as a full EIA.

3.14.2 Social Screening

The overall objective of the study is to assess the likely impact on persons/families in the process of land acquisition needed in the process of construction of project road.

Social assessment would be conducted to broadly assess the extent of impacts due to the project on persons and properties within the corridor of impact. Both desk research and identification of major settlements within project area through field survey are conducted.

Social assessment study also aims at identifying the project affected people (PAP) and project affected families (PAF) analysing their socio-economic status, assessing losses due to project implementation. Remedial measures are proposed in the RAP to ensure that the income levels of PAPs, after the project implementation, are improved or at least restored to the pre-project level.

3.14.2.1 Secondary data collection

Available information is collected from various agencies that have worked in the state. The information includes constitutional provisions, status of social related legislation and policies of the central government and the state of Uttar Pradesh, guidelines for entitlement framework and community, social, ethnic and economic indicators of the population.

3.14.3 Social Impact Screening

During this preliminary screening stage, the consultants made an initial visit to the site in order to develop a clear understanding of the proposed road changes that may be undertaken and to identify the impact on housing, business and agricultural activities expected to arise out of the changes to be adopted. The social impact screening concentrated on the areas where there is likely to be the greatest impact on the population.

The data is analysed and screening is done initially, through a reconnaissance survey.

The various indicators considered are:

- Community life and economic activities
- Severance of community
- Encroachment on local community facilities
- Encroachment on local economic activities
- Encroachment on the access to and rights of resources
- Cultural heritage / property
- Social structure, institution and customs
- Cultural shock
- Road safety
- Public health
- Waste

Land acquisition and resettlement

- Expropriation of resources
- Involuntary resettlement
- Conflict between target population and host population
- Indigenous or traditional population

The results of the screening are plotted on maps and tabulated to identify any major conflicts and extent of conflicts.

3.15 Schemes for Development and Assessment

From the existing field data a few alternatives are 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 are listed thereby establishing the procedures, design controls and general engineering practice required.

In the review of project alignment due considerations are given to the environmental implications, land acquisition and impact on project affected people, using information, provided in the discipline desk study reports undertaken earlier.

3.16 Preliminary Cost Estimates

The rates of materials adopted in the preliminary cost estimate are based on the SoR from respective districts of the Uttar Pradesh. The basis of rate analysis is the MoRT&H Stan-dard Data Book. For the working out of preliminary cost estimate, work items are split into the following sub-heads:

- Site clearance and Dismantling
- Earth Work
- Granular Sub Base Courses and Base Courses (Non- Bituminous)
- Bituminous Courses
- Box Culverts
- Minor Bridges
- Major Bridges
- VUP/LVUP/PUP
- ROB
- Flyover and NH & SH Crossing
- Interchange and Junctions
- Retaining Wall
- Drainage & Protective Works
- Traffic signs, Road markings and other road appurtenances
- Toll Plaza
- Approach to Wayside Amenities, Toilet block & Median Opening
- Environmental Cost (Civil Works)
- Miscellaneous Works
- ATMS for Access Controlled Expressway,

4. TRAFFIC STUDIES

4.1 Introduction

This Chapter examines the Traffic Studies for the present day traffic and traffic forecast besides "Toll Studies" which section contains the analyses of system options, makes recommendations regarding the level of toll to be applied to different vehicle categories.

The presently available routes for traffic between Meerut (Start Point of Expressway) & Prayagraj Bypass on NH-19 (old NH-2) (End Point of Expressway) are indicated on Figure 4.1.

The Expressway is access controlled with only entry/exit at Nodes (*intersecting points of National Highway or State Highways or Major District Roads – crossing with the proposed Expressway Alignment*) are lettered "A" to "R" as listed on Table 4.1:

Table 4.1: Details of Toll Nodes for entry / exit proposed on the Expressway

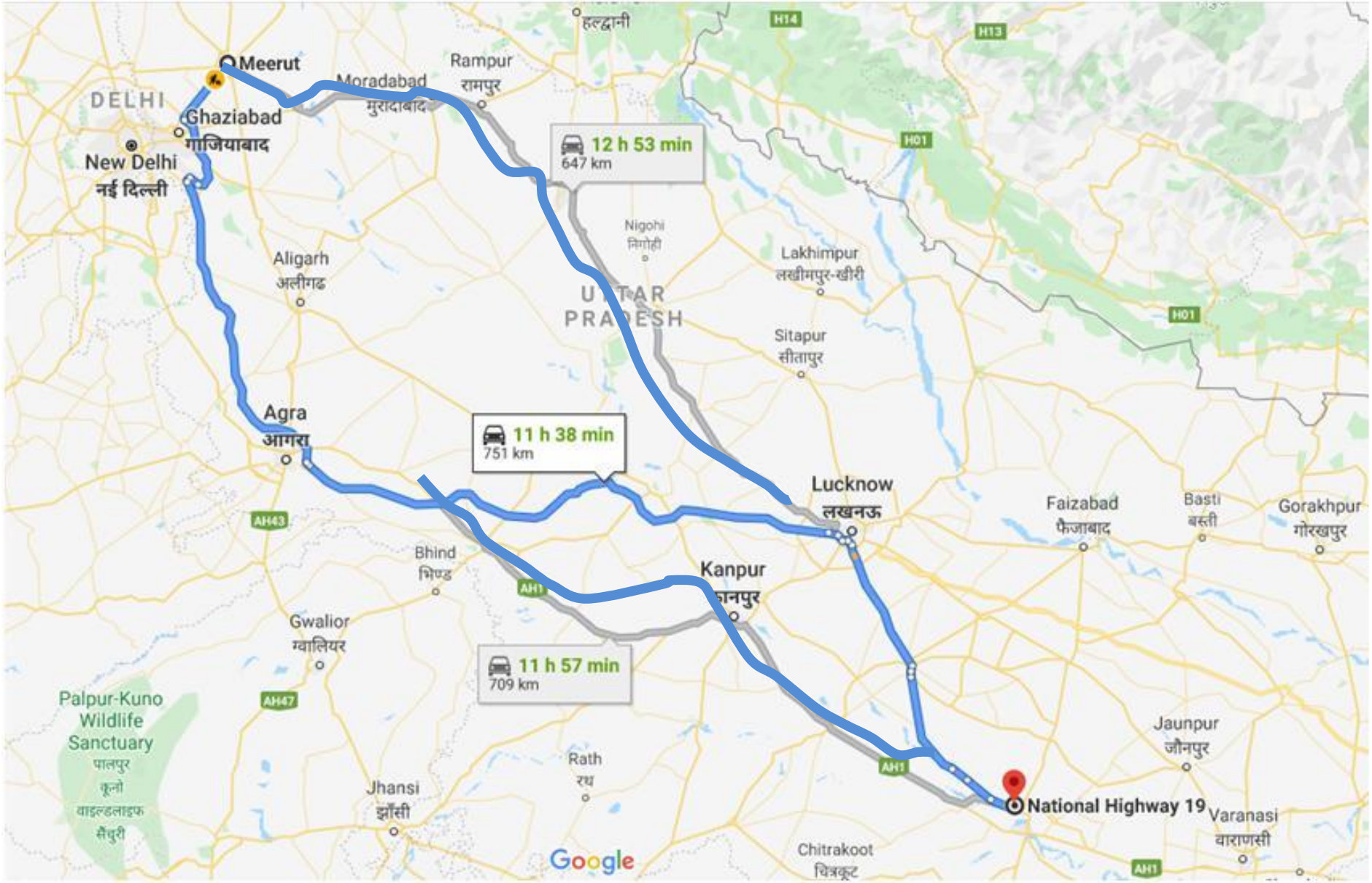
Toll Nodes	Chainage	Details of the Intersecting Roads	Road No.	Type of Intersection
A	0+100	Delhi - Meerut Expressway	Expressway	Dummy Node
B	8+920	Meerut – Hapur	NH-334	Trumpet
C	35+270	Hapur - Garhmukteshwar	NH-24	Diamond
D	54+640	Bulandshahr - Garhmukteshwar	SH-65	Diamond
E	74+181	Hasanpur-Anupshahar	MDR-162W	Diamond
F	102+427	Anupshahr - Moradabad	ODR	Diamond
G	123+288	Babrala - Chandausi	NH-509	Double Trumpet
H	173+454	Chandausi - Budaun	SH-125	Diamond
I	189+394	Budaun - Bareilly	SH-33	Double Trumpet
J	255+167	Farukkhabad - Shahjahanpur	SH-29	Double Trumpet
K	282+845	Farukkhabad - Shahbad	SH-138	Diamond
L	329+945	Kannauj– Hardoi	SH-21	Double Trumpet
M	378+136	Agra - Lucknow Expressway	Agra Lucknow Exp	Double Trumpet
N	420+932	Kanpur - Lucknow	NH-27	Diamond
O	487+285	Lalganj - Raebareli	NH-31	Double Trumpet
P	517+708	Raebareli–Unchahar	NH-30	Double Trumpet
Q	554+951	Manikpur - Bela Pratapgarh	MDR-102E	Diamond
R	600+457	Prayagraj Bypass	NH-19	Trumpet

Node A is revised and treated as Dummy Node in this Report, as the Start Point of the Ganga Expressway has been changed from Node A to Node B due to Engineering Design Constraints, with prior approval of UPEIDA. Table showing distances between various destinations from Ganga Expressway, that traffic which are likely to use the sections of Expressway between these lettered nodes "A"to "R" are provided as follows:

(a) on the presently available network of alternative routes – Table 4.2; and
(b) as estimated on the Proposed Expressway– Table 4.3.

Table 4.2 shows Traffic Zones from Expressway, the distances travelled by *"passenger cars"*. Distances travelled by truck are occasionally longer – these vehicles must use especially-designated truck routes.

Figure 4.1 Presently Available Routes for Through Traffic between Meerut and Prayagraj



National Highway NH 19 (old NH 2), Agra-Lucknow Expressway and NH 30 (Old NH24) are the alternate routes:

The present status of these alternate routes between Prayagraj and Meerut are as follows:

Alternate Route	Description of Route	Distance (Kms)	Travel Times (Hours : Minutes)	Journey Speed (Average) (Km/hr)
NH19 Route Prayagraj – Kanpur – Agra – Greater Noida – Dasna – Meerut	• Prayagraj - Kanpur (NH19, old NH2); • Kanpur – Bachhela/Bachheli – Agra (Agra Lucknow Expressway); • Agra – Greater Noida (Yamuna Expressway); • Greater Noida – Dasna (Easter Pheripheral Expressway); and • Dasna - Meerut (NH34, old NH58)	709	11h:57m *(includes lesser sections of other Expressways)*	59.33 (approx. 60 Km/hr)
Agra Lucknow Expressway Prayagraj – Lucknow – Agra – Greater Noida – Dasna – Meerut	• Prayagraj - Lucknow (NH 30); • Lucknow – Agra (Agra Lucknow Expressway); • Agra – Greater Noida (Yamuna Expressway); • Greater Noida – Dasna (Easter Pheripheral Expressway); and • Dasna - Meerut (NH34, old NH58)	751	11h:38m *(includes maximum sections of other Expressways)*	64.55 (approx. 65 Km/hr)
NH 30 Route (no sections of expressways) Prayagraj – Lucknow – Bareilly – Rampur – Moradabad – Garhmukteshwar – Meerut	• Prayagraj - Lucknow – Bareilly (NH 30); • Bareilly – Rampur (NH 530); • Rampur - Moradabad – Garhmukteshwar (NH9); and • Garhmukteshwar - Meerut (SH14)	647	12h:53m *(does not include any sections of other Expressways)*	50.21 (approx. 50 Km/hr)

Table 4.2: Distance (in Kms) to Destination Zones from Expressway

Name of District Centres	Origin Zones	Expressway Nodes (A to R)	Distance *(in Kms)*	Journey Speed *(Km/hr)*
Saharanpur	11	A	122.0	52
Muzaffarnagar	12	A	57.7	52
Bulandshahr	13	G	86.6	42
Ghaziabad	14	C	147.0	45
Meerut	15	B	11.0	-
Noida	16	C	74.3	49
Baghpat	17	B	60.9	44
Greater Noida	18	G	131.0	41
Shamli	19	A	75.2	51
Bijnor	20	E	86.4	39
Moradabad	21	G	61.6	43
Rampur	22	I	111.0	47
Jyotiba Phule Nagar	23	E	36.1	19
Kasganj	24	I	83.4	45
Bareilly	25	I	38.9	40
Pilibhit	26	J	129.0	43
Shahjahanpur	27	J	38.6	38
Ayodhya	28	M	217.0	55
Yusuf	29	-	-	-
Hardoi	30	L	26.7	38
Kheri	31	J	138.0	42
Lucknow	32	M	71.9	58
Raebareli	33	O	26.5	44
Sitapur	34	L	98.3	42
Unnao	35	N	9.0	54
Amethi	36	N	86.0	43
Hapur	37	C	17.1	45
Sambhal	38	F	7.0	53
Amroha	39	E	36.1	19
Bahraich	40	L	200.0	44
Barabanki	41	M	109.0	52
Faizabad	42	M	217.0	55
Gonda	43	M	199.0	51
Sultanpur	44	M	218.0	57
Ambedkar Nagar	45	M	283.0	63
Shrawasti	46	L	246.0	44
Balrampur	47	L	277.0	48
Budaun	48	I	13.2	36
Chitrakoot	49	R	129.0	43
Azamgarh	50	M	350.0	51
Basti	51	M	275.0	55
Deoria	52	M	399.0	54
Gorakhpur	53	M	351.0	55
Mau	54	M	395.0	60
Siddharth Nagar	55	M	351.0	53

Name of District Centres	Origin Zones	Expressway Nodes (A to R)	Distance *(in Kms)*	Journey Speed *(Km/hr)*
Mahrajganj	56	M	380.0	51
Padrauna	57	M	426.0	55
Sant Kabir Nagar	58	M	319.0	56
Hathras	59	M	304.0	68
Ballia	60	M	473.0	58
Ghazipur	61	M	422.0	58
Jaunpur	62	R	108.0	47
Mirzapur	63	R	120.0	41
Sonbhadra	64	R	213.0	43
Varanasi	65	R	134.0	44
Sant Ravidas Nagar	66	R	81.0	47
Chandauli	67	R	163.0	43
Kushinagar	68	M	426.0	55
Lakhimpur - Kheri	69	J	138.0	42
Prayagraj	70	R	10.0	60
Fatehpur	71	O	42.4	41
Pratapgarh	72	Q	41.9	44
Kaushambi	73	R	73.0	43
Kannauj	74	L	34.6	40
Etawah	75	M	149.0	68
Farrukhabad	76	J	50.5	39
Kanpur Dehat	77	N	89.6	42
Kanpur Nagar	78	N	21.6	26
Auraiya	79	M	125.0	50
Agra	80	M	260.0	76
Aligarh	81	M	362.0	69
Etah	82	I	101.0	44
Firozabad	83	M	219.0	67
Mainpuri	84	M	179.0	74
Mathura	85	M	320.0	76
Mahamaya Nagar	86	M	295.0	69
Kanshiram Nagar	87	I	70.1	45
Lalitpur	88	-	-	-
Mahoba	89	-	-	-
Banda	90	-	-	-
Hamirpur	91	-	-	-
Jalaun	92	-	-	-
Jhansi	93	-	-	-
Other Influence States Assam, Bihar, Chhattisgarh, Chandigarh, Gujarat, Himachal Pradesh, Haryana, Jharkhand, Karnataka, Maharashtra, Madhyapradesh, New Delhi, Nepal, Odisha, Punjab, Rajasthan, TamilNadu, Telangana, Uttarakhand, WestBengal	AS, BR, CG, CH, GJ, HP, HR, JH, KA, MH, MP, NDLS, Nepal, OR, PB, RJ, TN, TS, UK, WB	-	500+	-

Table 4.3: Distance Matrix between Toll Nodes (Nodes "A" to "R") of Expressway

(Distance in Kms)

Toll Nodes	A	B (NH 334)	C (NH 24)	D (SH 65)	E (MDR)	F (ODR)	G (NH 509)	H (SH 125)	I (SH 33)	J (SH 29)	K (SH 138)	L (SH 21)	M (EW)	N (NH 27)	O (NH 31)	P (NH 30)	Q (MDR 102E)	R (NH 19 Bypass)
A	0	8.92	35.27	54.64	74.18	102.43	123.29	173.45	189.39	255.17	282.85	329.95	378.14	420.93	487.29	517.71	554.95	600.46
B (NH 334)		0	26.35	45.72	65.26	93.51	114.37	164.53	180.47	246.25	273.93	321.03	369.22	412.01	478.37	508.79	546.03	591.54
C (NH 24)			0	19.37	38.91	67.16	88.02	138.18	154.12	219.90	247.58	294.68	342.87	385.66	452.02	482.44	519.68	565.19
D (SH 65)				0	19.54	47.79	68.65	118.81	134.75	200.53	228.21	275.31	323.50	366.29	432.65	463.07	500.31	545.82
E (MDR 162W)					0	28.25	49.11	99.27	115.21	180.99	208.66	255.76	303.96	346.75	413.10	443.53	480.77	526.28
F (ODR)						0	20.86	71.03	86.97	152.74	180.42	227.52	275.71	318.51	384.86	415.28	452.52	498.03
G (NH 509)							**0**	50.17	66.11	131.88	159.56	206.66	254.85	297.64	364.00	394.42	431.66	477.17
H (SH 125)								**0**	15.94	81.71	109.39	156.49	204.68	247.48	313.83	344.25	381.50	427.00
I (SH 33)									**0**	65.77	93.45	140.55	188.74	231.54	297.89	328.31	365.56	411.06
J (SH 29)										**0**	27.68	74.78	122.97	165.77	232.12	262.54	299.78	345.29
K (SH 138)											**0**	47.10	95.29	138.09	204.44	234.86	272.11	317.61
L (SH 21)												**0**	48.19	90.99	157.34	187.76	225.01	270.51
M (EW)													**0**	42.80	109.15	139.57	176.82	222.32
N (NH 27)														**0**	66.35	96.78	134.02	179.53
O (NH 31)															**0**	30.42	67.67	113.17
P (NH 30)																**0**	37.24	83.57
Q (MDR 102E)																	**0**	46.33
R (NH 19 Bypass)																		0

Note: Distance for reverse routes shall have same diagonal values

4.2 Traffic Surveys

4.2.1 Introduction

The traffic surveys were of three main types:

(a) origin and destination surveys (which included willingness-to-pay *"stated-preference"* questions and, in one instance where this type of survey was possible, a *"revealed-preference"* survey – see below); and
(b) classified count surveys;

All three survey types were conducted in accordance with the guidelines specified in IRC 9-1972, IRC 102-1988 and IRC SP19-2001.

4.2.2 Origin and Destination Surveys

The origin and destination surveys were the most important traffic surveys - as it is from these that the **Candidate Traffic** was derived. The surveys were conducted at points close to where the proposed Expressway would intersect with the National, State and other highways/district roads and other locations from which, traffic that may eventually use the Expressway either partly or entirely. The traffic survey locations are shown on Figure 4.2 and listed on Table 4.4.

Table 4.4: Locations for Road-Side Origin and Destination (O-D) Surveys

OD.No.	Survey Location	Stretch & Road Name	Day & Date of O-D Survey
1	Siwaya Toll Booth	Muzaffarnagar - Meerut	Wednesday, 12thFebruary 2020
2	Nizampur	Meerut - Garhmukteshwar	Friday, 6th December 2019
3	Kurkawali	Hasanpur - Chandausi	Monday, 4th November 2019
5	Nagariya	Aligarh - Etah	Wednesday, 27th November 2019
6	Khankah e Niyaziya	Aliganj - Farrukhabad	Monday, 9th December 2019
7	Samdhan	Farrukhabad - Kannauj	Wednesday, 27th November 2019
8	Bilhaur	Kannauj - Kanpur	Monday, 2nd December 2019
9	Katohan Toll Booth	Fatehpur - Prayagraj	Monday, 16th February 2020
10	Agwanpur	Bijnor - Moradabad	Friday, 29th November 2019
11	Faridpur Toll Booth	Bareilly - Shahjahanpur	Monday, 2nd December 2019
12	Nawada	Chandausi - Budaun	Thursday, 28th November 2019
13	Usawan	Budaun - Farrukhabad	Thursday, 5th December 2019
14	Shahabad	Shahjahanpur - Hardoi	Friday, 29th November 2019
15	Safipur	Bangarmau - Unnao	Wednesday, 4th December 2019
16	Semari	Unnao - Lalganj	Friday, 6th December 2019
17	Andiyari	Unchahar - Prayagraj	Tuesday, 10th December 2019

At all sites, the questions, besides *"origin"* and *"destination"*, ascertained trip purpose, type frequency, and for freight vehicles the nature of any loads and the tonnage carried.

For the purpose of analysing the data from origin and destination surveys,

(i) all of the areas on either sides of the proposed Expressway alignment were divided into 72 Zones, i.e. each on left side and right side of 18 nodes - A to R; and in order to arrive at the

candidate traffic and homogeneous traffic sections for the proposed alignment of Expressway, traffic with origin and destinations in this area are considered more likely to use certain sections of the Expressway and a percentage of it that may use the entire length of the Expressway.

(ii) The rest of the areas were divided into 83 (district) Zones lying within the State of Lucknow, and into 20 Zones for other States (project influence) of India.

These zones served principally to assess the proportion of traffic that travels even less than 25 Kms using existing roads that may divert to the Expressway (refer Table 4.5).

Figure 4.2 Traffic Survey Sites

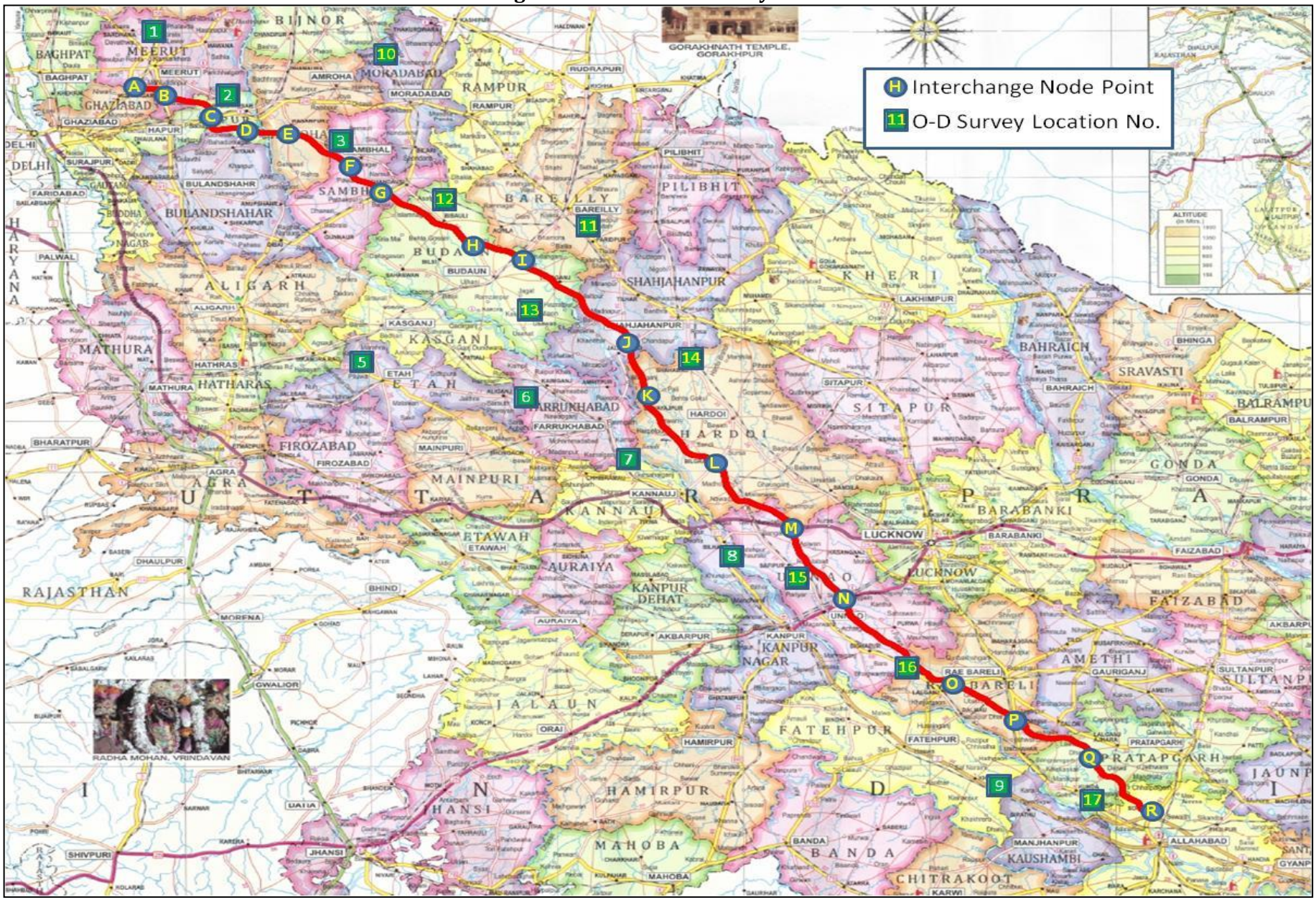


Table 4.5 Zoning Definitions

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
1.	Saharanpur	11	Abdal Pur, Abdalpur, Abdalpur Up, Ananybad, Badhu, Bedhu, Bhaidpur, Bongarpur, Boral, Deoband, Deoband Up, Dhorshi, Gagoh, Gangohi, Gangohi Up, Hardakheda, Jaroda, Jaroda Up, Jharoda Up, Maqsoodpur, Marv, Punkaji, Sahanranpur, Saharanpur, Saharanpur, Saharanpur Up, Sedpur, Sharanpur, Sheikhpur, Shigna, Shiman Up, Sholda, Sholda Up, Shondi, Shopur, Sispodi, Sodkhand, Wajeerpur
2.	Muzaffarnagar	12	Baghra, Baghra Up, Bawrala, Chapar, Chaper, Chapur, Chhapar, Chhapar Up, Chittorganj, Jambalhera, Jhiyad, Johad, Khatoli, Khatoli Up, Kiranabad, Mansupur, Morna, Muzaffar Nagar, Muzaffar Nagar Up, Muzaffarnagar, Muzaffarnagar, Muzzafar Nagar, Purkaji, Sambalhera, Sambhalhera, Sapur, Shahpur, Shahpur Up, Shampur, Shapur, Sipoli, Sisholi, Sisoli Up, Sisona, Tigree
3.	Bulandshahr	13	Adainagar, Aurang, Aurangabad Up, Baharpur, Banche, Bejuee, Bhalt, Bilsuri, Binuvat, Borha, Bulandhahr, Bulandhshahr, Bulandshahr, Bulandshahr, Bulandshahr Up, Bulandshehar, Bundnio, Chawali, Dhatori, Dhaturi Up, Dibai, Dibai Up, Ganga, Ghort, Halpura, Halwani, Jahanpur, Jaharpur, Jamunanagar Up, Jehangirabad, Jehangirabad Up, Karada, Karliya, Kheja, Khurga, Khurja, Khurja Up, Kurzo, Lakhoti, Lakhoti Up, Nowganj, Noydd, Pahasu Up, Pahsu, Palsa, Plunger, Polwayi, Pousha, Really, Ridshi, Sarangpur, Shamal, Shamul, Shikapur, Shikarpur, Shikarpur Up, Sikandrabad, Vilashi, Village, Vilshi, Vilshi Up, Vinvat, Zahidpur
4.	Ghaziabad	14	Gajiyabad, Gaziabad, Gaziabad Up, Gaziyabad, Ghaziabad, Ghaziabad, Sabibabad Up, Sahibabad, Vishali
5.	Meerut	15	All, College, Daurala, Gedpur, Gorum, Has, Meerut, Meerut, Meerut Up
6.	Noida	16	Noida
7.	Baghpat	17	Baghpat
8.	Greater Noida	18	Bahtta, Bhatta, Buhtta, Greater Noida, Habibpur, Haldoni, Jhajhar, Junad, Noida, Noida Hr, Noida Up, Sambalpur, Sambhalpur
9.	Shamli	19	Shamli
10.	Bijnor	20	Akbarabad, Akbarpur Up, Akbrabad, Bangal Rawra, Bangarpul Up, Bangarpur, Berulu, Bhinor Up, Bijnor, Bijnor, Bijnore, Bijnour, Chandpur, Dhampur, Dhundhli, Dhundhlijhalu, Gurdaspur, Haldar, Jhalu, Kanth, Karabali, Kiratpur, Nagina, Najibabad, Noorpur, Qadarganj, Samshabad, Sarai, Seohara, Shadpur, Shamsabad, Shamshabad, Shashabad, Shikhora, Shungrmeda
11.	Moradabad	21	Agwanpur, Barkheda, Barkhera, Bilari, Gherat Up, Janmot, Kandarki, Karula, Karula Up, Karulabad, Kundarki, Moradabad, Moradabad, Moradabad , Muradabad, Pakwara, Palanpur, Umri Kalan, Umrikalan
12.	Rampur	22	Ali Nagar, Alinagar, Alinagar Up, Bahapur, Bikli, Bilaspur, Degarpur, Hajitpur, Kashipur, Khau, Milak, Milock, Rampur, Rampur
13.	Jyotiba Phule Nagar	23	Jyotiba Phule Nagar

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
14.	Kasganj	24	Alipur, Amanpur, Badhonu, Badhun, Bahedia, Bahodia, Dariyaganj, Kasganj, Kasganj, Kashganj, Sahwar, Shahawar, Shahway
15.	Bareilly	25	Bachoom, Bachrom, Bahari, Bahedi, Baheri, Baliamirand, Baliatpur, Barali, Barapeli, Bareilly, Bareily, Bareily Up, Bareli, Bareli Up, Bareliey, Barely, Bariely, Barili, Biharipur, Billpur, Bilpur, Bilwa, Borali, Dakni, Devchara Up, Faridpur, Fatehganj Purbi, Folar, Ganj, Gatsol, Hafizganj, Izzatnagar, Jade, Jasdanpur, Kargaina, Kesarpur, Manpur, Mirganj, Mirgunj, Mokalganj, Nahoma, Nakitsy, Paiga, Parsakheda, Rafiabad, Rafiyabad, Rampura Ratan, Rampuraratan, Richha, Richola, Tajua, Tisua, Umarsia
16.	Pilibhit	26	Bebor, Bisalpur, Bishalpur, Changli, Pilibhit, Pilibhit, Pilibhit Up, Puranpur, Satipur, Shitarganj, Sitaraganj, Sitarganj, Vishalpur
17.	Shahjahanpur	27	Banisha, Banthra, Bathra, Feroz, Katra, Kattra, Khandelwal, Khutar, Khutar Up, Kurpur, Maanhila, Madnapur, Maikalganj, Mohanpur, Morena, Morewa, Nagashi, Nagasi, Nighoi, Nighroi, Nigohi, Patiana, Pedu, Rampura, Sahajanpur, Sahjanpur, Samdil, Sasanpur, Sashanpur, Shahajahnpur, Shahjahanpur, Shahjahanpur, Shahjahnpur, Shahjanpur, Shahjapur, Shahjehanpur, Tilhar, Tillor, Vashari, Vashri
18.	Ayodhya	28	Ayodhya
19.	Yusuf	29	Yusuf
20.	Hardoi	30	Atarli, Athroli, Atrali, Atroli, Bagholi, Balamau, Bharti, Gopamau, Hardoi, Hardoi, Hardoi Up, Jiman, Launi, Malechabad, Malehabad, Malihabad, Mandara, Naruganj, Pihani, Pihoni, Sahabad, Sandi, Sandila, Shabad, Shahabad, Shahbad, Shamshapur, Sondila, Tandila,
21.	Kheri	31	Kheri
22.	Lucknow	32	Agar, Atal Nagar, Behta, Bhagwaniya, Kalampur, Lucknow, Lucknow, Lucknow Up, Mohanlal Ganj, Nazirabad, Nizampur, Paliya, Samoshi, Transport Ngr, Ushmi
23.	Raebareli	33	Aihar, Bursganj, Burshaganj, Dedaur, Kondganj, Rae, Raebareily, Raebareli, Raebareli, Raebareli Up, Raibareily, Raibareli, Raibareli Up, Raibarely, Raibariely, Raibawali, Salon, Salon Up
24.	Sitapur	34	Ailiya, Aruwa, Bandya, Benaura, Bhawana Up, Biswa, Biswan, Dewaji, Dewayi, Dewyi, Dhanayi, Diryi, Diwai Up, Diwayi, Diyi, Guzra, Itina, Kamoli, Katiya, Khairabad, Khirbad P, Kutub Nagar, Laharpur, Local Up, Maholi, Maholi Up, Maigalganj, Misrikh, Mohali, Mohali Up, Neri, Sheswan, Sindhauli, Sindhauli Up, Sitapur, Sitapur, Sitapur P, Tandua, Titapur
25.	Unnao	35	Ajgain, Azgen, Bakram, Chimor, Ganjmurkhed, Hasanganj, Hindokheda, Hinduheda, Hindukheda, Indoptan, Lakhmi, Nawab Ganj, Nawabganj, Orash, Saraon, Shrodhi, Simri, Unnao, Unnao, Vgo,
26.	Amethi District	36	Amethi
27.	Hapur	37	Badgoo, Bajooda, Garh Mukteshwar, Garhmukteshwar, Garmukteshwar Up, Hapad, Hapud, Hapur, Hapur, Hapur Up
28.	Sambhal	38	Baboala, Babrala, Dhanry, Faizapur, Jargaon, Sambal, Sambhal, Sambhal, Sambhal Up

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
29.	Amroha (J.P. Nagar)	39	Ampko, Amplio, Amro, Amroh, Amroha, Amroha (J.P. Nagar), Dhanora, Dharora, Didauli, Gangeshwari, Gangeshwari Up, Hashampur, Jalsurya, Jalwaray, Joya,Kalampur Up
30.	Bahraich	40	Bahraich, Bangal, Behraich, Bengal, Bichuna
31.	Barabanki	41	Bara Banki, Barabanki, Barabanki, Barabanki Up, Bheriya, Haidargarh, Haidargarh Up, Jaroli, Kotara, Mehmoodpur,
32.	Faizabad	42	Bachholi, Chirra, Faizabad, Faizabad, Faizabad Up, Kurbabad, Ranchi, Satna, Wazeerganj,
33.	Gonda	43	Gonda, Shidpur
34.	Sultanpur	44	Baranpur, Gauriganj, Goriganj, Katawabul, Nayoda, Nayrda, Rajuh, Shakhana, Sulanpur, Sultanpur, Sultanpur, Sultanpur Up, Sultanpuri, Uchhgaon
35.	Ambedkar Nagar	45	Akbarpur, Ambedkar Nagar, Ambedkar Nagar, Malipur, Ravi, Ravipur, Warora
36.	Shrawasti	46	Shrawasti
37.	Balrampur	47	Balrampur, Deonagar, Kamda, Vithar
38.	Budaun	48	Aapna, Adhapur, Alapu, Aldarmali, Allapur, Badaan, Badam, Badaun, Badayu, Badayun, Badhayun, Barahkalan, Bilhar, Bilhari, Bilhawad, Bilshi, Bilsi, Bisli, Budaun, Chiroli, Deputa, Diblai, Gaawan, Gaawana Up, Gauram, Gavan, Gawan, Gennor, Ginnor, Ginnor Up, Gonar, Guneer, Gunnoor, Hoista, Jharpur, Kakarala, Kakrala, Kokrala, Kurau, Mek, Mev, Miahu, Mithu, Myau, Narora, Narorda, Osawa, Palaw Sarai, Ramghat, Ramghat Up, Risrodi, Sahaswan, Sane, Sasman, Saswan, Seshwan, Shanpur, Shrugimo, Singhpur, Singpur, Thanugadi, Ughani, Ujhani, Usawa, Usawan, Usawat, Uset, Velopur, Workapur, Yenor
39.	Chitrakoot	49	Chitrakoot, Manikpur
40.	Azamgarh	50	Azamgarh, Azamgarh, Gopalpur, Kamhepur, Kasba, Madia, Newada, Pihargaon, Vidhyapur,
41.	Basti	51	Bahanpur, Basti, Budhiya, Karza, Khatiyar,
42.	Deoria	52	Bagra, Deoria, Deoria, Gohari, Gohri, Guhari, Madanpur,
43.	Gorakhpur	53	Gorakhpur, Gorakhpur, Gorakhpur Up, Mahu,
44.	Mau	54	Kasari, Kawala, Mau, Mau Up, Paligarh, Siura, Udarn,
45.	Siddharth Nagar	55	Banshi, Bansi, Bansy, Bhatal, Bhatul, Bhutal, Kesar, Kusawa, Santa, Siddharth Nagar,
46.	Mahrajganj	56	Dashrathpur, Farendu, Mahrajganj
47.	Padrauna	57	Padrauna
48.	Sant Kabir Nagar	58	Sant Kabir Nagar, Upraudh, Uprauth
49.	Hathras	59	Hasayan, Hasayan Up, Hathras, Hathras, Hathras Up, Khati, Murasa, Pashayan, Piprama
50.	Ballia	60	Azahar, Azhar, Baliya, Ballia, Balliya, Bori, Bouri, Khari, Ujair,
51.	Ghazipur	61	Badorose, Chhatarpur, Firozpur, Gazipur, Ghazipur, Kurshyaganj, Malikpur, Mohamadabad, Mohammadabad, Raipur, Saidpur, Sonwal, Tajpur,
52.	Jaunpur	62	Ambikapur, Bithar, Bithor, Faridabad, Jaunpur, Jaunpur, Jaunpur Up, Jhampur, Jhanpur, Jonpur, Kalapur, Kanhapur, Machhlishahar,

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
53.	Mirzapur	63	Chunaar, Chunar, Dauhya, Daulatpur, Gopiganj, Gyanpur, Kanhaipur, Khalapur, Mirzapur, Mirzapur,
54.	Sonbhadra	64	Kewal, Renukoot, Robatsganj, Robitsganj, Sonbhadra, Sonpat,
55.	Varanasi	65	Badoh, Ballabhpuram, Banaras, Banaras Up, Behaura, Bhainsa, Gul, Gula, Gulab Bagh, Kash, Pahladpur, Ramnagar, Ramnau, Varanasi, Varanasi, Varanasi Up,
56.	Sant Ravidas Nagar	66	Bhadohi, Bhadoni, Darwaji, Darwashi, Darwayi, Dhavarsi, Dhawarasi Up, Dhawarsi, Dorwyi, Sant Ravidas Nagar,
57.	Chandauli	67	Besila, Candoli, Chandauli, Chandauli, Chandauli Up, Chandoli, Kamalpur, Kamalpur Up, Mugalsarai, Mughal Sarai, Mughalsarai, Pathhan,
58.	Kushinagar	68	Kushinagar
59.	Lakhimpur - Kheri	69	Bhuria, Darra, Gokarnath, Gorakhnath, Islamabad, Jangbahadur Ganj, Jangbahadurganj, Khiri, Khitai Up, Lakhimpur, Lakhimpur - Kheri, Lakhimpur Kheri, Lakhimpur P, Mahdi, Mailani, Mailani Up, Mirpur, Mohamadi, Nigasan, Pilia, Piliya, Pillya, Sarkhanpur
60.	Prayagraj	70	Allahabad, Allahabad, Allahabad Up, Allahapur, Allahpur, Andheridham, Basahi, Bhatoripura, Billhore, Chalapurgaon, Dhanupur, Fafaamor, Fulbattis, Handia, Handiya, Jeri, Jhusi, Kadhabool, Kareli, Katayali, Mahjapur, Meerganj, Mollawa, Naini, Phaphamau, Phoolpur, Phophamau, Prayagraj, Prayagraj Up, Sahjadpur, Sirsa, Soraon, Surabgaon
61.	Fatehpur	71	Ajhawa, Ajhuwa, Bahua, Bilanda, Bindhki, Bindki, Binki, Budwan, Fatehpur, Fatehpur, Fatehpur Up, Hardoan, Hardod, Haswa, Iskuri, Jakhmi, Katagham, Katogham, Khaga, Khajuha, Kodarpur, Kora Jahanabad, Kotagham, Maharajpur, Malwan, Malwan Up, Mannikheda, Pichhuli, Pilhi, Raiwardi, Rewari, Sauran, Tharian, Thariaon, Vidhki
62.	Pratapgarh	72	Aghiya, Ajhar, Ajhar Up, Basauli, Kashar, Kunda, Patava, Pati, Pratapgarh, Pratapgarh, Rakha, Rakri
63.	Kaushambi	73	Bariya, Bharwari, Chail, Daranagar, Devrand, Dolchi, Karari, Kasiya, Kaushambi, Mandook, Manoharganj, Moradpur, Saraibhajitamal, Sirathu, Sirothu, Sitahu
64.	Kannauj	74	Anash, Annajj, Arash, Bidai, Chhipra, Chhipramau, Chibramau, Garshayera, Gathoshi, Gatoshi, Ghosar, Gotashi, Gursaganj, Gursahaiganj, Gursaiganj, Gursarai, Gurusaiganj, Guthashi, Jaryapur, Kadhaganj, Kadhganj, Kahukawad, Kandganj, Kannauj, Kannauj, Kannauj Up, Kannoj, Kannoz, Khudaganj, Kodaganj, Kundaganj, Ladhar, Locla, Majhana, Makanpur, Makhanpur, Mushyna, Sahmadhan, Samdhan, Shadhan, Shamdhan, Shandhan, Sirdi, Sirli, Sudaganj, Sundhan, Talgram, Terara, Terru, Uncha
65.	Etawah	75	Aman, Aorema, Aroj, Aroz, Balarayi, Balragi, Balrai, Balrai Up, Balraji, Balrayi, Balruji, Balryi, Bedpur, Bedpura, Bharthana Up, Chithbhaon, Dhamua, Dhanua, Etawa, Etawa Up, Etawa Upq, Etawah, Etawah, Etawah Up, Jaswant Nagar, Jaswant Nagar Up, Jefayi, Karawani, Kewala, Nowali, Saifai, Saifai Up, Sarai Bhopat Up, Saryi Bhopat, Sefayi, Suryibhopat, Udhampur, Udrampur,
66.	Farrukhabad	76	Amritpur, Atena, Barshayaganj, Basili, Borili, Chiwarmau, Chiwramal, Daltun, Dursamganj, Farrukhabad, Farrukhabad, Farrukhabad Up, Fatehgarh, Geari, Geri, Gueri, Jarari, Kalan,

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
			Kalantar, Kamalganj, Kamganj, Kayamganj, Kharsuiya, Kudaganj, Roshan, Roshanabad, Roshnabad, Sagar, Sagaria, Saraiadhhar, Saraighat, Sarraiadhar, Tathiya, Tatia
67.	Kanpur Dehat (Rural)	77	Anti, Bara, Bihari, Kakwan, Kanpur Dehat Rural), Kokwan, Rajpura, Ramiya, Rania, Raniya, Raniya Up, Rasulabad, Roniya, Sarayan, Sukhabad
68.	Kanpur Nagar	78	Amiliha, Amiliya, Araul, Atrapuri, Bakathi, Bakedi, Bakhuti, Bakodi, Bakothi, Barra, Barro, Bihaur, Bilhaur, Bilhore, Billore, Bilohre, Chobepur, Chorepur, Dalhai, Dehrampur, Ghimau, Gimau, Harshnagar, Hathipur, Kalyanpur, Kamri, Kanpur, Kanpur Nagar, Kanpur Up, Karachi Khana, Koriya, Korliya, Mandhana, Manthana, Manthna, Monthana, Naramau, Nison, Pilar, Pormi, Prempur, Ramaipur, Rawatpur, Roma, Rooma, Sarsaul, Shivrajpur, Shubhampur, Shuklapur, Suklaganj, Tatiyaganj, Tatyaganj, Udetpur, Udetpur Up,
69.	Auraiya	79	Amla, Aoraiya, Aoraiya Up, Aorya, Auraiya, Auraiya, Babarpur, Bidhuna Up, Bidona, Billawa, Bithona, Houriya, Oraiya, Oriya, Vidhana
70.	Agra	80	Agra, Agra, Agra Up, Amritpuri, Bamdha, Barham, Barhanshi, Beelpura, Bidhari, Bordi, Fatehabad, Fatehpur Sikri, Gajol, Sakganj, Shahganj, Sirauli, Siroli
71.	Aligarh	81	Aligarh, Aligarh, Aligarh Up, Barauli, Bharatpur, Bharatpur Up, Bhartpur, Bidhana, Dudpur, Ekri, Enkri, Harduaganj, Harduaganj P, Jalali Up, Jalalpur, Jatpur, Jatpura, Jidali, Jilali, Kankit, Kannore, Kasimpur, Khair, Khair Up, Lathgarh, Madrak, Madrak Up, Malhapur, Manai, Manai Up, Manesar, Purhan, Shiddha, Siddha, Siddhu, Singhar, Vishanpur
72.	Etah	82	Ahmadpur, Aliganj, Barigo, Barigo Up, Baringo, Barthar Up, Barther, Bather, Bathore, Borthor, Burigo, Dharra, Eta Up, Etah, Etah, Etha, Ganjdulware, Jaithara, Jaythara, Khatia, Khera, Kishangarh, Local, Malawan, Manjhana, Miyau, Myuni, Nagriya, Nogriya, Paringo, Patiyali, Patyali, Pilua, Pilua Up, Pilwa, Pinoa, Salali, Sarni, Saroni, Sidhpura, Sunashi, Sunshi, Yamuna
73.	Firozabad	83	Asfabad, Bilahna, Bilahna Up, Dabrai, Darayi, Darbai, Durbai, Fathgyi, Firojabad Up, Firozabad, Firozabad, Firozabad Up, Jaithgyi, Jashrama, Jasrana, Jasrana Up, Jathgyi, Nilhoma, Parham, Parham P, Paruji, Sargai, Satgai Up, Sathgyi, Sershaganj, Shatgay, Shekhoyabad, Shersaganj, Shikhobad, Shikhohabad, Shikohabad, Shikohabad Up, Sikohabad, Sirlaganj, Sirsaganj, Sirsaganj Up, Undani, Undani Up, Undashi
74.	Mainpuri	84	Andani, Barnahal, Barnal Up, Chandpura, Karahal Up, Karalia Up, Karhal, Kurawali Up, Kurwali, Mainpuri, Mainpuri, Muimpuri, Nayagaon, Pakhna, Udham, Udhan, Udhanaj
75.	Mathura	85	Badhon, Barshna, Dehgaon, Dolatpur, Mathura, Mathura, Mathura Up, Nagaria, Nagariya, Naroli, Naroli Up, Nawali, Palar, Sankit Up, Semari, Semri,
76.	Mahamaya Nagar	86	Mahamaya Nagar (Hathras)
77.	Kanshiram Nagar	87	Kanshiram Nagar (Kasganj)
78.	Lalitpur	88	Bhadramandi, Lalitpur, Nagda

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
79.	Mahoba	89	Mahoba, Mahoba, Mahoba Up
80.	Banda	90	Banda, Manipur
81.	Hamirpur	91	Atra, Bebar, Beobar, Bewar, Bilga, Bilgaon, Hamirpur, Hamirpur, Orath, Sumerpur
82.	Jalaun	92	Bigapur, Bijapur, Bilua Up, Chandawali, Chandola, Chandwali, Chanuwali, Jalaun, Kalpi, Kosba, Kudhod, Orai, Orai Mp, Rewa
83.	Jhansi	93	Bijoli, Bukhara, Jhansi, Jhansi, Katera, Lalitpur, Launda, Sajjanpur
84.	Node A Left South	AL1	Johiri,
85.	Node A Left North	AL2	Kirwa, Modi Nagar, Modinagar, Mohannagar, Nabali, Nabli, Partapur, Sheyana Up, Simana Up, Siwai Up, Siyana, Siyana Up, Siyna
86.	Node A Right South	AR1	Ganela, Jaani, Jani, Jani Up, Khore, Khori,
87.	Node A Right North	AR2	Baralwad, Bodha, Budana, Budhana, Budhana Up, Budhna, Khiwai, Khiwai Up, Khiwaji, Khiwayi, Khiwyi, Lakhwa, Mator, Pohli, Samli, Shamoli
88.	Node B Left South	BL1	Bana, Bharala, Gokalpur, Gokulgaon, Gokulpur, Gokulpur Gaon, Nagli Sadharan
89.	Node B Left North	BL2	Dohrala, Dorala, Dordla, Dorla, Dortal, Dorula, Medpur Up, Murlipur, Murlipur Up, Rahsa, Ruhasa, Sakaveti, Sakoti, Sardhana, Sardhana Up, Sarthana Up, Sirdhana, Ukawa
90.	Node B Right South	BR1	Chatri
91.	Node C Left South	CL1	Baksar
92.	Node C Left North	CL2	Mukteshwar, Nanpur
93.	Node C Right South	CR1	Sikhera
94.	Node C Right North	CR2	Babugarh, Madhapur
95.	Node D Left South	DL1	Aali Nagar, Gaaran Up, Kheda
96.	Node D Left North	DL2	Bhaina Up, Dholpur, Hastinapur, Nagli, Nawana Up, Nigli, Salonda
97.	Node D Right South	DR1	Bagrasi, Bugrasi, Bugrasi Up
98.	Node D Right North	DR2	Shiyna
99.	Node E Left South	EL1	Hasanpur, Hasanpur Up, Hashanpur, Hashpur, Rajabpur, Rajabpur Up, Ujhari, Ujhari Up
100.	Node E Left North	EL2	Galshua, Gulsua, Naagli
101.	Node E Right South	ER1	Bhavarsi
102.	Node E Right North	ER2	Gagrola, Gajaraula, Gajrala, Gajratola, Gajraula, Gajrola, Gajrola Up, Garola, Gazota, Gazrolla, Gorula

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
103.	Node F Left South	FL1	Saraitarin, Sirsha, Sirshi, Sirsi
104.	Node F Left North	FL2	Asmoli, Dehpa, Sujatpur, Syed Nagri
105.	Node G Left South	GL1	Baniyakhera, Chandausi, Chandausi Up, Chandoshi, Chandoshi Up, Chandosi, Chandroshi, Faizganj, Faizgaon, Nehta
106.	Node G Left North	GL2	Afzalpur, Afzalpur Up, Akroli, Narauli, Pawas, Pawsa, Pawsa Up, Sarthal
107.	Node G Right South	GR1	Bahjai, Bahjoi, Bahroi Up, Behjayi, Bejoi, Islam Nagar, Islamnagar, Islamnagar Up, Naroda, Naroda Up
108.	Node H Left North	HL2	Bisauli, Bisolee, Bisoli, Karanpur, Raheria, Raherial, Raheriya, Sureni, Urari, Vajirganj, Wajeerganj, Wazirganj
109.	Node I Left South	IL1	Binarar, Binawar Up, Dataganj, Dhakka, Kanshi, Narka Patta, Narkheda
110.	Node I Left North	IL2	Aonia, Aonla, Aowla
111.	Node I Right North	IR2	Kuthiya
112.	Node J Left North	JL2	Muzaffarpu,Muzaffarpur
113.	Node J Right South	JR1	Dahena, Dhena, Jalalabad
114.	Node J Right North	JR2	Dasiya, Sakhanu
115.	Node K Left South	KL1	Pali
116.	Node K Left North	KL2	Akri
117.	Node K Right South	KR1	Baron, Baroun
118.	Node K Right North	KR2	Allaganj, Allganj
119.	Node L Left South	LL1	Sanjalhera
120.	Node L Right South	LR1	Bilgram, Billgram
121.	Node L Right North	LR2	Panthora, Panthro,
122.	Node M Left South	ML1	Kulha,
123.	Node M Left North	ML2	Gosganj, Goshganj, Mallawa, Mallawan, Mallowa,
124.	Node M Right South	MR1	Bagarmau, Bagarmaw, Bangarmau, Bangarmuva, Darola, Ugo, Ugu,
125.	Node M Right North	MR2	Aazmen, Parmi, Raghpur
126.	Node N Left South	NL1	Katha

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
127.	Node N Left North	NL2	Chagalwanshi, Jagdahpur, Jagdishpur
128.	Node N Right South	NR1	Achalganj,Acharganj, Anuppur, Badarka, Gandhinagar
129.	Node N Right North	NR2	Bethor, Safipur, Supipur
130.	Node O Left North	OL2	Fatehganj, Gonamau
131.	Node O Right South	OR1	Dalamun, Dalmau, Dolmau, Dolmoon, Domau, Kaammau, Korihara, Lalganj, Lalganj Up, Raithana
132.	Node O Right North	OR2	Akthi, Augadh, Bighapur, Bighpur, Bihar, Bihargaon, Kushela, Lakhyapuri, Lakshipur, Lalkua, Lalkuan, Pidua, Poova, Sareni, Takiya
133.	Node P Left South	PL1	Bhikh, Parhari, Unchahar
134.	Node P Left North	PL2	Bhena
135.	Node Q Right South	QR1	Barai, Bhulsa, Chakerhum, Intaura, Mangarh
136.	Node Q Right North	QR2	Pariyawaan, Pariyawan
137.	Node R Left North	RL2	Kharga, Kurga, Mendara, Raiya
138.	Node R Right South	RR1	Bajha
139.	Node R Right North	RR2	Anapur, Bedhan, Deeha, Dheemi, Dhophamau, Kasimpur Jharha, Kaurihar, Lalgopalganj, Lankapuri
140.	Assam	ZAS	Assam, Goahati, Guwahati, Guwahati Ms, Katoni, Sonali Bodar, Varywer
141.	Bihar	ZBR	Gaya, Patna, Patna Bihar, Patna Br, Purni, Purniya, Siwan, Aurangabad, Aurangabad , Aurangabad Br, Baliya Br, Bedhna, Bhagalpur Uk, Chandi, Gopalganj, Hatwa, Kewla, Kishanganj, Kishanganj Br, Kosiya, Lohni, Mourawan, Nalanda, Ramapur, Renukoot Br, Sarh, Sasaram, Vithoma
142.	Chattisgarh	ZCG	Bhilai Cg, Bilaspur Cg, Bilhama, Bilhma, Chhattisgarh, Danyo, Korba Cg, Merai, Pithora, Raipur Cg
143.	Chandigarh	ZCH	Chadigarh Up, Chandigarh, Chandigarh Ch, Chandigarh Cn, Chandigarh Pb
144.	Gujarat	ZGJ	Gujrat, Jamnagar, Kambola, Khangan
145.	Himachal Pradesh	ZHP	Baddi, Himachal, Kalka, Kulu Manali, Kunala, Manaji, Nalagarh Hp, Shimla, Shimla Hp, Simla, Solan Hp
146.	Haryana	ZHR	Ambala, Ambala Pb, Badrai, Banaas, Bidhuki, Bidhuwa, Damla, Dehya, Gurgaon, Gurgaon Hr, Gurugram, Gurugram Up, Haryana, Hisar Hr, Jatoli, Jhajjar, Jindi, Jondhan, Kaithla, Karnal, Karnal Hr, Kundal, Kurnal, Kurukshetra, Malram, Malran, Milkpur, Narayangarh Hr, Palwal Hr, Panipat, Panipat Hr, Punchkula, Rohtak, Sonipat, Tarolikheda, Yamuna Nagar, Yamuna Nagar Up, Yamunanagar, Yamunanagar Hr
147.	Jharkhand	ZJH	Bagodar, Bokaro, Chaibasa, Dhanabad, Dhanbad, Dhanbad Jh, Hazaribagh, Jamshedpur, Jharkhand, Kandi, Katbhori, Ranchi Jh

Sl. No.	Region / City / District / State	Zoning Code	Origin/Destination Villages/Places
148.	Karnataka	ZKA	Mangalore
149.	Maharashtra	ZMH	Daund, Jaywant Nagar, Nagpur, Porla, Pune Mh, Walwan, Mumbai Mh
150.	Madhya Pradesh	ZMP	Bhind, Bhind Mp, Bhojipura, Bhopal, Bhopal Mp, Bijawar, Chanderhi, Chhatarpur Mp, Dhyanpur, Dochara, Gwalior, Harda, Ichhapur, Jabalpur, Jabalpur Mp, Jaranpur, Kajroda, Kannod, Kannod Up, Kardiya, Kasrawad, Katni, Katni Mp, Khatiya, Khumar, Kudpur, Orchhi, Piyani, Piyon, Rewa Mp, Satna Mp, Shajapur, Shihuda, Shivpuri, Shivpuri Mp, Udabi, Udani, Udhani, Udhyani, Ujhawan, Urai Mp
151.	New Delhi	ZNDLS	Anand Vihar, Delhi, Delhi Dl, Kabil, Mangla Sahab, New Delhi, Polar
152.	Nepal	ZNEPAL	Amritganj, Znepal
153.	Orissa	ZOR	Bhuwaneshwar, Cuttack, Odisha, Penga, Pikla, Salipur
154.	Punjab	ZPB	Amritsar, Amritsar Pb, Hoshiarpur, Jalandhar, Jalandhar Pb, Ludhiana, Ludhiana Pb, Ludhiyana, Manyi, Pathan, Pathankot, Patiala, Patiali, Patiyala, Punjab
155.	Rajasthan	ZRJ	Ajmer, Bagroli, Bhavri, Bundi, Chittorgarh Rj, Dholpa Rj, Hathipura Rj, Jaipur, Jaipur Rj, Jakhoni, Karawali Up, Mandhawa, Mandhawan, Nareyli, Nayala, Puriya, Shekhawad, Sinhli Agir, Sinhli Jagir Up, Thakri
156.	Tamil Nadu	ZTN	Tamil Nadu
157.	Telangana	ZTS	Secunderabad
158.	Uttarakhand	ZUK	Aldwani, Almoda, Almora, Almora Uk, Aroli, Badrinath, Bharli, Budhan, Chamoli, Chamoli Uk, Champavat, Chan, Chayli, Deban Uk, Dehradoon, Dehradoon Uk, Dehradun, Dehradun Uk, Devprayag, Dewan Uk, Dhella, Dohalam, Dohra, Donda, Haldwani, Haldwani Uk, Ardiwar, Haridwar, Haridwar Uk, Hariyali, Hridwar, Joshi, Joshimath, Karbali, Kathiya, Kedarnath, Khandila, Khatar, Khoatar, Lalkuan Uk, Maneshwar, Masoori, Masoorie, Mosari Uk, Moshri Uk, Nagoli, Nagoria, Nainital, Nainital Uk, Nehu, Pilighoti, Piran Kaliya, Piran Aliyar, Pirankalihar, Pithoragarh, Pithoregarh, Purthi, Puthri Up, Rachna Up, Ranikhet, Ranikhet Uk, Ranikot Up, Rishikesh, Roorkee, Roorkie, Roorkie Uk, Roorkie Up, Rudrapr, Rudraprayag, Rudrapur, Rudrapur Uk, Sawa, Srinagar, Srinagar Uk, Tanakpura, Uttar Ashipur Uk, Uttarakhand, Uttarkashi, Uttarkashi Uk
159.	West Bengal	ZWB	Akharpur, Asansole, Darjelling, Doband, Kadarpur, Kharagpur Wb, Khibayi, Khirai, Kolkata, Kolkata (Wb), Kolkata Wb, Siligudi, Siligurhi, Siliguri, Unab

4.2.3 Classified Count Surveys

The principal purpose of the classified count surveys on Traffic Survey Locations (existing alternate roads to the proposed Expressway), was to establish Expansion Factors for the origin and destination data – thus permitting to establish average daily traffic flows.

4.2.3.1 Average Daily Traffic

Seven-day count using video coverage was undertaken on National Highways/State Highways/Major District Roads where Road Side Origin-Destination Surveys were carried out –

results **(Average Daily Traffic - ADT**) are shown on Tables 4.6 and detailed counts at each location are provided in Appendix.

The survey form, divided vehicles into the normal classifications for such surveys in India. The larger trucks were, however, further divided into following sub-categories:
(a) 2-axled truck;
(b) 3-axled truck;
(c) 4+ axled vehicles (Multi Axle Vehicle- MAV)

This latter category MAV, although frequently observed at present, can be expected to grow in importance once the Varanasi Port[1] becomes fully operational and it is possible to assess whether, or not, it would be appropriate to charge such vehicles a higher toll.

The classified counts were undertaken at the same locations as the origin and destination surveys and were for periods which incorporated the days in which the origin and destination surveys were undertaken. The classified count information, besides providing the above-referred to expansion factors, was used to indicate the hours of the week that might be categorised as:
(a) *"peak"*;
(b) *"shoulders"* to the peak; and
(c) *"off-peak"* periods.

These are important data, needed when calculating likely journey time-savings and vehicle operating cost savings. When congestion is less on Expressways comparatively, a smaller proportion of through-traffic will be prepared to pay tolls.

A summary of the variations in flow by direction is also shown on Table 4.7. There is very little difference in the pattern of in-bound and out-bound flows (to Fatehpur / to Prayagraj) and, for this reason, all further analyses are in terms of total two-directional flows. The division of the hours of the week into these 3 periods is shown on Table 4.8 and summarised below:

(a) *"Peak"* hours: 08:00 to 18:00 (70 hours total per week)
(average two-way flows on the NH19 (old NH2) near Katoghan Toll Plaza are **1515 vehicles/hour,** i.e. ***average peak hour factor of 5.74%*****)**

(b) *"Shoulder"* hours: 07:00 to 08:00 & 18:00 to 01:00 (56 hours total per week)
(average two-way flows on the NH19 (old NH2) near Katoghan Toll Plaza are **959 vehicles/hour,** i.e. ***average shoulder factor of 3.63%*****)**

(c) *"Off-Peak"* hours: 01:00 to 07:00 (42 hours total per week)
(average two-way flows on the NH19 (old NH2) near Katoghan Toll Plaza are **599 vehicles/hour** i.e. ***average off-peak hour factor of 2.27%***).

The time divisions are assumed to be the same for all sections of the proposed Expressway.

[1] **Varanasi Multi-Modal Terminal** or **Varanasi Port** is an Inland river port situated in the city of Varanasi, Uttar Pradesh. The port is located on the River Ganga. This port is built under the central government's **Jal Marg Vikas** project. The port has provided a direct link with the Port of Kolkata and Haldia Port

Table 4.6: Average Daily Traffic (ADT) on Existing Alternate Roads

Vehicle Classification			PCU Factor	Muzaffarnagar - Meerut	Aligarh - Etah	Aliganj - Farrukhabad	Farrukhabad - Kannauj	Kannauj - Kanpur	Budaun - Farrukhabad	Meerut - Garhmukteshwar	Hasanpur - Chandausi	Chandausi - Budaun	Bijnor - Moradabad	Bareilly - Shahjahanpur	Shahjahanpur - Hardoi	Bangarmau - Unnao	Unnao - Lalganj	Unchahar - Prayagraj	Fatehpur - Prayagraj
Passenger Vehicles	Two Wheeler		0.5	**5380**	1750	2813	3569	2723	1776	3683	2285	3453	7080	**9565**	3514	6026	2838	6245	3162
	Three Wheeler		1.5	**877**	605	124	658	415	87	695	254	212	934	**1749**	347	362	74	586	300
	Car/Van/ Jeep		1.0	**12525**	736	679	1921	2444	964	4879	855	2027	5179	**5976**	2476	2163	1282	4632	3094
	Mini Bus		1.5	**21**	4	18	9	35	7	11	8	7	39	**21**	19	31	3	52	32
	Bus		3.0	**1253**	541	37	75	249	244	430	202	278	581	**578**	197	191	210	490	469
Govt. & Others Vehicles	Tempo/ LCV		1.5	**1048**	346	226	344	795	315	842	510	707	745	**1794**	783	742	618	956	1274
	Commercial Vehicles	2 Axle	3.0	**484**	1061	73	85	853	430	599	164	456	263	**1509**	231	280	493	448	1033
		3 Axle	3.0	**325**	1066	50	90	877	438	561	176	447	283	**1453**	392	491	501	656	1062
		M-Axle	4.5	**665**	826	138	146	972	454	481	152	509	143	**2375**	467	606	778	1171	2464
Agricultural Vehicles	Tractor		1.5	**20**	26	17	17	20	31	48	26	50	43	**26**	28	38	20	34	13
	Tractor with Trailer		4.5	**71**	82	139	99	103	151	250	250	282	325	**206**	243	111	37	356	89
Passenger Vehicles	Cycle		0.5	**42**	152	950	357	239	286	385	82	500	125	**527**	835	500	570	501	151
	Cycle Rickshaw		2.0	**11**	2	0	0	0	9	23	3	7	26	**0**	0	0	0	0	11

Vehicle Classification			PCU Factor	Muzaffarnagar – Meerut	Aligarh - Etah	Aliganj – Farrukhabad	Farrukhabad - Kannauj	Kannauj – Kanpur	Budaun – Farrukhabad	Meerut - Garhmukteshwar	Hasanpur – Chandausi	Chandausi – Budaun	Bijnor – Moradabad	Bareilly - Shahjahanpur	Shahjahanpur – Hardoi	Bangarmau – Unnao	Unnao – Lalganj	Unchahar – Prayagraj	Fatehpur – Prayagraj
Goods Vehicles	Animal Drawn	Bullock Cart	8.0	**0**	2	13	10	1	24	50	0	6	14	**84**	30	16	17	47	0
		Horse	8.0	**0**	3	0	0	0	35	0	0	24	11	**0**	0	0	0	0	0
	Hand Cart		3.0	**0**	0	0	0	0	1	0	0	1	1	**0**	0	0	0	0	0
	Other (Pl. Specify)		2.0	**24**	10	0	3	6	17	28	7	14	42	**29**	31	1	9	3	16
Total Vehicles (Nos.)				**22749**	**7212**	**5277**	**7383**	**9733**	**5269**	**12966**	**4974**	**8980**	**15833**	**25892**	**9594**	**11558**	**7449**	**16178**	13170
Total Vehicles (PCUs)				**27761**	**15313**	**4975**	**7364**	**16617**	**9240**	**17867**	**6692**	**12859**	**17245**	**39371**	**12376**	**13428**	**11487**	**22484**	26414

Note: Data may not add up to the total due to rounding.

Table 4.7: Average Daily Traffic (ADT) Direction Flows on NH19 (old NH2) (near Katoghan Toll)

(7 day Average)

Vehicle Classification			PCU Factor	Prayagraj to Fatehpur	Fatehpur to Prayagraj	Both Directions
Passenger Vehicles	Two Wheeler		0.5	1686	1476	3162
	Three Wheeler		1.5	154	146	300
	Car/Van/ Jeep		1.0	1633	1461	3094
	Mini Bus		1.5	16	16	32
	Bus		3.0	233	236	469
Govt. & Others Vehicles	Tempo/ LCV		1.5	640	634	1274
	Commercial Vehicles	2 Axle	3.0	520	513	1033
		3 Axle	3.0	535	527	1062
		M-Axle	4.5	1239	1225	2464
Agricultural Vehicles	Tractor		1.5	8	5	13
	Tractor with Trailer		4.5	42	47	89
Passenger Vehicles	Cycle		0.5	85	67	151
	Cycle Rickshaw		2.0	5	6	11
Goods Vehicles	Animal Drawn	Bullock Cart	8.0	0	0	0
		Horse	8.0	0	0	0
	Hand Cart		3.0	0	0	0
	Other (Pl. Specify)		2.0	11	5	16
Total Vehicles (Nos.)				**6807**	**6364**	**13170**
Total Vehicles (PCUs)				**13406**	**13008**	**26414**

Note: Data may not add up to the total due to rounding.

Table 4.8 Hourly PCUs Variation over the Week on NH19 (old NH2) (near Katoghan Toll)

(Total No. of Vehicles per hour)

Date & Hour of Day	17-02-20	18-02-20	19-02-20	20-02-20	14-02-20	15-02-20	16-02-20	7 – Day Average
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
00:00 - 01:00	722	802	876	698	839	924	790	807.3
01:00 - 02:00	*766*	*699*	*853*	*559*	*638*	*766*	*651*	*704.4*
02:00 - 03:00	*682*	*535*	*831*	*478*	*608*	*718*	*482*	*619.1*
03:00 - 04:00	*635*	*471*	*662*	*424*	*566*	*644*	*465*	*552.4*
04:00 - 05:00	*568*	*424*	*494*	*664*	*484*	*548*	*399*	*511.4*
05:00 - 06:00	*512*	*439*	*639*	*677*	*393*	*417*	*738*	*545.0*
06:00 - 07:00	*748*	*674*	*648*	*611*	*615*	*624*	*707*	*661.0*
07:00 - 08:00	946	889	848	841	784	886	868	866.0
08:00 - 09:00	**1427**	**1554**	**1428**	**1586**	**1600**	**1510**	**1513**	**1516.9**
09:00 - 10:00	**1382**	**1507**	**1428**	**1566**	**1466**	**1600**	**1451**	**1485.0**
10:00 - 11:00	**1475**	**1627**	**1543**	**1581**	**1569**	**1505**	**1485**	**1540.7**
11:00 - 12:00	**1354**	**1460**	**1327**	**1388**	**1339**	**1365**	**1318**	**1364.4**
12:00 - 13:00	**1486**	**1493**	**1610**	**1569**	**1607**	**1592**	**1524**	**1554.4**
13:00 - 14:00	**1377**	**1495**	**1427**	**1552**	**1549**	**1542**	**1561**	**1500.4**
14:00 - 15:00	**1499**	**1403**	**1445**	**1322**	**1418**	**1499**	**1380**	**1423.0**
15:00 - 16:00	**1557**	**1581**	**1591**	**1524**	**1622**	**1475**	**1591**	**1563.0**
16:00 - 17:00	**1474**	**1727**	**1307**	**1690**	**1843**	**1761**	**1750**	**1650.3**
17:00 - 18:00	**1305**	**1753**	**1676**	**1650**	**1645**	**1536**	**1313**	**1554.0**
18:00 - 19:00	1256	1273	1343	1086	972	1095	1186	1173.0
19:00 - 20:00	991	946	1019	1030	1085	1007	928	1000.9
20:00 - 21:00	911	1006	1048	1532	803	867	946	1016.1
21:00 - 22:00	1055	998	959	1180	1116	1081	912	1043.0
22:00 - 23:00	1057	804	1017	826	943	883	891	917.3
23:00 - 24:00	975	844	878	730	811	866	811	845.0
Total (24 hr PCUs)	**26,154**	**26,399**	**26,890**	**26,757**	**26,310**	**26,708**	**25,655**	**26,414**
Avg. Peak Hr. Traffic	1433	1560	1478	1543	1566	1538	1488	**1515**
Peak Hour Factor	5.48%	5.91%	5.50%	5.76%	5.95%	5.76%	5.80%	**5.74%**
Avg. Shoulder Traffic	989	945	998	990	919	951	916	959
Shoulder Hour Factor	3.78%	3.58%	3.71%	3.70%	3.49%	3.56%	3.57%	3.63%
Avg. Off-Peak Hr. Traffic	652	540	688	569	550	619	573	599
Off Peak Factor	2.49%	2.05%	2.56%	2.12%	2.09%	2.32%	2.24%	2.27%

Note: Data may not add up to the total due to rounding.

4.2.3.2 Past Traffic Data

Review of Literature: Past Traffic data has been collected from Toll Plaza at Sasaram on NH-19 (old NH2) and its vehicle wise data area shown on Table 4.9.

Table 4.9: Annual Average Daily Traffic on NH19 (old NH 2)
Vehicle Type: Car+Jeep+Van (CJV)

Month	2011	2012	2013	2014	2015	2016	2017
Jan	0	1971	2248	2204	2517	3092	2937
Feb	0	2319	3084	2718	3139	3589	2504
Mar	0	2293	2527	2590	2960	3486	2006
Apr	0	2626	2624	2389	3126	4021	3428
May	0	2113	3316	2947	3561	3107	3910
Jun	0	2520	2406	2880	3061	3026	3581
Jul	0	2226	2051	2226	2397	3177	2925
Aug	0	1848	1944	2089	2781	2897	2784
Sep	3459	1778	1933	2431	2426	3057	3550
Oct	3034	2400	2210	2514	2887	3163	3610
Nov	2823	2328	2504	2513	2985	2150	0
Dec	1854	2381	2293	2523	3142	2311	0
AADT	**2787**	**2238**	**2424**	**2500**	**2913**	**3096**	**3126**

Source: Toll Booth Operator at Sasaram

The **annual growth rate of Car traffic** on NH-19 (old NH2) over 5 year period between Year 2012 and Year 2017 is about **6.91%**

Vehicle Type: Bus

Month	2011	2012	2013	2014	2015	2016	2017
Jan		106	105	85	95	105	156
Feb		93	139	87	102	106	169
Mar		112	146	118	127	151	201
Apr		75	88	82	105	132	177
May		96	97	80	81	99	172
Jun		63	68	70	98	78	176
Jul		70	54	65	78	78	198
Aug		134	67	88	102	102	221
Sep	202	139	118	136	99	180	317
Oct	111	162	93	123	158	141	275
Nov	105	118	102	102	118	82	0
Dec	80	79	70	75	87	93	0
AADT	**2787**	**2238**	**2424**	**2500**	**2913**	**3096**	**3126**

Source: Toll Booth Operator at Sasaram

The **annual growth rate of Bus traffic** on NH19 (old NH2) over 5 year period between Year 2012 and Year 2017 is about **14.62%**

Vehicle Type: Mini Bus

Month	2011	2012	2013	2014	2015	2016	2017
Jan		238	232	228	229	260	290
Feb		269	291	276	273	290	252
Mar		244	269	177	253	276	133
Apr		286	276	128	278	293	283
May		266	303	272	311	280	336
Jun		268	265	269	270	271	297
Jul		261	249	241	223	278	273
Aug		263	226	221	258	280	278
Sep	288	233	231	234	198	281	287
Oct	392	244	238	232	169	275	246
Nov	96	252	253	251	252	170	0
Dec	204	251	235	231	245	225	0
AADT	**246**	**257**	**255**	**230**	**246**	**266**	**267**

Source: Toll Booth Operator at Sasaram

The **annual growth rate of Mini Bus** on NH19 (old NH2) over 5 year period between Year 2012 and Year 2017 is about **0.81%.**

Vehicle Type: Light Commercial Vehicle (LCV)

Month	2011	2012	2013	2014	2015	2016	2017
Jan		282	261	294	219	227	291
Feb		237	278	326	193	239	305
Mar		247	301	343	199	294	310
Apr		262	310	328	208	229	275
May		242	295	298	182	212	254
Jun		258	276	308	182	230	247
Jul		282	299	334	189	220	223
Aug		238	252	297	196	216	251
Sep	0	255	281	306	191	236	276
Oct	0	260	256	245	178	229	204
Nov	346	252	280	330	199	121	0
Dec	289	290	310	314	237	252	0
AADT	**159**	**260**	**283**	**310**	**198**	**226**	**263**

Source: Toll Booth Operator at Sasaram

The **annual growth rate of LCV traffic** on NH19 (old NH2) over 5 year period between Year 2012 and Year 2017 is about **0.27%**

Vehicle Type: 2-Axle Truck

Month	2011	2012	2013	2014	2015	2016	2017
Jan		651	485	434	525	642	733
Feb		692	522	456	623	706	835
Mar		642	524	469	598	700	808
Apr		616	533	447	575	670	831
May		690	531	462	542	717	804
Jun		623	480	493	558	724	759
Jul		514	441	415	538	683	668
Aug		498	415	408	508	697	759
Sep	565	476	467	482	573	766	804
Oct	665	509	436	397	562	759	597
Nov	634	479	411	437	575	396	0
Dec	623	511	463	445	700	681	0
AADT	**622**	**576**	**475**	**445**	**573**	**681**	**759**

Source: Toll Booth Operator at Sasaram

The **annual growth rate of 2-axle truck traffic** on NH19 (old NH2) over 5 year period between Year 2012 and Year 2017 is about **5.65%.**

Vehicle Type: Multi Axle Vehicle (MAV) Trucks

Month	2011	2012	2013	2014	2015	2016	2017
Jan		4866	5290	5032	4742	6920	6846
Feb		5439	5338	5601	6816	6372	8127
Mar		5794	5457	5558	6580	5926	8173
Apr		5523	4799	5596	6472	6806	7916
May		5826	4792	5645	6908	7095	9135
Jun		5650	4906	6305	6926	7011	8538
Jul		5065	4483	5387	5604	5272	5478
Aug		4685	4285	4798	5214	5279	5863
Sep	4327	4615	5232	5907	5419	5962	6253
Oct	4768	5180	5004	5610	5745	6870	5475
Nov	5102	5079	5510	6351	6371	4888	0
Dec	4812	5364	5597	5737	6373	6369	0
AADT	**4753**	**5271**	**5055**	**5623**	**6089**	**6248**	**7167**

Source: Toll Booth Operator at Sasaram

The **annual growth rate of MAV Truck** on NH19 (old NH2) over 5 year period between Year 2012 and Year 2017 is about **6.34%**

4.2.3.3 Annual Average Daily Traffic (AADT)

Factors for seasonal corrections were also derived from the sale of fuel (petrol for passenger vehicles like cars, two wheelers and diesel for commercial vehicles like light commercial vehicles, trucks and larger vehicles) at fuel pump stations available along the proposed alignment of Expressway. **Annual Average Daily Traffic (AADT)** is established considering the Seasonal Correction Factors of 1.003 for Passenger Vehicles and 1.063 for commercial vehicles – results (**Annual Average Daily Traffic - ADT**) are shown on Table 4.10.

Table 4.10: Annual Average Daily Traffic (AADT) on Existing Alternate Roads

Vehicle Classification			PCU Factor	Muzaffarnagar - Meerut	Aligarh - Etah	Aliganj - Farrukhabad	Farrukhabad - Kannauj	Kannauj - Kanpur	Budaun - Farrukhabad	Meerut - Garhmukteshwar	Hasanpur - Chandausi	Chandausi - Budaun	Bijnor - Moradabad	Bareilly - Shahjahanpur	Shahjahanpur - Hardoi	Bangarmau - Unnao	Unnao - Lalganj	Unchahar - Prayagraj	Fatehpur - Prayagraj
Passenger Vehicles	Two Wheeler		0.5	5396	1755	2821	3580	2731	1781	3694	2292	3463	7101	9594	3525	6044	2847	6264	3171
	Three Wheeler		1.5	880	607	124	660	416	87	697	255	213	937	1754	348	363	74	588	301
	Car/Van/ Jeep		1.0	12563	738	681	1927	2451	967	4894	858	2033	5195	5994	2483	2169	1286	4646	3103
	Mini Bus		1.5	22	4	19	10	37	7	12	9	7	41	22	20	33	3	55	34
	Bus		3.0	1332	575	39	80	265	259	457	215	296	618	614	209	203	223	521	499
Govt. & Others Vehicles	Tempo/ LCV		1.5	1114	368	240	366	845	335	895	542	752	792	1907	832	789	657	1016	1354
	Commercial Vehicles	2 Axle	3.0	514	1128	78	90	907	457	637	174	485	280	1604	246	298	524	476	1098
		3 Axle	3.0	345	1133	53	96	932	466	596	187	475	301	1545	417	522	533	697	1129
		M-Axle	4.5	707	878	147	155	1033	483	511	162	541	152	2525	496	644	827	1245	2619
Agricultural Vehicles	Tractor		1.5	21	28	18	18	21	33	51	28	53	46	28	30	40	21	36	14
	Tractor with Trailer		4.5	75	87	148	105	109	161	266	266	300	345	219	258	118	39	378	95
Passenger Vehicles	Cycle		0.5	42	152	950	357	239	286	385	82	500	125	527	835	500	570	501	151
	Cycle Rickshaw		2.0	11	2	0	0	0	9	23	3	7	26	0	0	0	0	0	11
Goods Vehicles	Animal Drawn	Bullock Cart	8.0	0	2	13	10	1	24	50	0	6	14	84	30	16	17	47	0
		Horse	8.0	0	3	0	0	0	35	0	0	24	11	0	0	0	0	0	0
	Hand Cart		3.0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	Other (Pl. Specify)		2.0	24	10	0	3	6	17	28	7	14	42	29	31	1	9	3	16
Total Vehicles (Nos.)				**23047**	**7470**	**5332**	**7456**	**9995**	**5408**	**13196**	**5078**	**9169**	**16026**	**26445**	**9761**	**11741**	**7630**	**16474**	**13595**
Total Vehicles (PCUs)				**28,504**	**16,117**	**5,109**	**7,530**	**17,389**	**9,661**	**18,485**	**6,965**	**13,387**	**17,703**	**40,986**	**12,822**	**13,907**	**12,020**	**23,341**	**27,762**

Note: Data may not add up to the total due to rounding.

4.2.4 Origin – Destination (O-D) Matrices

O-D matrices for Tollable Traffic (vehicle types as listed in Table 4.11) are generated from the information recorded during the Origin-Destination Surveys, and expanded by multiplying with corresponding Expansion Factors to arrive at the Expanded O-D Matrix (Vehicle Type, Existing Alternate Road) and results are annexed to Appendix.

4.2.4.1 Expansion Factors

Expansion Factors were derived from the percentage of tollable vehicles interviewed during the origin and destination surveys to that of the ADT arrived for respective roads. The values of expansion factors for tollable traffic type at each of the origin & destination survey locations are given shown on Table 4.11.

Table 4.11: Expansion Factors for O-D Matrices (Tollable Traffic)

Survey Location	Tollable Vehicles	Car	Bus	LCV	2-Axle Truck	3-Axle Truck	MAV (4 + axles)
On Muzaffarnagar - Meerut Stretch at Siwaya Toll Booth	% Interviewed	2.46%	5.49%	6.11%	9.12%	10.12%	9.19%
	Expansion Factor	40.65	18.22	16.38	10.96	9.88	10.88
On Fatehpur - Prayagraj Stretch at Katodhan Toll Booth	% Interviewed	7.58%	7.02%	6.87%	4.56%	3.81%	3.55%
	Expansion Factor	13.20	14.25	14.56	21.95	26.25	28.16
On Meerut - Garhmukteshwar Stretch at Nizampur	% Interviewed	6.19%	13.23%	5.14%	1.88%	1.68%	6.07%
	Expansion Factor	16.15	7.56	19.46	53.10	59.66	16.48
On Hasanpur - Chandausi Stretch at Kurkawali	% Interviewed	18.87%	8.90%	7.19%	11.47%	13.37%	18.52%
	Expansion Factor	5.30	11.23	13.90	8.72	7.48	5.40
On Chandausi - Budaun Stretch at Nawada	% Interviewed	11.17%	12.18%	5.46%	5.77%	3.37%	5.91%
	Expansion Factor	8.95	8.21	18.33	17.32	29.68	16.92
On Aligarh - Etah Stretch at Nagariya	% Interviewed	18.42%	11.42%	7.07%	6.57%	5.65%	6.95%
	Expansion Factor	5.43	8.76	14.14	15.23	17.70	14.39
On Aliganj - Farrukhabad Stretch at Khankah e Niyaziya	% Interviewed	24.81%	28.09%	18.76%	38.46%	44.84%	24.45%
	Expansion Factor	4.03	3.56	5.33	2.60	2.23	4.09
On Farrukhabad - Kannauj Stretch at Samdhan	% Interviewed	7.79%	13.85%	10.38%	26.46%	12.48%	20.66%
	Expansion Factor	12.84	7.22	9.63	3.78	8.01	4.84
On Kannauj - Kanpur Stretch at Bilhaur	% Interviewed	6.81%	8.32%	6.03%	3.31%	1.72%	4.55%
	Expansion Factor	14.68	12.02	16.58	30.21	58.26	21.99
On Budaun - Farrukhabad Stretch at Usawan	% Interviewed	18.02%	16.21%	17.33%	11.15%	7.73%	10.57%
	Expansion Factor	5.55	6.17	5.77	8.97	12.93	9.46
On Bijnor - Moradabad Stretch at Agwanpur	% Interviewed	3.75%	4.86%	6.94%	10.00%	7.64%	6.60%
	Expansion Factor	26.64	20.57	14.40	10.00	13.09	15.16
On Bareilly - Shahjahanpur Stretch at Faridpur Toll Booth	% Interviewed	3.95%	5.37%	2.94%	4.80%	5.18%	4.87%
	Expansion Factor	25.29	18.61	34.05	20.83	19.30	20.53
On Shahjahanpur - Hardoi Stretch at Shahabad	% Interviewed	5.44%	8.60%	4.57%	8.94%	4.79%	4.84%
	Expansion Factor	18.39	11.63	21.90	11.18	20.86	20.68
On Bangarmau - Unnao Stretch at Safipur	% Interviewed	8.16%	10.36%	5.68%	9.78%	5.64%	6.94%
	Expansion Factor	12.25	9.65	17.61	10.23	17.72	14.41
On Unnao - Lalganj Stretch at Semari	% Interviewed	11.21%	16.16%	5.26%	7.84%	5.07%	5.45%
	Expansion Factor	8.92	6.19	19.00	12.75	19.73	18.34
On Unchahar - Prayagraj Stretch at Andiyari	% Interviewed	3.59%	4.22%	5.70%	8.61%	7.03%	5.46%
	Expansion Factor	27.82	23.68	17.53	11.61	14.23	18.30

4.2.4.2 Candidate Traffic for Proposed Expressway (All trip lengths)

Candidate Traffic is that traffic on the alternate existing roads whose travel pattern (origin-destination) can be serviced by the proposed Expressway. Origin-Destination pairs that can be serviced by the proposed Expressway are extracted from the Expanded O-D Matrix, and thus form the Candidate Traffic for proposed Expressway.

Derived *"Candidate"* traffic are shown on Appendix

For cars and trucks, these volumes were obtained from:

(a) a careful examination of the origin and destination data and the elimination of trips that would not find travel by the proposed Expressway useful (mainly trips to and from Zones East/West perpendicularly to the proposed Expressway alignment); and

(b) by multiplying the above-derived numbers by the earlier-described Expansion Factors and applying the appropriate Seasonal Correction Factors.

For buses, these volumes were obtained from an examination of advertised origins and destinations. Only those services known to be on journeys to and from points beyond corresponding Interchange Nodes in (north direction) & (south direction) were considered.

4.2.4.3 Candidate Traffic for Proposed Expressway

However, the it is prudent not to restrict the Candidate Traffic of those traffic whose trip lengths would be even lesser than ~25 Kms (*approximate usage of any one package of the proposed alignment of expressway*), this is basically to reflect the users choice of intending to the Expressway for shorter trip lengths (shorter trip lengths may incur time savings/perceived cost savings/avoid congestion, i.e. does trigger route choice).

The Zones (Origins & Destinations) as shown on Table 4.5 served as base, with Trip Matrix for O-D pairs as shown in Table 4.12 were used to generate the Candidate Traffic between designated Toll Nodes (Nodes A to R) of the Proposed Expressway.

While movement "AE" shown in the matrix from Node A to Node E represents traffic that will use the Expressway from Node A to Node E and "EA" shown in the matrix from Zone E to Zone A represents traffic that will use the Expressway from Node E to Node A.

Trip Matrix was matched with Expanded OD Matrices to arrive the Candidate Traffic; Movement Matrix-Tollable Traffic results are shown on Tables 4.13 to Tables 4.18

Table 4.12: Trip Matrix for O-D Pairs (Trips within Districts of Uttar Pradesh)

| Zones | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 |
|---|---|---

Trip Matrix for O-D Pairs (Trips between Districts of Uttar Pradesh and Expressway Interchange Node Zones+Other States of India)

| Zones | AL1 | AL2 | AR1 | AR2 | BL1 | BL2 | BR1 | CL1 | CL2 | CR1 | CR2 | DL1 | DL2 | DR1 | DR2 | EL1 | EL2 | ER1 | ER2 | FL1 | FL2 | GL1 | GL2 | GR1 | HL2 | IL1 | IL2 | IR2 | JL2 | JR1 | JR2 | KL1 | KL2 | KR1 | KR2 | LL1 | LR1 | LR2 | ML1 | ML2 | MR1 | MR2 | NL1 | NL2 | NR1 | NR2 | OL2 | OR1 | OR2 | PL1 | PL2 | QR1 | QR2 | RL2 | RR1 | RR2 | ZAS | ZBR | ZCG | ZCH | ZGJ | ZHP | ZHR | ZJH | ZKA | ZMH | ZMP | ZNDLS | ZNepal | ZOR | ZPB | ZRJ | ZTN | ZTS | ZUK | ZWB |
|---|---|---

Trip Matrix for O-D Pairs (Trips between Expressway Interchange Node Zones + Other States of India and Districts of Uttar Pradesh)

| Zones | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 |
|---|---|---

Trip Matrix for O-D Pairs (Trips between Interchange Node Zones and Other States of India)

| Zones | AL1 | AL2 | AR1 | AR2 | BL1 | BL2 | BR1 | CL1 | CL2 | CR1 | CR2 | DL1 | DL2 | DR1 | DR2 | EL1 | EL2 | ER1 | ER2 | FL1 | FL2 | GL1 | GL2 | GR1 | HL2 | IL1 | IL2 | IR2 | JL2 | JR1 | JR2 | KL1 | KL2 | KR1 | KR2 | LL1 | LR1 | LR2 | ML1 | ML2 | MR1 | MR2 | NL1 | NL2 | NR1 | NR2 | OL2 | OR1 | OR2 | PL1 | PL2 | QR1 | QR2 | RL2 | RR1 | RR2 | ZAS | ZBR | ZCG | ZCH | ZGJ | ZHP | ZHR | ZJH | ZKA | ZMH | ZMP | ZNDLS | ZNepal | ZOR | ZPB | ZRJ | ZTN | ZTS | ZUK | ZWB |
|---|---|---

Table 4.13: Movement Matrix – Car

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Total
A	0	90	20	111	209	0	66	72	12	37	0	35	48	45	22	9	43	83	**901**
B	163	0	20	5	48	0	34	8	11	0	0	0	0	8	8	0	11	5	**323**
C	0	0	0	0	0	4	24	5	0	0	1	0	0	0	2	0	0	20	**55**
D	22	5	0	0	0	0	5	0	0	2	0	0	5	0	0	0	0	0	**39**
E	81	32	0	0	0	0	7	11	34	50	0	19	21	17	5	0	0	20	**297**
F	0	4	2	0	2	0	0	6	0	4	0	0	0	0	26	0	0	12	**56**
G	76	52	7	0	4	4	0	33	0	12	1	8	14	3	5	0	0	47	**265**
H	84	36	4	0	2	3	18	0	0	4	0	1	4	0	0	0	0	0	**156**
I	25	11	0	2	60	0	3	0	0	2	36	87	93	62	26	0	0	62	**469**
J	22	0	0	0	91	3	23	1	4	0	0	129	33	16	0	0	1	25	**347**
K	3	3	1	0	0	0	8	0	53	0	0	0	0	6	7	0	0	3	**84**
L	35	3	1	6	48	3	33	1	92	104	0	0	7	48	77	0	0	43	**501**
M	34	22	9	5	9	12	16	0	56	30	0	8	0	6	37	3	9	150	**406**
N	38	7	0	0	20	0	4	0	32	3	0	97	0	0	66	3	18	96	**384**
O	66	0	1	0	3	20	23	0	52	15	8	96	93	23	0	0	0	424	**824**
P	36	11	0	0	0	0	9	0	0	9	0	3	5	9	0	0	0	231	**314**
Q	0	0	0	0	0	3	0	0	0	0	0	9	3	13	0	0	0	9	**38**
R	150	23	41	0	52	7	40	0	61	22	7	27	210	91	315	240	0	0	**1285**
Total	**834**	**299**	**106**	**129**	**546**	**57**	**313**	**137**	**408**	**295**	**53**	**520**	**535**	**347**	**598**	**255**	**81**	**1230**	

Note: Data may not add up to the total due to rounding.

Table 4.14: Movement Matrix – Bus

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Total
A	0	0	0	9	10	0	23	9	0	19	0	1	1	42	0	8	0	20	**143**
B	0	0	0	0	3	0	6	3	0	4	0	0	0	4	0	0	0	0	**19**
C	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	5	**9**
D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E	0	5	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	11	**20**
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	**14**
G	13	23	4	0	0	4	0	0	0	0	0	2	0	0	0	0	0	11	**55**
H	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**
I	0	0	0	0	0	0	0	0	0	0	0	10	6	4	0	0	0	7	**27**
J	12	0	0	0	0	0	0	0	0	0	0	16	0	0	7	0	0	0	**34**
K	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
L	2	0	0	0	0	0	0	0	0	12	0	0	0	24	2	0	0	0	**39**
M	6	3	0	0	0	0	3	0	6	4	0	0	0	0	11	0	0	28	**61**
N	6	17	0	0	0	0	0	0	4	0	0	6	0	0	6	0	0	10	**49**
O	7	0	2	0	0	0	0	0	0	0	0	0	9	8	0	0	0	16	**42**
P	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	32	**34**
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	**10**
R	15	0	9	0	7	7	4	0	1	0	7	0	17	16	24	32	0	0	**139**
Total	**60**	**51**	**16**	**9**	**20**	**11**	**39**	**12**	**11**	**38**	**9**	**35**	**33**	**110**	**51**	**39**	**0**	**153**	

Note: Data may not add up to the total due to rounding.

Table 4.15: Movement Matrix – LCV

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Total
A	0	0	0	0	49	0	27	56	6	9	7	15	11	29	12	6	6	57	**291**
B	0	0	0	6	6	0	6	21	6	0	0	0	8	11	0	0	0	0	**66**
C	0	0	0	0	0	0	9	5	0	29	0	12	1	0	0	0	0	0	**56**
D	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**
E	42	0	0	0	0	0	0	0	27	24	0	14	5	6	0	0	1	6	**125**
F	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	**7**
G	16	5	0	0	5	0	0	0	0	26	0	1	12	4	0	0	0	0	**68**
H	49	26	5	0	0	0	0	0	0	5	0	2	0	2	0	0	0	0	**88**
I	0	0	0	0	31	0	0	0	0	2	79	71	12	35	0	0	0	13	**244**
J	6	0	21	0	12	8	25	5	1	0	0	84	7	9	38	0	0	13	**230**
K	0	0	0	0	0	0	11	0	24	0	0	0	0	0	7	0	0	18	**60**
L	32	0	12	0	18	0	1	2	62	41	0	0	0	18	22	3	0	40	**251**
M	22	0	11	0	0	0	6	0	22	19	0	0	0	0	3	0	0	99	**183**
N	30	8	0	0	0	0	5	2	23	16	0	12	0	0	0	0	6	155	**256**
O	6	0	3	0	0	0	3	0	0	18	7	25	13	10	0	0	0	50	**134**
P	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	**34**
Q	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**
R	52	8	0	0	0	0	5	0	14	25	16	33	105	194	57	35	0	0	**545**
Total	**268**	**53**	**52**	**6**	**121**	**8**	**99**	**90**	**187**	**221**	**110**	**269**	**175**	**317**	**139**	**45**	**14**	**478**	

Note: Data may not add up to the total due to rounding.

Table 4.16: Movement Matrix – 2 Axle Truck

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Total
A	0	0	0	0	18	0	3	15	0	5	52	52	60	38	20	0	0	70	**333**
B	0	0	0	0	0	0	18	0	0	3	6	0	26	28	1	0	0	0	**81**
C	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	8	**15**
D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E	0	0	0	0	0	0	3	0	0	14	7	0	18	4	7	0	0	8	**60**
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
G	6	0	0	0	0	0	0	0	0	0	14	7	41	7	3	0	0	18	**96**
H	14	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**43**
I	0	0	0	0	0	0	0	0	0	0	7	0	48	38	11	0	0	21	**126**
J	23	3	7	0	7	0	4	0	0	0	0	7	0	11	0	0	0	7	**69**
K	12	9	3	0	7	0	14	0	7	0	0	0	0	0	0	0	0	55	**106**
L	50	0	2	0	0	0	7	2	9	11	0	0	0	0	0	0	0	22	**102**
M	44	15	4	0	4	0	29	0	26	7	0	0	0	0	17	0	0	164	**309**
N	77	7	9	0	3	0	7	0	12	7	0	0	3	0	0	0	0	27	**154**
O	43	6	0	0	0	0	1	0	0	3	6	0	9	4	0	0	0	4	**76**
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	**22**
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
R	56	18	6	0	11	0	18	0	47	8	98	11	152	31	4	22	0	0	**481**
Total	**324**	**85**	**31**	**0**	**50**	**0**	**103**	**17**	**101**	**66**	**189**	**77**	**358**	**162**	**63**	**22**	**0**	**425**	

Note: Data may not add up to the total due to rounding.

Table 4.17 Movement Matrix – 3 Axle Truck

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Total
A	0	4	0	0	0	0	7	4	0	4	23	45	148	175	71	0	0	180	**661**
B	0	0	0	0	0	0	0	0	0	0	10	6	26	20	20	0	0	35	**117**
C	0	0	0	0	0	0	0	0	0	0	0	0	8	7	0	0	0	61	**76**
D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
E	0	0	0	0	0	0	0	0	0	0	0	0	18	0	10	0	0	16	**44**
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
G	7	0	2	0	2	0	0	0	0	0	0	0	7	6	19	0	0	26	**69**
H	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**
I	0	0	0	0	0	0	0	0	0	0	6	7	13	6	0	0	0	89	**122**
J	8	0	0	0	0	0	0	0	0	0	0	21	7	7	12	0	0	24	**79**
K	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**11**
L	35	0	0	0	0	0	0	0	0	14	0	0	0	0	7	0	0	0	**56**
M	73	25	9	0	20	0	13	0	25	0	0	0	0	3	0	0	0	149	**316**
N	119	7	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	24	**157**
O	88	28	4	0	0	0	7	0	0	0	4	0	0	2	0	0	0	5	**137**
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
R	183	34	44	0	9	0	42	0	72	21	0	0	175	31	11	0	0	0	**623**
Total	**522**	**102**	**62**	**0**	**32**	**0**	**69**	**4**	**97**	**38**	**43**	**79**	**401**	**256**	**149**	**7**	**0**	**609**	

Table 4.18: Movement Matrix – Multi Axle Truck

Nodes	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Total
A	0	0	7	0	0	0	0	0	0	9	2	29	192	154	65	0	0	755	**1212**
B	0	0	0	0	0	0	0	0	0	0	0	0	25	5	6	0	0	38	**74**
C	0	0	0	0	0	0	0	0	0	0	0	0	10	0	2	0	0	38	**50**
D	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**
E	0	5	0	0	0	0	0	0	0	0	0	0	14	2	0	0	0	34	**55**
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
G	11	0	0	0	0	0	0	0	2	0	0	0	14	5	0	0	0	83	**114**
H	0	2	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	**8**
I	5	0	0	0	0	0	0	0	0	0	0	7	9	4	31	0	0	42	**98**
J	14	0	13	0	0	0	0	0	0	0	0	7	0	1	12	0	0	19	**65**
K	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**
L	27	0	2	0	0	0	0	0	7	0	0	0	0	0	0	0	0	15	**51**
M	182	16	9	0	11	0	30	0	27	0	0	0	0	0	5	0	0	146	**425**
N	102	5	3	0	0	0	8	0	2	1	0	0	0	0	0	0	0	12	**133**
O	58	7	3	0	0	0	0	0	0	0	6	0	5	0	0	0	0	20	**99**
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	**7**
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
R	882	71	18	0	14	0	71	0	77	18	0	24	114	12	6	5	0	0	**1313**
Total	**1299**	**108**	**54**	**0**	**25**	**0**	**114**	**0**	**114**	**28**	**8**	**66**	**383**	**182**	**126**	**5**	**0**	**1209**	

Note: Data may not add up to the total due to rounding.

From the above tables; the Candidate Traffic i.e. the sectional traffic loads on each section of the proposed Expressway i.e. between Node "A" to Node "R" is shown in Table 4.19

Table 4.19: Candidate Traffic/Day for Proposed Expressway

Section	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K	K-L	L-M	M-N	N-O	O-P	P-Q	Q-R
Car	1735	1852	1932	1816	1917	2009	2032	1762	2324	2456	2379	2189	2279	2187	2242	2615	2515
Bus	203	273	298	288	293	318	262	246	284	288	292	282	317	263	249	302	292
LCV	559	679	787	787	838	854	884	740	1029	1120	1033	817	901	1057	997	1043	1023
2 Axle Truck	657	823	869	870	945	945	1086	1030	1256	1245	1266	1152	1176	986	863	906	906
3 Axle Truck	1183	1394	1532	1532	1607	1607	1708	1700	1918	2012	1964	1843	1779	1493	1239	1232	1232
Multi Axle Truck	2511	2693	2783	2780	2849	2849	3055	3048	3246	3269	3258	3219	2950	2683	2511	2522	2522
Total Vehicles (Nos.)	**6849**	**7713**	**8201**	**8073**	**8450**	**8582**	**9027**	**8525**	**10058**	**10391**	**10193**	**9501**	**9402**	**8668**	**8100**	**8621**	**8491**
Total Vehicles (PCUs)	**20,004**	**22,456**	**23,733**	**23,577**	**24,529**	**24,720**	**26,273**	**25,513**	**28,852**	**29,483**	**29,157**	**27,729**	**26,719**	**24,071**	**22,085**	**22,852**	**22,691**

Note: Data may not add up to the total due to rounding.

4.2.5 Other Traffic Survey Data

Analyses of other data derived from the Origin and Destination Surveys (and used mainly in the financial and economic appraisals) for Passenger & Goods Statistics are provided on Chapters 1 to 5 of Appendix. For passengers, these data relate to the average occupancy of vehicles, trip purpose and the origin and destination of trips that are from/to Interchange Nodes and the immediate areas. For freight, these data refer to commodities carried, axle loads and the origins and destination of trips that are from/to Interchange Nodes and the immediate areas.

4.2.6 Speed-Time Surveys

Travel times have been estimated using passenger car for *"peak"* travel times and for those portions of each trip on 2/4/6 lane roads, with free access from sides and urban sections on these roads. It can be seen that, during peak periods, the full length journeys are:

(a) ***for 2-lane configuration in rural areas with free access to road from either sides**:* requiring 45 minutes to complete the average 34.1 km between Meerut outer point and Garhmukteshwar outer point – implying an average speed of about **45.46 km/hour**.

(b) ***for 4-lane configuration toll roads**:* requiring 66 minutes to complete the 71.1 km between Moradabad and Bareilly on National Highway NH530 (old NH24)– implying a spot speed of about **64.63 km/hour;** however, the **journey speeds** observed on alternate route *(journey combines 4-lane National Highway & 2-lane State Highways, Hasanpur – Chandausi – Budaun sections)* in the project influence areas, the average journey speed falls to about **35.0 Km/hour**

(c) ***for 6-lane/4-lane configuration in rural areas with heavily built up areas**:* requiring average of 11 hours 38 minutes to complete the approx. 751 km (maximum sections of access controlled Expressway) – implying an average speed of about **64.55 km/hour**.

4.3 Traffic Assignments

Traffic assignments of Candidate Traffic has been done using diversion curve method, wherein a logit model computes expected diversion % based on the ratio of perceived cost on the existing alternate roads and proposed Expressway. The perceived cost is the financial vehicle operating cost and the vehicle operating time saving cost including toll charges (if any).

The estimated *"generalised"* costs for travel between Node A and Node R on the proposed Expressway and between outer origins & outer destinations while in two comparing circumstances:

(a) when using the presently available alternate through route NH19 (old NH2) (4/6-lane dual carriageway without service roads or with service roads on either/one side at few urban stretches with traffic signals causing travel time delays); and
(b) when using the proposed Expressway (6-lane dual carriageway access controlled facility with 2 lane services road on either/one side).

These *"generalised"* costs are:

(a) *for buses and trucks:* the **financial costs of travel (including passenger and other time costs)** plus any tolls;
(b) *for cars:* the **perceived costs of travel** (a term applied mainly to private users who are known to make route and modal choice decisions not on total, or even marginal costs, but on the costs of only a few specific items – normally fuel, tyres and time)

Vehicle Operating Costs (VOC) and Vehicle Operating Time (VOT) Costs have been estimated using the relationships presented in IRC Special Publication SP-30 2009, Manual on Economic Evaluation of Highway Projects in India, Indian Road Congress 2009. Perceived cost (VOC + VOT

+Toll charges) in Rs/Km computed for presently available alternate route NH 19 (existing condition) vis a vis proposed Expressway (6-lane dual carriageway) is shown on Appendix.

According to logit model a vehicle user will shift if the perceived cost on the proposed Expressway is lower in comparison to existing alternate road NH19 (old NH2). The diversion equations for carrying out traffic assignment have been adopted from Study on Expressway System Planning, March 1991 done by Wilbur Smith Associates for Ministry of Surface Transport, Govt. of India.

Diversion percentages using Cost Ratio relationships as explained below, were estimated for alternate route NH 19 (old NH 2) versus proposed Expressway (Refer Table 4.20)

Table 4.20: Diversion Formulae (Logit Model)

Vehicle	Cost Ratio (CR)	Relationship
Car	CR < 0.634	% Div = 98.75 – ((CR/0.634)*8.125
	0.634 <= CR < 1.465	% Div = 90.625 – ((CR – 0.634)/0.831)*84.375
	1.465 <= CR <=2.00	% Div = 6.25 – ((CR – 1.465)/0.535))*5.25
Bus & Truck	CR < 0.75	% Div = 100 – ((CR/0.75)*5)
	0.75 <= CR < 1.25	% Div = 95 – ((CR-0.75)/0.5)*90
	1.25 <= CR <= 2.00	% Div = ((2-CR)/0.75)*5

Thus the perceived cost (VOC + VOT +Toll charges) in Rs/Km for different alternate routes (a combination of four/six lane dual carriageway with free access - *in future*) vis a vis proposed Expressway (6-lane dual carriageway) with restricted access will determine the route choice of the user; the link characteristics as shown on Table 4.21 adopted here represents better Level of Service of roads under tolling scenario, for calculation of Vehicle Operating Costs – results (VOC & VOT) are shown on Table 4.22

All the alternate routes NH19 (old NH2) are either toll operated 4/6 Lane dual carriageway (*a combination of NH19 (old NH2), Agra-Lucknow Expressway, Lucknow–Moradabad, Moradabad–Garhmukteshwar, Garhmukteshwar-Meerut*) or under various stages of widening i.e. from existing two lane to four lane standards or from existing four lane to six lane; for instance, the stretch from Meerut to Garhmukteshwar is presently two lane, proposed for four laning in near future and instance of six laning of National Highway NH19 at various sections from Prayagraj to Agra. Similarly National Highways/State Highways/Major District Roads which intersect with the proposed Expressway are under various stages of improvement including 2/4/6-laning by Central/State Agencies.

Toll charges (Rs/km) is likely to be charged on the proposed Expressway is per UPEIDA Toll Rules, similarly the Agra to Prayagraj (under widening scheme by NHAI/MoRTH) will also be tolled as per NH Toll Rules; However, the Expressway is expected to have higher toll rates due to the fact that Expressway will have more structures like Bridges, ROBs, and Viaducts at some interchanges/crossings.

Table 4.21 Link Characteristics for VOC Calculations

Description	Expressway	Alternate Road (NH 19)
Lane Configuration	6 lane Dual Carriageway	4/6 lane dual carriageway
Access Control	Restricted Access	Free Access
Traffic 2020 (PCUs)	21173	27762
Car Speed (Km/hr)	89.81	81.10
Roughness (mm/km)	Between 1800 and 2500	Between 2500 and 3000
Rise & Fall (m)	1	3

Diversion percentage between Proposed Expressway and alternate 4/6 lane toll road NH19 (AR) as per Cost Ratios – results (diversion percentages) are shown in Table **4.22**

Table 4.22: Diversion of Traffic

Perceived Cost	Car		Bus		LCV		2-Axle Truck		3-Axle Truck		MAV(4+Axles)	
Roads	**PR**	**AR**	**PR**	**PR**	**PR**	**AR**	**PR**	**AR**	**PR**	**AR**	**PR**	**AR**
VOC (Rs./km)	5.51	5.57	14.04	16.57	12.57	14.78	13.91	16.67	24.86	30.61	26.49	32.79
VOT (Rs./km)	2.81	3.57	1.35	1.93	38.13	49.45	4.38	6.56	6.09	10.78	8.25	14.60
Toll (Rs./km)	1.95	0.86	3.10	1.41	6.23	2.90	6.23	3.21	9.58	3.21	9.58	5.56
Total Cost (Rs./km)	10.26	10.00	18.49	19.91	56.94	67.12	24.53	26.44	40.54	44.60	44.33	52.95
Cost Ratio (PR/AR)	**1.042**		**0.976**		**0.891**		**0.997**		**0.951**		**0.876**	
% Diversion	**49.20%**		**54.34%**		**69.69%**		**50.49%**		**58.80%**		**72.38%**	

Diversion percentages were applied to the Candidate Traffic as shown in Table 4.19 to arrive at the Tollable Traffic on each section of the proposed Expressway, i.e. sectional traffic between Node 'A' and Node 'R' is shown on Table 4.23.

Table 4.23: Tollable Traffic/Day for Proposed Expressway

Section	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K	K-L	L-M	M-N	N-O	O-P	P-Q	Q-R
Car	854	911	950	893	943	988	999	866	1143	1208	1170	1077	1121	1076	1103	1287	1237
Bus	141	190	207	201	204	221	182	171	198	201	203	197	221	183	173	211	203
LCV	304	369	428	421	449	457	474	395	552	602	562	444	490	574	542	567	556
2 Axle Truck	332	416	439	439	476	476	547	519	633	628	639	582	594	498	436	458	458
3 Axle Truck	696	819	901	901	945	945	1004	999	1128	1183	1155	1084	1046	878	728	724	724
Multi Axle Truck	1817	1949	2015	2011	2060	2060	2210	2204	2348	2365	2358	2330	2135	1942	1817	1826	1826
Total Vehicles (Nos.)	**4144**	**4654**	**4939**	**4864**	**5077**	**5148**	**5417**	**5156**	**6003**	**6186**	**6088**	**5712**	**5606**	**5151**	**4799**	**5072**	**5004**
Total Vehicles (PCUs)	**12,995**	**14,510**	**15,298**	**15,193**	**15,764**	**15,874**	**16,856**	**16,449**	**18,416**	**18,787**	**18,617**	**17,811**	**17,044**	**15,352**	**14,104**	**14,530**	**14,442**

Note: Data may not add up to the total due to rounding.

4.4 Diverted and Generated Traffic

4.4.1 Diverted Traffic

In this Study, the term "diverted" traffic refers to traffic which has diverted from other modes. Traffic diverting from other roads was, of course, considered above.

Although rail freight traffic is growing, the modal-share of surface transport that the railways enjoy has fallen, nationally, from about 78.45% in 1955 to 26% in 2001. The railways although reporting operating revenues in excess of operating expenditures are, also, not recovering sufficient revenue for needed capital investments and, when these items are taken into account, it is estimated that the users are being subsidised by the equivalent of about 20% of current tariffs. Also, the growth of Rail Freight and Road Freight in terms of Billion Tonnes Kilo Meters (BTKM) is 4% and 9% respectively from 1950-51 to 2000-01 (five decades).

As the nascent access controlled expressway system in India (esp. Uttar Pradesh) grows and, as the quality-of-service offered by road transport companies grows in-line, it is likely that there will be further shifts away from rail and towards road. This has been the experience of other countries. Additional shifts towards road transport will also occur if the railways are required to recover their full capital expenditures from users. The share of road transport will also continue to increase given the highly competitive nature of road transport, convenience and flexibility in tariffs, and the capability of road to handle smaller loads vis a vis rail transport.

While the general trend away from rail will undoubtedly continue, it can be seen that almost all rail freight movements along the proposed truck route are bulk in nature and that, as such, these are not cargoes likely soon (or ever) to shift to the proposed Expressway.

It is, moreover, noted that, except for occasional bulk raw material deliveries, agro processing, food processing, textiles, leather based industry, handloom and handicrafts, sports goods, bio-technology, mineral based industry, tourism and IT and ITeS industries, including software, captive business process outsourcing (BPO) and electronics industries now dominating the Uttar Pradesh economy, have high-value inputs and outputs, generally unsuited to rail transport.

It is worth noting that Indian Railways operate two trains only which directly connect Meerut City Junction station and Prayagraj Junction station, and travel times of these trains are somewhere between 10 hours 45 minutes and 13 hours 35 minutes costing about Rs. 360 per one way trip, but has passenger load factor of more than 1 all round the year, primarily is linked to patrons/matrons of law from Meerut attending the Judicial Complex at Prayagraj on a regular basis. This waitlisted passenger may shift to the Expressway, on either as bus/mini bus trips, car pool trips or private trips, as the travel times between Meerut and Prayagraj shall reduce by 3 hours.

For the purposes of this Study, it is assumed no immediate shift from rail to road. Any long term trend in the shift from rail to road will, of course, shall be accounted for in the described forecasts for natural growth later in this report.

The share of inland waterways and pipelines, which are both energy efficient modes of transport have relatively lower chances of being operative in the next few decades and hence not being projected and its impact in this report.

4.4.2 Generated Traffic

The project road, which will comprise various elements of an Expressway from Meerut (District Meerut) to Prayagraj Bypass (District Prayagraj) and which will have restricted access, is of itself unlikely to cause the generation of much locally-based traffic. There are, however, two elements of generated traffic that should be considered:

(a) *increase in traffic will occur from Expressway development purposely located close to interchanges* – such developments, while possibly substantial, are, however, notoriously difficult to predict – the best approach has therefore been to test the effect on Economic Internal Rate of Return (EIRRs) of the assumption that the growth in traffic (***will be proportionate to growth of the population/migration in the Interchange Node areas***) during the first five years of the Project, increases by an additional 1% per year (*factored over the development period*) as a direct result of the Project and that this additional traffic, on average, will use any section of the proposed Expressway to access its destination.

(b) *Varanasi Multi Modal Terminal or Varanasi Port* - One very important generator of traffic, that also needs special mention will be the Varanasi Port[2] towards (about 120 Kms away from Prayagraj) on the Southern End of the proposed Expressway. The timing of this project, featuring prominently on the centre's development plans, accentuates need of an access controlled highway (*probably phase 2 of the Ganga Expressway*) connecting the proposed Expressway to the Varanasi port. Noting that inland waterways offer significant economic advantages compared to overland logistics in India, with average cost of moving one ton of cargo by ship/waterways estimated at Rs. 1.10 per km versus Rs. 1.41 per km by Train/railways and Rs. 2.28 per km by Truck. Nonetheless, it can be stated that:

(i) when *Phase 2 of Ganga Expressway* is constructed by the State or Centre/MoRTH, the Varanasi Port will be a direct generator (and, from the land side development (*about 150 ha. of land parcel-sweetner under the port based special economic zone (SEZ development*) induced to locate around the Varanasi Port site, also an indirect generator of large volumes of road traffic – though the extent of such generation remains unknown; and

(ii) most of the traffic generated will be out of the Meerut/Prayagraj and, thus, large volumes that have origins and destinations far outside the Meerut/Prayagraj might be induced to use the Expressway as it is presently conceived (in this regard, **a direct Expressway from Meerut to Prayagraj Bypass and to the Varanasi Port** would carry more port related traffic – such a Expressway, more usefully, serving destinations on the outskirts of the Uttar Pradesh State as well).

In/Out Bound Heavy Vehicle Traffic of Varanasi Port: The cargo handling capacity of the Varanasi port or multi modal terminal is estimated to be 1.2 million metric tons per year (MTPA), i.e. about 3287 TEUS (Twenty Foot Equivalent Unit) or roughly about 150 Trucks per day would be handled at Varanasi Port; most of which will access NH 19 (old NH2) from the northern direction, as the Varanasi Port traffic on southern side would be through waterways to reach Kolkata Port/Haldia Port. About 50% of these may use the proposed Expressway (from Node M to Node R).

It should finally be noted that the Centre/MoRTH is only ever prepared to invest funds in such capital intensive projects, to take into account revenues about which they are absolutely certain – i.e. deriving from either existing traffic or from land parcels/developments that are: clearly committed; for which financing has already been arranged; and/or for which construction is about to commence or under construction. It has, therefore, deemed appropriate to include the benefit from the development of Varanasi Port in both the economic or financial analyses.

[2] **Varanasi Multi-Modal Terminal** or **Varanasi Port** is an Inland river port situated in the city of Varanasi, Uttar Pradesh. The port is located on the River Ganga. This port is built under the central government's **Jal Marg Vikas** project. The port has provided a direct link with the Port of Kolkata and Haldia Port

4.4.3 Base Estimates of Tollable Traffic (2020) Section-by-Section for Proposed Expressway

The base year (2020) estimates of total traffic on each section of the Expressway are shown on Table 4.24.

Table 4.24: Base Estimates of Tollable Traffic (2020) Section including Varanasi Port bound Traffic

Section	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K	K-L	L-M	M-N	N-O	O-P	P-Q	Q-R
Car	854	911	950	893	943	988	999	866	1143	1208	1170	1077	1121	1076	1103	1287	1237
Bus	141	190	207	201	204	221	182	171	198	201	203	197	221	183	173	211	203
LCV	304	369	428	421	449	457	474	395	552	602	562	444	490	574	542	567	556
2 Axle Truck	332	416	439	439	476	476	547	519	633	628	639	582	594	498	436	458	458
3 Axle Truck	696	819	901	901	945	945	1004	999	1128	1183	1155	1084	***1121***	***953***	***803***	***799***	***799***
Multi Axle Truck	1817	1949	2015	2011	2060	2060	2210	2204	2348	2365	2358	2330	2135	1942	1817	1826	1826
Total Vehicles (Nos.)	**4144**	**4654**	**4939**	**4864**	**5077**	**5148**	**5417**	**5156**	**6003**	**6186**	**6088**	**5712**	5681	5226	4874	5147	5079
Total Vehicles (PCUs)	**12,995**	**14,510**	**15,298**	**15,193**	**15,764**	**15,874**	**16,856**	**16,449**	**18,416**	**18,787**	**18,617**	**17,811**	**17,269**	**15,577**	**14,329**	**14,755**	**14,667**

Note: Data may not add up to the total due to rounding.

50% of all commercial vehicles (3-Axle Truck) assumed to handle Port bound traffic at Varanasi may use stretch between Node R (Prayagraj Bypass) and Node M (Agra Lucknow Expressway)

4.4.4 Capacity Constraints

The Indian recommended design service volumes (DSV) of expressways for Level of Service B (LoS-B) and peak hour traffic in the range of 6% (actual peak hour traffic on the project highway is likely to be lower – no more than 6%) for plain terrain shall be 1300 PCU/hr/lane are shown below (source: IRC SP: 99-2013), viz Table 4.25:

Table 4.25: Design Service Volume (DSV) in PCUs per day for Level of Service (LOS) B

Peak Hour	4-Lane	6-Lane	8-Lane
6%	86,000	1,30,000	1,73,000
8%	65,000	98,000	1,30,000

It can be seen from Table 4.26 that the lane requirement for the Base Estimates of Traffic (2020) for all sections is two lane configurations.

Table 4.26: Lane Requirement at DSV for LOS B for Proposed Expressway (2020)

Sections	Base Traffic (PCUs)	Peak Hour (6%)	Peak Hour (8%)
A-B	12,995	780	1040
B-C	14,510	871	1161
C-D	15,298	918	1224
D-E	15,193	912	1215
E-F	15,764	946	1261
F-G	15,874	952	1270
G-H	16,856	1011	1348
H-I	16,449	987	1316
I-J	18,416	1105	1473
J-K	18,787	1127	1503
K-L	18,617	1117	1489
L-M	17,811	1069	1425
M-N	17,269	1036	1382
N-O	15,577	935	1246
O-P	14,329	860	1146
P-Q	14,755	885	1180
Q-R	14,667	880	1173

Note: DSV of 1300 PCU/h/lane has been considered

For the purposes of Development Proposal of Expressway, the lane configuration requirement shall be carried for a forecasted traffic for a 25 Year period from year 2024 (*year of start of traffic operations on the Expressway*), i.e. 3 year (36 months) construction period and 20 year operations period (for 20 year design)

4.5 Traffic Growth

4.5.1 Vehicular Registration

Data showing growth in numbers of registered vehicles throughout Uttar Pradesh is provided on Table 4.27. It can be seen that the decadal and recent annual growth in:

(a) the *"all-vehicle"* fleet has been:
- 11.61% per year from 2000 to 2015;
- 11.53% per year from 2005 to 2015; and
- 10.65% per year from 2010 to 2015

(b) the truck fleet (goods vehicles) has been:
- 12.93% per year from 2000 to 2015;
- 11.83% per year from 2005 to 2015; and
- 7.21% per year from 2010 to 2015

(c) the motor-car fleet (passenger vehicles) has been:
- 9.23% per year from 2000 to 2015;
- 11.88% per year from 2005 to 2015; and
- 6.62% per year from 2010 to 2015,

it may be noted that the annual growth last year of motor-car fleet has been about 13.5%;

(d) the two-wheeler fleet has been:
- 12.71% per year from 2000 to 2015;
- 11.54% per year from 2005 to 2015; and
- 12.10% per year from 2010 to 2015

Table 4.27: Vehicle Registration Data in Uttar Pradesh

Year	Motor Cycle	Motor Car	Bus	Mini Bus	Truck	Wheel Delivery	Tractor	Tempo / Auto Rickshaw	Others	Total
1	2	3	4	5	6	7	8	9	10	11
1980-81	41401	3810	1242	-	5591	-	14146	-	5112	71302
1981-82	-	-	-	-	-	-	-	-	-	0
1982-83	57393	4019	1587	-	5222	-	12216	-	4311	84748
1983-84	71136	3625	1862	250	2776	529	13364	1714	3209	98465
1984-85	85004	4256	2194	117	3634	433	13835	2792	4095	116360
1985-86	92711	6111	1187	116	4396	370	15222	2601	4257	126971
1986-87	140014	8081	1747	157	4117	455	18644	2474	4657	180346
1987-88	160370	12123	1640	238	5324	532	19435	3295	2024	204981
1988-89	149013	9768	1611	208	5648	571	25586	5023	1858	199286
1989-90	179676	10358	1574	264	6994	974	27176	6692	6141	239849
1990-91	187436	11104	1209	633	8056	1314	35933	7337	2922	255944
1991-92	173703	10009	1198	367	6411	1472	36289	6847	2722	239018
1992-93	128816	6973	1521	1104	3706	709	27506	3974	4102	178411
1993-94	152398	11687	1213	889	3713	911	28175	4179	3848	207013
1994-95	167258	12200	1493	1092	5953	1156	30467	4811	3468	227898
1995-96	168676	13978	1400	763	7310	2093	28450	5083	6686	234439
1996-97	230933	27309	1146	588	10581	3659	34718	10796	11162	330892
1997-98	254225	28985	1813	730	9593	3112	39311	10145	8439	356353
1998-99	325793	33197	1244	814	9282	3837	52650	10698	12882	450397
1999-00	329633	42766	1575	1031	8312	3921	51286	10934	10897	460355
2000-01	406216	39840	1450	1439	7202	4817	84141	11933	7625	564663
2001-02	364839	64241	730	745	3619	2325	38750	6927	16550	498726
2002-03	552378	43827	1452	1005	7051	3531	40715	9546	9912	669417
2003-04	585013	47189	1182	910	13259	3766	39421	11302	8773	710815
2004-05	665589	52311	1223	942	16827	4260	42714	9691	9130	802687
2005-06	769183	60090	1570	1209	17825	5216	52705	12627	14364	934789
2006-07	773478	71213	1565	1206	22895	4909	45173	20235	16189	956863
2007-08	748731	81158	1402	1080	24590	5282	41338	14078	21894	939553
2008-09	831946	92423	1910	1471	23529	5789	46219	21404	24928	1049619
2009-10	1120748	116706	2628	2024	36353	6620	80123	34034	42809	1442045
2010-11	1269550	127116	3097	2385	43474	7112	83287	34480	42814	1613315
2011-12	1368524	134580	2753	2120	50178	7766	73513	38374	50068	1727876
2012-13	1455867	140549	3594	2768	61370	5712	77972	38254	68556	1854642
2013-14	1713375	141646	3709	2858	53105	6099	87315	32062	58829	2098998
2014-15	1653456	134004	2804	2161	42905	4306	78991	26359	47814	1992800
Total (Lakhs)	**173.75**	**16.07**	**.59**	**0.33**	**5.40**	**1.04**	**14.36**	**4.21**	**5.43**	**221.20**
Population	215609813									
Ownership%	**8.06**	**0.75**	**0.03**	**0.02**	**0.25**	**0.05**	**0.67**	**0.20**	**0.25**	**10.26**

Source: Annual Report of Transport Department, Govt. of Uttar Pradesh

4.5.2 Regional Influences on Traffic Growth

The findings from the economic profile of the project influence areas and the data contained herein are highly relevant to forecasts for future traffic growth, viz:

(a) *freight:* the majority of *"candidate"* road freight is agricultural (often perishable) goods and goods destined for the secondary, manufacturing and construction sectors; and goods for the non-agricultural primary sector (mining and quarrying) etc. and bulk products for the secondary sector travel mainly by rail (see below) – and goods for the tertiary sector (mainly service industries) are light and while, no doubt most are travelling by road, these do not contribute significantly to total *"candidate"* road freight traffic (see Appendix for the commodity distribution by freight traffic)

(b) *passenger:* most *"candidate"* passenger travel is by persons with incomes much higher than the average (even when those persons are travelling by bus) – the average income of car passengers is half the national average and the average income of bus passengers about a quarter of the national average; in Uttar Pradesh total vehicle ownership is only 10.26 per 100 head of population; and car ownership is only 0.75 per 100 head of population (see Table 4.27) – which data implies that there is much scope for growth in this sector.

Consequently, it better to believe that future growth in:

(a) *candidate freight traffic:* might reasonably be linked to growth in the *"NSDP"* of those regional and State economies which are presently contributing candidate traffic; and

(b) *candidate passenger traffic*: might reasonably be linked to two factors in combination:

- growth in the *"populations"* (P) of those regional and State economies which are presently contributing *"candidate"* traffic; and

- growth in the *"average per capita incomes"* (I) of those regional and State economies which are presently contributing *"candidate"* traffic.

Recent growth in three indices for the above and for each of regions and States that contribute *"trip-ends"* for *"candidate"* traffic are shown on Tables 4.28.

Table 4.28: Zonal Influence Factors (%)

State Name	Car	Bus	LCV	2-Axle Truck	3-Axle Truck	Multi-Axle Truck
Uttar Pradesh	94.36 %	84.20%	94.08%	84.95%	74.55%	56.82%
Assam	0.08%	-	0.13%	0.23%	0.05%	0.06%
Bihar	0.51%	-	1.16%	0.94%	3.02%	5.94%
Chandigarh	0.04%	-	0.18%	0.00%	0.43%	0.19%
Chattisgarh	-	0.19%	0.28%	0.47%	0.87%	4.84%
Himachal Pradesh	0.06%	-	0.23%	0.28%	0.36%	1.08%
Haryana	0.43%	0.47%	0.63%	3.08%	3.91%	6.42%
Jharkhand	0.35%	-	-	0.17%	0.11%	1.81%
Maharashtra	-	-	-	-	0.24%	0.41%
Madhya Pradesh	0.03%	-	-	0.57%	0.87%	0.35%
New Delhi	1.60%	7.94%	1.65%	3.34%	2.85%	3.42%
Orissa	0.07%	-	0.00%	0.10%	0.41%	0.32%
Punjab	0.25%	-	0.68%	1.19%	4.85%	10.84%
Rajasthan	-	-	-	-	-	0.08%
Telangana	0.12%	-	-	-	-	-
Uttarakhand	1.99%	6.80%	0.84%	3.76%	6.24%	6.27%
West Bengal	0.12%	0.40%	0.13%	0.90%	1.25%	1.15%

From the zonal influence factors, it is clear that the growth rate of passenger car and bus (public transport) shall be regressed with growth of per capita income and growth of population of states of Uttar Pradesh and its neighbouring states respectively – results are shown on Table 4.29 and Table 4.30

On the Table 4.29 and 4.30, a weighted average for each of these indices has been derived and in the case of passenger traffic, the *"growth in car traffic"* was correlated against the *"growth in relevant per capita incomes"* and for bus traffic *multiplied by the growth in relevant populations"*.

In the case of freight, the *"growth in freight traffic"* correlated against the weighted average for *"NSDP"* as shown on Table 4.31.

Table 4.29: Regression Co-efficient of Car Growth with Per Capital Income of Project Influence Areas

State / Union Territory	Regression Variables	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	Growth Rate (2012-19)	Regression Co-efficient (Elasticity Value)	R Square	t-stat	Factored Growth	Zone Influence Factors	Weighted Growth Rate
Assam	Cars	318627	366884	445177	539920	578122	582024	676337	734778	**12.68%**	1.87	0.86	6.06	9.78%	0.08%	**0.01%**
	PCI	41142	41609	43002	44809	50642	53745	57099	58833	**5.24%**						
Bihar	Cars	256346	297507	346120	390770	434258	482962	526792	572163	**12.15%**	2.13	0.85	5.75	10.66%	0.51%	**0.05%**
	PCI	21750	22201	22776	23223	24064	25825	28101	30617	**5.01%**						
Haryana	Cars	988958	1134514	1293065	1454182	1609544	1764448	1920484	2076589	**11.18%**	1.55	0.98	16.10	10.52%	0.43%	**0.05%**
	PCI	106085	111780	119791	125032	137748	148193	157649	168209	**6.81%**						
Himachal Pradesh	Cars	162723	209116	234788	265384	297514	332505	364808	397514	**13.61%**	1.86	0.97	13.79	12.18%	0.06%	**0.01%**
	PCI	87721	92672	98816	105241	112723	122208	128840	136881	**6.56%**						
Jharkhand	Cars	557932	627945	563713	248949	282929	332671	332671	332671	**7.52%**	0.79	0.35	1.26	3.19%	0.35%	**0.01%**
	PCI	41254	44176	43779	48781	44524	48826	54246	57157	**4.04%**						
Madhya Pradesh	Cars	526970	598810	686456	767032	871334	925644	1018526	1101141	**11.10%**	1.66	0.95	10.86	10.30%	0.03%	**0.00%**
	PCI	38551	41287	42778	44336	47763	53253	55677	58706	**6.19%**						
Odisha	Cars	247575	287183	328836	367217	412257	460486	498408	540641	**11.80%**	1.66	0.93	8.72	10.71%	0.07%	**0.01%**
	PCI	48370	50714	54109	54210	57592	66240	69864	74927	**6.45%**						
Punjab	Cars	554699	583850	605714	627577	649441	671304	695597	718502	**3.77%**	0.82	0.99	21.21	3.66%	0.25%	**0.01%**
	PCI	85577	88915	93238	95807	100141	105848	110834	116222	**4.47%**						
Telangana	Cars	0	0	797546	885318	976312	1145108	1234491	1347859	**11.07%**	1.28	0.98	16.17	11.00%	0.12%	**0.01%**
	PCI	91121	92732	96039	101424	112267	121568	132380	145082	**8.60%**						
Uttar Pradesh	Cars	1208699	1367795	1523603	1779146	2161533	2435390	2623049	2873626	**13.17%**	2.90	0.96	11.37	12.59%	94.36%	**11.88%**
	PCI	32002	32908	34044	34583	36923	38965	41082	43102	**4.35%**						
Uttara khand	Cars	177363	223329	267432	304674	340644	345318	399356	434469	**13.65%**	1.85	0.93	8.96	11.90%	1.99%	**0.24%**
	PCI	100305	106318	112803	118788	126952	138286	147204	155151	**6.43%**						
West Bengal	Cars	572466	2573013	991981	1063592	1137056	1187057	1237058	1287059	**12.27%**	0.63	0.03	0.46	3.24%	0.12%	**0.00%**
	PCI	51543	53157	53811	54520	57255	60618	65497	73202	**5.14%**						
Chandigarh	Cars	268410	290075	313792	248187	265660	291356	277168	276479	**0.42%**	0.01	0.00	0.04	0.05%	0.04%	**0.00%**
	PCI	159116	169492	180779	183029	195595	210405	232116	235167	**5.74%**						
Delhi	Cars	2258434	2303052	2547877	2691282	2859620	3009234	3168294	3327354	**5.69%**	0.95	0.98	18.73	5.73%	1.60%	**0.09%**
	PCI	185361	193175	202216	215726	235737	247255	262682	279601	**6.05%**						
														Car Traffic Growth Rate for FY 2020		**12.37%**

Source: Transport Research Wing Ministry of Surface Transport & National Statistical Office (NSO)
Note: PCI - Per Capita Income (in Rs.) are at 2011-12 Constant Prices as Independent Variable & Cars (no. of registered vehicles) as Dependent Variable

Table 4.30: Regression Co-efficient of Bus Growth with Population of Project Influence Areas

State / Union Territory	Regression Variables	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	Growth Rate (2012-19)	Regression Co-efficient (Elasticity Value)	R Square	t-stat	Factored Growth	Zone Influence Factors	Weighted Growth Rate
Chhattisgarh	Bus	8596	12049	13071	48501	52783	58026	72649	84214	**12.40%**	28.01	0.89	7.04	35.41%	0.19%	**0.07%**
	Population	24258	24585	24909	25232	25555	25879	26186	26488	**3.76%**						
Haryana	Bus	35646	39153	42800	45893	50207	53348	56984	60549	**11.18%**	5.04	1.00	48.32	7.60%	0.47%	**0.04%**
	Population	25439	25854	26266	26675	27079	27477	27868	28253	**6.81%**						
Uttar Pradesh	Bus	31922	34428	40501	45607	51866	57939	62461	67818	**13.17%**	6.97	0.99	29.10	11.36%	84.20%	**9.56%**
	Population	200764	204250	207739	211217	214671	218088	221469	224829	**4.35%**						
Uttarakhand	Bus	8066	8504	8997	9962	10716	7736	9592	9762	**13.65%**	1.46	0.17	1.11	1.90%	6.80%	**0.13%**
	Population	9943	10084	10224	10362	10499	10632	10761	10887	**6.43%**						
West Bengal	Bus	34184	35603	51660	53899	56878	44771	58066	61466	**12.27%**	8.47	0.65	3.30	7.39%	0.40%	**0.03%**
	Population	89499	90320	91122	91920	92725	93550	94334	95109	**5.14%**						
Delhi	Bus	45757	20142	19912	19590	19695	43723	43615	50768	**5.69%**	2.91	0.20	1.24	8.42%	7.94%	**0.67%**
	Population	8596	12049	13071	48501	52783	58026	72649	84214	**6.05%**						
														Bus Traffic Growth Rate for FY 2020		**10.49%**

Source: Transport Research Wing Ministry of Surface Transport & National Statistical Office (NSO)
Note: Population (in 000') as Independent Variable & Buses (no. of registered vehicles) as Dependent Variable

Table 4.31: Regression Co-efficient of Multi-Axle Truck Growth with NSDP of Project Influence Areas

State / Union Territory	Regression Variables	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Growth Rate (2012-18)	Regression Co-efficient (Elasticity Value)	R Square	t-stat	Factored Growth	Zone Influence Factors	Weighted Growth Rate
Assam	Goods Vehicle	171878	191479	69342	226612	243409	254929	265773	**7.53%**	1.85	0.33	1.58	11.73%	0.06%	**0.01%**
	NSDP	129354	132518	138725	146425	167629	175745	186992	**6.33%**						
Bihar	Goods Vehicle	73472	83191	103211	109010	123744	141242	152276	**12.91%**	1.96	0.89	6.47	12.29%	5.94%	**0.73%**
	NSDP	228497	236933	246915	255739	268333	294890	328824	**6.25%**						
Chhattisgarh	Goods Vehicle	127610	141441	155981	171840	186960	204692	218537	**9.38%**	1.52	0.97	13.41	9.27%	4.84%	**0.45%**
	NSDP	142273	148760	163494	165418	175362	190841	203174	**6.12%**						
Haryana	Goods Vehicle	389546	417632	445020	479951	516633	550506	580221	**6.87%**	0.91	0.99	27.37	6.98%	6.42%	**0.45%**
	NSDP	271152	289414	314224	331413	361231	392729	422969	**7.69%**						
Himachal Pradesh	Goods Vehicle	99294	96855	128017	136760	143008	144977	162380	**8.54%**	1.22	0.89	6.32	8.69%	1.08%	**0.09%**
	NSDP	60536	64519	69398	74553	80563	86186	91593	**7.15%**						
Jharkhand	Goods Vehicle	35330	39389	41242	105786	117759	158508	174557	**30.51%**	6.03	0.86	5.48	31.03%	1.81%	**0.56%**
	NSDP	137383	149526	150609	170568	158231	177622	185623	**5.14%**						
Madhya Pradesh	Goods Vehicle	195627	217618	242811	263039	297188	374592	380522	**11.73%**	1.56	0.99	23.37	12.16%	0.35%	**0.04%**
	NSDP	282371	306853	322598	339247	369929	417903	443183	**7.80%**						
Maha rashtra	Goods Vehicle	973788	1067825	1142091	1273256	1360214	1396713	1514610	**7.64%**	1.01	0.95	10.28	7.29%	0.41%	**0.03%**
	NSDP	1126595	1189711	1267538	1345388	1454411	1598422	1712905	**7.23%**						
Odisha	Goods Vehicle	219691	239749	267615	285887	303035	324105	346367	**7.88%**	1.12	0.95	9.95	7.61%	0.32%	**0.02%**
	NSDP	204226	216301	233122	235935	255713	282775	302909	**6.79%**						
Punjab	Goods Vehicle	169553	201758	201758	201758	201758	352427	312939	**10.75%**	1.97	0.74	3.77	11.07%	10.84%	**1.20%**
	NSDP	239227	251813	267515	278485	294895	314402	332072	**5.62%**						
Rajasthan	Goods Vehicle	385796	431537	478379	467758	564152	617367	645339	**8.95%**	1.34	0.95	9.67	8.60%	0.08%	**0.01%**
	NSDP	395331	409802	434292	465599	498138	535208	573628	**6.40%**						
Uttar Pradesh	Goods Vehicle	307058	338977	400061	467786	511631	562503	617627	**12.35%**	2.07	0.95	9.50	11.89%	56.82%	**6.75%**
	NSDP	645132	673552	707469	729686	790993	846834	901353	**5.73%**						
Uttara khand	Goods Vehicle	39169	50456	52098	58232	62789	84657	84957	**13.77%**	1.84	0.94	8.78	12.98%	6.27%	**0.81%**
	NSDP	101960	109529	117777	125702	136144	143975	153601	**7.07%**						
West Bengal	Goods Vehicle	248776	281995	436839	468719	495790	407229	536444	**13.66%**	1.92	0.51	2.29	10.09%	1.15%	**0.12%**
	NSDP	473205	492901	503952	515702	546988	590958	642999	**5.24%**						

State / Union Territory	Regression Variables	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	Growth Rate (2012-18)	Regression Co-efficient (Elasticity Value)	R Square	t-stat	Factored Growth	Zone Influence Factors	Weighted Growth Rate
Chandigarh	Goods Vehicle	24331	25704	27077	29416	30031	30668	34572	**6.03%**	0.81	0.95	9.42	5.62%	0.19%	**0.01%**
	NSDP	16930	18305	19813	20353	22296	23681	25331	**6.95%**						
Delhi	Goods Vehicle	242331	129339	131715	142203	153406	281159	207708	**9.94%**	0.64	0.13	0.86	5.26%	3.42%	**0.18%**
	NSDP	314650	334193	356528	388183	429149	465770	503507	**8.54%**						
													Multi Axle Truck Traffic Growth Rate for FY 2020		**11.47%**

Source: Transport Research Wing Ministry of Surface Transport & National Statistical Office (NSO)
Note: NSDP– Net State Domestic Product (in Crores) are at 2011-12 Constant Prices as Independent Variable & Goods Vehicle (no. of registered vehicles) as Dependent Variable.

Elasticities were then derived. In the case of freight, the weighted average elasticity of MAVs is 1.94 and, in the case of passengers the average elasticity is 2.80, in case of bus the average elasticity is 6.31 – implying that:

(a) growth in freight travel is growing faster than growth in the *"NDSP"* of the regional and State economies which presently contribute candidate traffic; and

(b) growth in passenger travel is growing faster than growth in the *"per capita incomes"* of the regional and State economies which presently contribute candidate traffic.

(c) growth in bus travel is growing faster than growth in the *"populations"* of the regional and State which presently contribute candidate traffic.

The weighted average elasticites changes for LCVs, 2-Axle Trucks and 3-Axle Trucks change marginally from weighted average elasticies of 1.94 obtained for MAVs because of change in project influence area factors, as 2.03, 1.98 and 1.98 respectively

This is, as expected, and typical of developing economies that, like Uttar Pradesh and the rest of India, are experiencing a surge in economic growth. The elasticity can however be expected to fall with time. The *"best estimate"* forecasts for traffic, which assume continued growth in the *"NSDP"* sectors and in *"per capita incomes"* at projected rates and a convincing increase in average loads caused by the use of greater numbers of larger trucks, and an improvement in load factors, refer Appendix for year wise projections for *"NSDP"* and *"per capita incomes"*.

The growth in multi-axle vehicles (which are mainly articulated MAVs) is assumed to be 0.25% per annum higher than those of LCVs. There is relatively higher number of multi-axle vehicles amongst the candidate vehicles. The experience of almost all other developing countries at a similar stage of development has been for a major growth in these vehicles types – particularly when nascent expressway systems across the country are being developed.

During the last few years growth in real incomes started raising above growth in per capita GDP – it is expected that over the next decade that trend should continue. Also during the last few years growth in population is falling behind growth – it is expected that over the next few decade that trend should reduce)

These growth rates may initially seem high (*additional 1% per year factored for induced traffic as a direct result of the Project*) and, over the next twenty five years, are consistent with: a 7.5 fold increase in *"candidate"* freight traffic; a 12.4 fold increase in car traffic (*implying car ownership of still only about 0.75 per 100 head of population*) and a 6.0 fold increase in bus passengers. These are not unreasonable expectations.

Summary of annual growth rate for vehicles during the development period of the expressway and further 25 year Horizon is shown in Table 4.32.

Table 4.32: Annual Growth Rates for Vehicles Development Period & further 25 Year Horizon

Year	Cars	All Buses	LCV	2-Axle Trucks	3-Axle Trucks	MAV (4+ axles)
FY 2021	12.31%	10.24%	11.66%	11.49%	11.41%	11.41%
FY 2022	12.24%	9.99%	11.37%	11.20%	11.13%	11.13%
FY 2023	12.17%	9.75%	11.07%	10.92%	10.85%	10.85%
FY 2024	12.08%	9.51%	10.79%	10.65%	10.58%	10.57%
FY 2025	11.98%	9.26%	10.50%	10.38%	10.31%	10.30%
FY 2026	11.87%	9.02%	10.22%	10.11%	10.05%	10.04%
FY 2027	11.76%	8.79%	9.95%	9.85%	9.79%	9.78%
FY 2028	11.63%	8.55%	9.68%	9.59%	9.54%	9.52%
FY 2029	11.49%	8.31%	9.41%	9.33%	9.29%	9.27%
FY 2030	11.35%	8.08%	9.15%	9.08%	9.04%	9.02%
FY 2031	11.19%	7.85%	8.89%	8.83%	8.80%	8.78%
FY 2032	11.03%	7.62%	8.63%	8.59%	8.55%	8.54%
FY 2033	10.86%	7.40%	8.38%	8.34%	8.32%	8.30%
FY 2034	10.67%	7.17%	8.13%	8.11%	8.08%	8.07%
FY 2035	10.48%	6.95%	7.88%	7.87%	7.85%	7.83%
FY 2036	10.28%	6.73%	7.63%	7.63%	7.62%	7.60%
FY 2037	10.07%	6.51%	7.39%	7.40%	7.39%	7.38%
FY 2038	9.84%	6.29%	7.15%	7.17%	7.17%	7.15%
FY 2039	9.61%	6.07%	6.91%	6.95%	6.95%	6.93%
FY 2040	9.37%	5.86%	6.68%	6.72%	6.73%	6.71%
FY 2041	9.12%	5.65%	6.44%	6.50%	6.51%	6.50%
FY 2042	8.86%	5.44%	6.21%	6.28%	6.29%	6.28%
FY 2043	8.59%	5.23%	5.98%	6.06%	6.08%	6.07%
FY 2044	8.31%	5.02%	5.75%	5.84%	5.87%	5.86%
FY 2045	8.02%	4.82%	5.53%	5.62%	5.66%	5.65%

Given the uncertain nature of traffic forecasting, for financial analysis sensitivity purposes, assumptions are:

(a) low or pessimistic growth rates of 0.9 times these values; and

(b) high or optimistic growth rates of 1.1 times these values.

This is in line with normal practice in such situations.

4.5.3 Traffic Projections

Base Estimates of Tollable Traffic (2020) section by section of proposed Expressway as shown in Table 4.24 have been projected by assigning the above annual growth rates for the corresponding periods – results are shown in Tables 4.33 to 4.35

Table 4.33: Traffic Forecast (FY 2025) Section by Section of Proposed Expressway

Sections	Cars	All Buses	All LCVs	2-Axle Trucks	3-Axle Trucks	MAV (4-6axles)	Total Traffic Nos.	Total Traffic PCUs.
A-B	1515	225	514	558	1165	3042	**7018**	**21816**
B-C	1617	303	624	698	1372	3262	**7875**	**24349**
C-D	1687	330	723	737	1508	3372	**8357**	**25670**
D-E	1584	320	712	737	1508	3366	**8226**	**25490**
E-F	1673	325	759	800	1582	3449	**8588**	**26452**
F-G	1753	353	773	800	1582	3449	**8710**	**26637**
G-H	1773	290	801	919	1681	3699	**9164**	**28293**
H-I	1538	273	669	872	1673	3690	**8714**	**27598**
I-J	2028	316	934	1064	1888	3931	**10160**	**30918**
J-K	2143	320	1018	1054	1980	3958	**10474**	**31546**
K-L	2077	324	950	1073	1933	3948	**10305**	**31257**
L-M	1911	313	750	977	1814	3900	**9665**	**29896**
M-N	1990	352	828	997	1876	3574	**9616**	**28988**
N-O	1909	292	971	836	1595	3250	**8853**	**26161**
O-P	1957	276	916	731	1345	3042	**8267**	**24075**
P-Q	2283	335	959	769	1338	3056	**8740**	**24798**
Q-R	2196	324	940	769	1338	3056	**8622**	**24648**

Note: Data may not add up to the total due to rounding.

Table 4.34: Traffic Forecast (FY 2035) Section by Section of Proposed Expressway

Sections	Cars	All Buses	All LCVs	2-Axle Trucks	3-Axle Trucks	MAV (4-6axles)	Total Traffic Nos.	Total Traffic PCUs.
A-B	4392	484	1219	1316	2739	7145	**17296**	**51992**
B-C	4688	652	1481	1647	3226	7662	**19356**	**57963**
C-D	4890	711	1717	1738	3546	7920	**20523**	**61093**
D-E	4593	689	1689	1738	3546	7905	**20161**	**60619**
E-F	4851	699	1801	1889	3720	8100	**21061**	**62929**
F-G	5083	759	1836	1889	3720	8100	**21387**	**63393**
G-H	5141	625	1902	2169	3954	8688	**22479**	**67336**
H-I	4459	588	1587	2058	3934	8667	**21292**	**65578**
I-J	5880	680	2217	2511	4440	9232	**24959**	**73639**
J-K	6215	688	2416	2488	4657	9297	**25762**	**75178**
K-L	6023	697	2254	2533	4547	9272	**25325**	**74457**
L-M	5542	674	1781	2305	4266	9159	**23727**	**71164**
M-N	5770	757	1966	2353	4412	8393	**23652**	**69056**
N-O	5536	628	2305	1973	3750	7634	**21828**	**62405**
O-P	5675	595	2174	1726	3162	7144	**20477**	**57534**
P-Q	6621	722	2275	1814	3147	7177	**21756**	**59380**
Q-R	6367	697	2231	1814	3147	7177	**21434**	**58986**

Note: Data may not add up to the total due to rounding.

Table 4.35: Traffic Forecast (FY 2045) Section by Section of Proposed Expressway

Sections	Cars	All Buses	All LCVs	2-Axle Trucks	3-Axle Trucks	MAV (4-6axles)	Total Traffic Nos.	Total Traffic PCUs.
A-B	10596	848	2303	2497	5202	13554	**35000**	**100683**
B-C	11310	1141	2797	3126	6127	14533	**39035**	**112088**
C-D	11797	1245	3244	3299	6734	15024	**41343**	**118104**
D-E	11081	1207	3191	3299	6734	14994	**40506**	**117061**
E-F	11703	1224	3403	3583	7066	15366	**42345**	**121572**
F-G	12263	1329	3467	3583	7066	15366	**43075**	**122545**
G-H	12401	1094	3592	4116	7510	16481	**45195**	**130114**
H-I	10756	1029	2998	3904	7471	16440	**42599**	**126448**
I-J	14186	1190	4187	4764	8432	17512	**50271**	**142428**
J-K	14993	1205	4564	4721	8845	17636	**51965**	**145516**
K-L	14529	1220	4257	4806	8636	17587	**51037**	**144047**
L-M	13369	1180	3364	4374	8101	17374	**47763**	**137565**
M-N	13919	1325	3714	4465	8380	15921	**47725**	**133647**
N-O	13355	1100	4354	3745	7123	14482	**44158**	**120957**
O-P	13691	1041	4107	3276	6006	13551	**41672**	**111801**
P-Q	15972	1264	4298	3443	5977	13614	**44567**	**115732**
Q-R	15359	1220	4214	3443	5977	13614	**43828**	**114865**

Note: Data may not add up to the total due to rounding.

4.5.4 Capacity Constraints and Proposed Intervention

The 25 year horizon traffic forecasts (FY 2045) on all sections from Node A to R of the proposed expressway exceeds 86,000[3] PCUs per day, i.e. the requirement is 6-lane requirement and on 5 sections viz. G-H, I-J, J-K, K-L, L-M and M-N, the traffic forecasts (year 2045) exceeds 1,30,000[4] PCUs per day, i.e the requirement is 8-lane requirement.

The projected traffic warrants the following the lane requirement for each section to maintain a design service volume for Level of Service B on the proposed expressway at the years mentioned in Table 4.50

Table 4.50: Lane Requirement to maintain Level of Service B on the Expressway

Sections	4-Lane requirement (threshold 40,000 PCUs)	6-Lane requirement (threshold 86,000 PCUs)	8-Lane requirement (threshold 130,000 PCUs)
A-B	FY 2032	FY 2043	After FY 2045
B-C	FY 2031	FY 2041	After FY 2045
C-D	FY 2030	FY 2040	After FY 2045
D-E	FY 2030	FY 2040	After FY 2045
E-F	FY 2030	FY 2040	After FY 2045
F-G	FY 2030	FY 2040	After FY 2045
G-H	FY 2029	FY 2039	After FY 2045
H-I	FY 2029	FY 2039	FY 2045
I-J	FY 2028	FY 2038	FY 2044
J-K	FY 2028	FY 2037	FY 2044
K-L	FY 2028	FY 2037	FY 2044
L-M	FY 2029	FY 2038	FY 2045
M-N	FY 2029	FY 2039	FY 2045
N-O	FY 2030	FY 2040	After FY 2045
O-P	FY 2031	FY 2041	After FY 2045
P-Q	FY 2031	FY 2041	After FY 2045
Q-R	FY 2031	FY 2041	After FY 2045

Note: DSV of 1300 PCU/h/lane has been considered

[3] the DSV for LOS B on 4-lane (refer Table 4.39)
[4] the DSV for LOS B on 6-lane configuration(refer Table 4.39)

It can be seen that a 6-lane configuration can cater to the forecasted traffic till FY 2043, i.e. (20 year design period/operations period) from start of operations of the Expressway; beyond which, widening of few sections of the Expressway to 8-lane configuration becomes necessary.

Thus, the development proposal for expressway shall be a 6-lane dual carriageway configuration with Structures (Culvets, Underpassess, Flyovers, ROBs) of 8-lane configuration so that road widening (median side) is possible as and when warranted by traffic. Thus the life cycle cost of development of the Expressway is justified.

5. HIGHWAY DESIGN, PROPOSED TYPICAL CROSS-SECTIONS, SERVICE ROADS, ROADSIDE DRAINS & AIR STRIPS

5.1 GEOMETRIC DESIGN

The proposed expressway would be of 6 lanes (expandable to 8 Lanes) and fenced to prevent unauthorized access. The expressway will be fully access controlled and designed for a closed toll system, so except at the ends of the expressway [where it ties or connects back via grade separated interchanges back to existing road networks] the intermediate connectivity/ access will be through grade-separated facilities i.e. interchanges with toll booths. Interchanges will generally be of the "trumpet" and "diamond" shape; in fact, significant connections to the existing network will sometimes require double trumpet layouts (or a trumpet on expressway plus another grade separated interchange of some type on road connected to) where the connection to a National Highway [from the expressway via an interchange on the expressway] itself also has to be grade separated.

5.1.1 Carriageway, Shoulder & Median Width

Carriageway: The expressway will be 6-lane wide. Lane width for each carriageway will be 3.75m width (therefore 3 lanes in each direction = 11.25 m width).

Paved Shoulder: Width of Paved shoulder on outer (left) edge of carriageway will be 3.0 m.

Edge Strip: A paved shoulder [called a right median side edge strip] of 0.75m will be provided on median side [adjacent to inner 3.75m wide carriageway].

Unpaved Shoulder: Width of unpaved shoulder on outer side of paved shoulder will be 2.0 m & towards median, it will be 1.0 m.

Width of median: As a rule 15.0 m wide depressed median will be provided, which includes 0.75m edge strip on both sides.

Typical Cross-Sections have been depicted in **Section 5.3** of this chapter.

5.1.2 Other Geometrical Features

Cross fall/Camber: Unidirectional Cross fall on all bituminous surfaces [such as paved shoulder, carriageways, and median side edge strip] shall be 2.5%. The cross fall for earth shoulders shall be 3.0%.

On horizontal curves, the shoulder on the high side of the supper elevated portion may be with reverse slope from the super-elevated carriageway portion, but ensuring the rate of change between pavement cross slope and outside shoulder is not exceeded by 7%.

Super Elevation: For the upper side, the cross fall variation would be calculated by using a linear function between the non-super-elevated cross fall -2.5% (for the minimum radius without transition curve: R=4000m for a 120kph design speed) and the maximum super-elevation 5% (R=1000m for a 120kph design speed). For the lower side, Cross fall is maintained at 2.5% until the opposite side has reached this cross fall. The change is then applied at the same rate as the opposite side.

Spirals (also known as Clothoid) will be used in the horizontal alignment plan design of Transition curves.

Minimum Radius of Horizontal Curve: The minimum radius of horizontal curve used for the 120 km/h expressway alignment design is 1000m. The minimum radius of horizontal curve where super elevation is not required is 4000m.

Visibility Criteria: The minimum ISD requirements can affect the overall expressway geometry locally on horizontal curves for instance where the outside barrier [both on expressway and bridges] and the median barrier [both on expressway and on bridges] are located relative to the carriageways.

Maximum Longitudinal Grade: Maximum longitudinal grade on the expressway will be 2.5%. Minimum longitudinal grade shall be 0.3% except in exceptional circumstances.

Emergency Crossover: Emergency crossovers [also called median openings in the Guidelines for Expressways] in the expressway median are necessary. These are designed fully paved areas in the median, with demountable median barriers that can only be removed and later replaced by the Operation Company.

They are used for instance during periods of emergency [accident fully blocking one direction and traffic must be temporarily moved to the other direction] and also sometimes for controlled heavy maintenance every few years [like pavement resurfacing or strengthening] when some traffic lanes on the expressway is temporarily switched to the opposite direction carriageway under a controlled traffic management operation (albeit when traffic is moving at any speed the opening widths designed for emergency crossovers are not large enough to easily transfer more than 1 to 2 lanes across due to the horizontal alignment characteristics of the S curve needed).

Spacing of the emergency crossovers adopted in general is 5 km along the mainline with provision on either side of mainline Expressway Interchanges. Crossovers are best located on straight sections where visibility is high. Length of emergency crossovers shall benot less than 20 m (for emergency and for repair/maintenance works). Detachable guard barrier shall be provided at every crossover.

It is necessary to close the full infrastructure of the expressway including the interchanges by fencing; this is necessary for safety reasons. There has to be no cross access to the expressway except via designed crossings as uncontrolled cross access will be extremely dangerous on such a high speed expressway and as the expressway will be a closed toll system facility (so no access apart from through controlled interchanges is to be allowed).

Grade Separation: All Intersections/Junctions will be provided as grade-separated with project expressway.

5.1.3 Proposed Right of Way

It has been proposed to acquire 120 m land for the ROW. Additional land shall be required at the location of interchanges, toll plazas, project facilities etc. as per design and same will be acquired.

5.2 CONSTRUCTION PACKAGING

The development proposal consists of new construction of 6-lane divided carriageway with paved shoulder (Expandable to 8 lanes) on both sides. The project corridor is divided into 12

construction packages as per the details given below in **Table-5.1**: Theproject under consideration is Package-9

Table-5.1 – Construction Package Details of Ganga Expressway

Package No.	Section Details	Chainage (km)		Length
		From	To	
I	From Village Bijoli (Dist. Meerut) to Village-Chandner (Dist. Hapur)	7.900	56.900	49.000
II	From Village-Chandner (Dist. Hapur) to Village-Mirzapur Dugar (Dist. Amroha)	56.900	86.900	30.000
III	From Mirzapur Dugar (Dist. Amroha) to Village-Nagla Barah (Dist. Budaun)	86.900	137.600	50.700
IV	From Village-Nagla Barah (Dist. Budaun) to Village-Binawar (Dist. Budaun)	137.600	189.700	52.100
V	From Binawar (Dist. Budaun) to Girdharpur (Dist. Shahjahanpur)	189.700	236.400	46.700
VI	From Village- Girdharpur (Dist. Shahjahanpur) to Village-Ubariya Khurd (Dist. Hardoi)	236.400	289.300	52.900
VII	From Village-Ubariya Khurd (Dist. Hardoi) to Village-Pandra Lakhanpur (Dist. Hardoi)	289.300	341.700	52.400
VIII	From Village-Pandra Lakhanpur (Dist. Hardoi) to Village-Raiyamau(Dist. Unnao)	341.700	391.900	50.200
IX	From Village- Raiyamau (Dist. Unnao) to Village-Sarso (Dist. Unnao)	391.900	445.000	53.100
X	From Village- Sarso (Dist. Unnao) to Village-Terukha (Dist. Raebareli)	445.000	496.800	51.800
XI	From Village-Terukha (Dist. Raebareli) to Village-Arro (Dist. Pratapgarh)	496.800	548.800	52.000
XII	From Village- Arro (Dist. Pratapgarh) to Village-Judapur Dando (Dist. Prayagraj)	548.800	601.847	53.047
Total				**593.947**

5.3 TYPICAL CROSS_SECTIONS

The chainage wise list of Typical Cross-sections applicable along the project is attached below in **Table-5.2** which is further followed by Typical Cross-Section Figures.

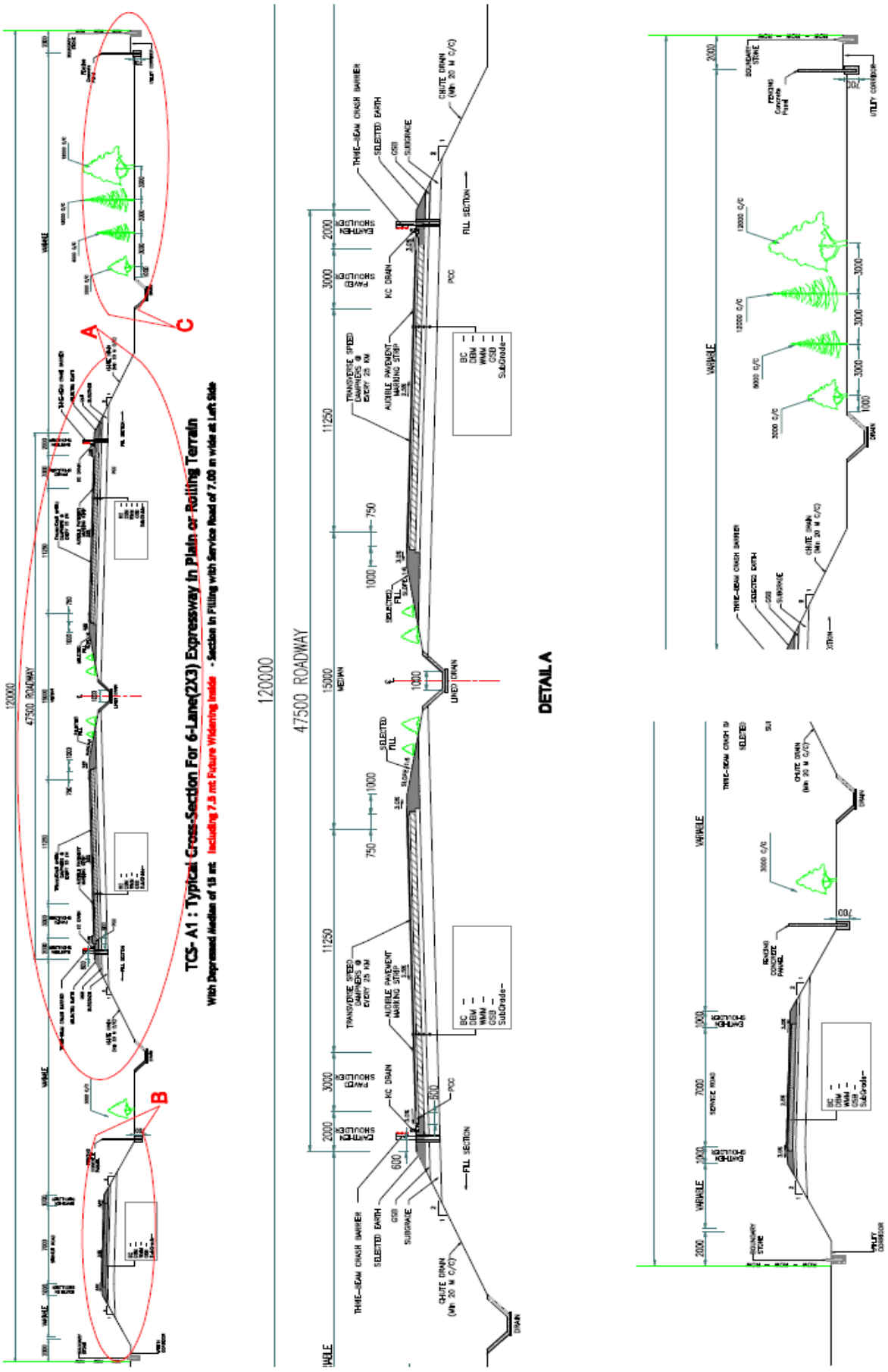
Table-5.2 Typical Cross-Sections along the Project

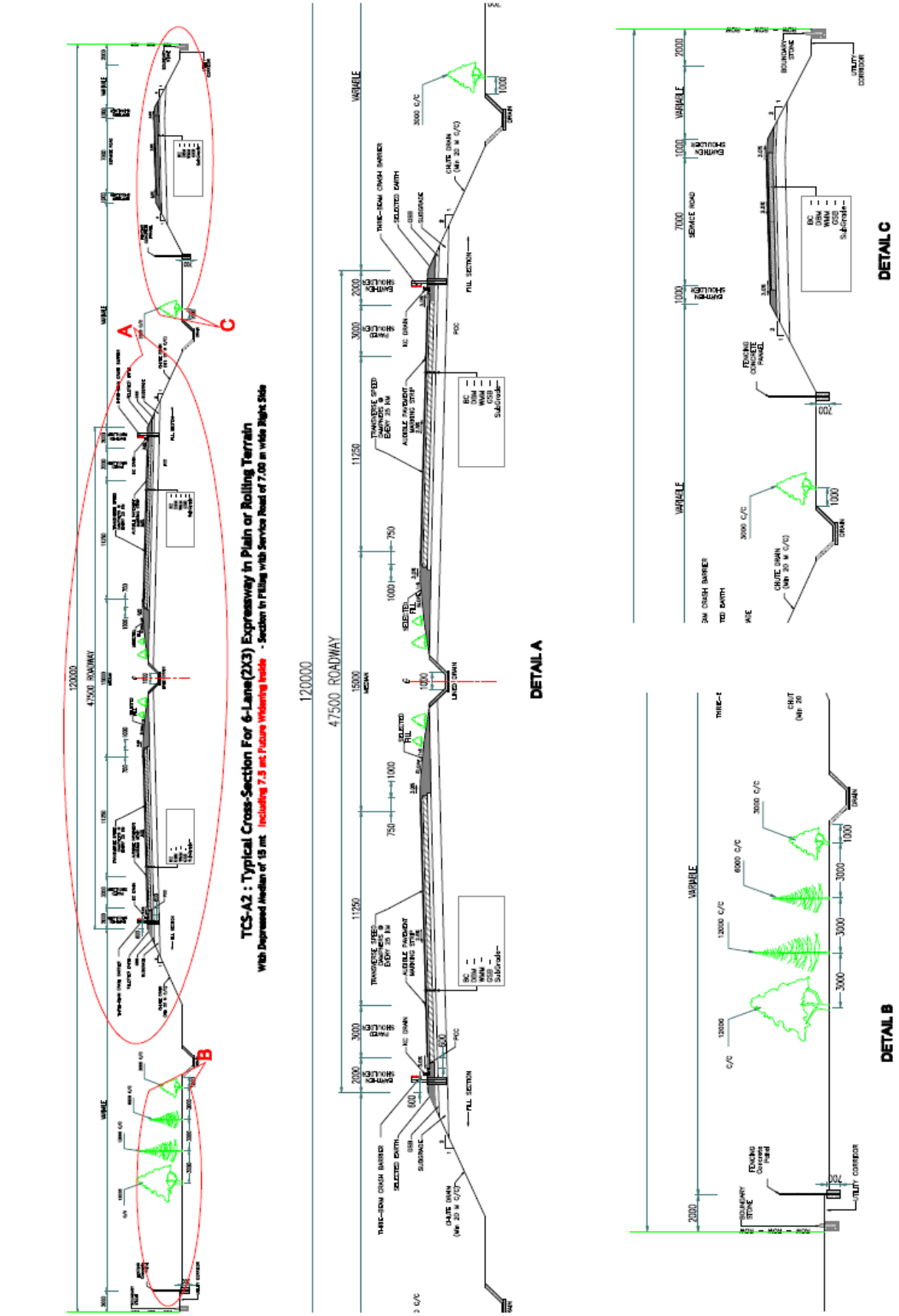
Chainage		Length (Km)	Service Road Width (Km)		Type of C/S	Package No.
From	To		LHS	RHS		
391.900	392.410	0.510	3.75	Nil	B1	Package-9
392.410	392.810	0.400	7.00	Nil	A1	Package-9
392.810	393.240	0.430	3.75	Nil	B1	Package-9
393.240	393.700	0.460	3.75	3.75	B3	Package-9
393.700	393.940	0.240	3.75	Nil	B1	Package-9
393.940	394.340	0.400	7.00	Nil	A1	Package-9

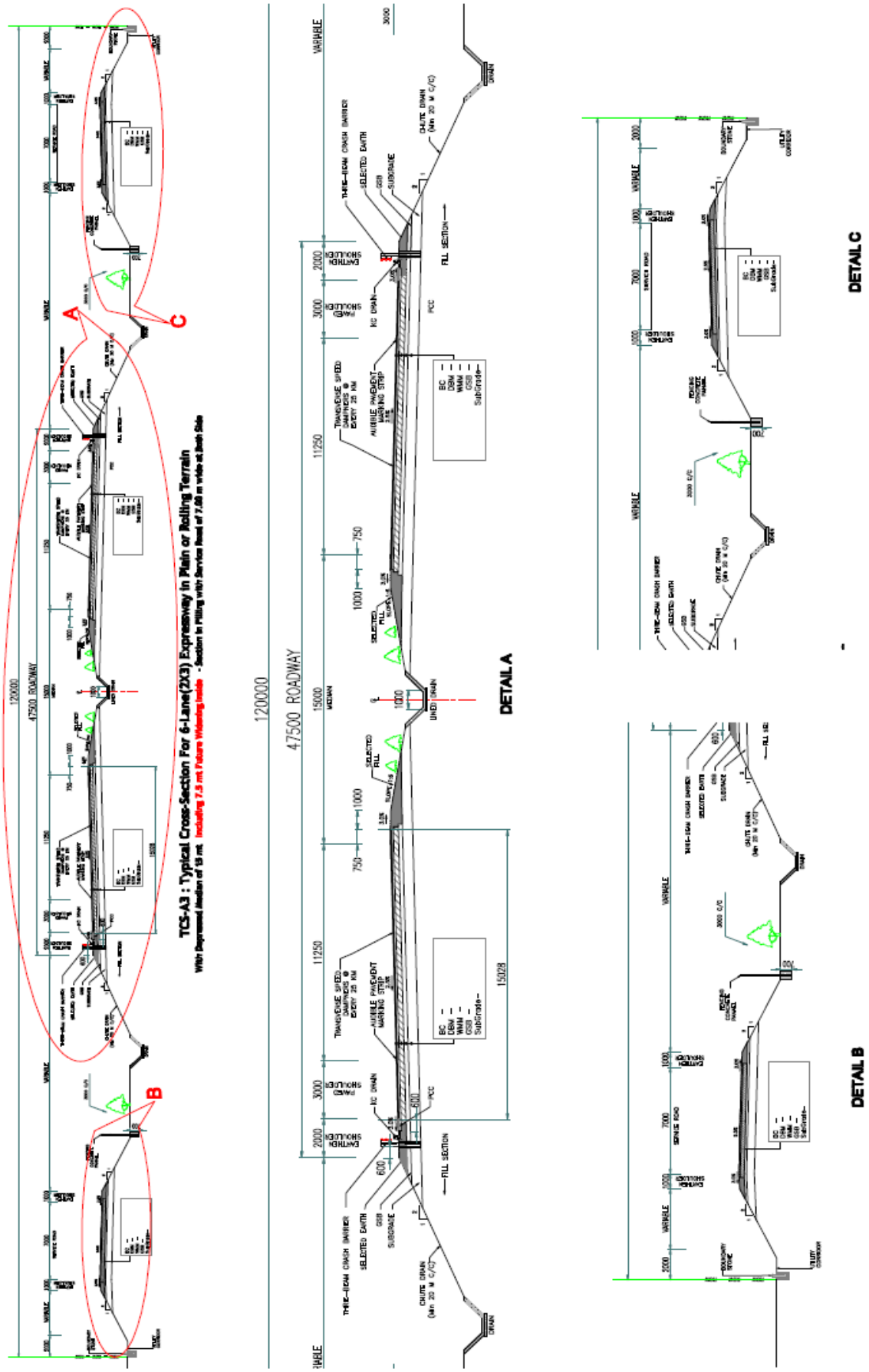
Chainage		Length (Km)	Service Road Width (Km)		Type of C/S	Package No.
From	To		LHS	RHS		
394.340	396.990	2.650	3.75	Nil	B1	Package-9
396.990	397.050	0.060	7.00	Nil	A1	Package-9
397.050	397.120	0.070	7.00	3.75	D	Package-9
397.120	397.390	0.270	7.00	Nil	A1	Package-9
397.390	398.640	1.250	3.75	Nil	B1	Package-9
398.640	399.180	0.540	3.75	3.75	B3	Package-9
399.180	400.950	1.770	Nil	3.75	B2	Package-9
400.950	401.280	0.330	Nil	7.00	A2	Package-9
401.280	401.360	0.080	7.00	7.00	A3	Package-9
401.360	401.750	0.390	3.75	3.75	B3	Package-9
401.750	402.550	0.800	Nil	3.75	B2	Package-9
402.550	402.950	0.400	Nil	7.00	A2	Package-9
402.950	403.850	0.900	Nil	3.75	B2	Package-9
403.850	404.950	1.100	3.75	3.75	B3	Package-9
404.950	406.260	1.310	Nil	3.75	B2	Package-9
406.260	406.840	0.580	3.75	3.75	B3	Package-9
406.840	407.240	0.400	Nil	7.00	A2	Package-9
407.240	408.130	0.890	Nil	3.75	B2	Package-9
408.130	408.530	0.400	Nil	7.00	A2	Package-9
408.530	409.270	0.740	Nil	3.75	B2	Package-9
409.270	409.650	0.380	3.75	3.75	B3	Package-9
409.650	411.530	1.880	Nil	3.75	B2	Package-9
411.530	411.830	0.300	3.75	3.75	B3	Package-9
411.830	413.210	1.380	3.75	Nil	B1	Package-9
413.210	413.620	0.410	3.75	3.75	B3	Package-9
413.620	414.410	0.790	Nil	3.75	B2	Package-9
414.410	414.610	0.200	Nil	7.00	A2	Package-9
414.610	414.810	0.200	7.00	7.00	A3	Package-9
414.810	415.390	0.580	3.75	3.75	B3	Package-9
415.390	417.100	1.710	Nil	3.75	B2	Package-9
417.100	417.790	0.690	3.75	3.75	B3	Package-9
417.790	418.920	1.130	Nil	3.75	B2	Package-9
418.920	419.600	0.680	3.75	3.75	B3	Package-9
419.600	419.710	0.110	3.75	Nil	B1	Package-9
419.710	420.950	1.240	Nil	Nil	C	Package-9
420.950	422.032	1.082	3.75	Nil	A1	Package-9

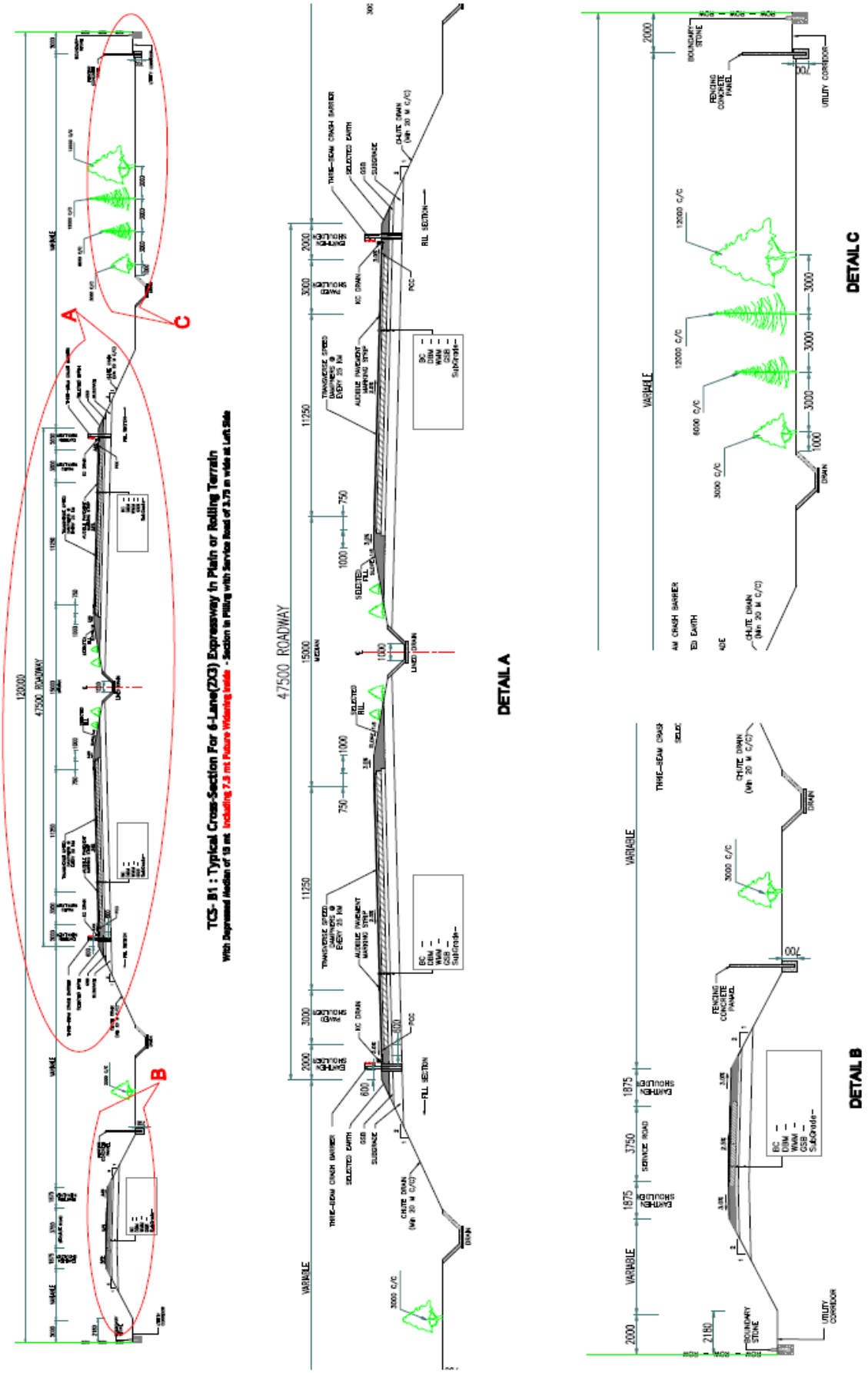
Chainage		Length (Km)	Service Road Width (Km)		Type of C/S	Package No.
From	To		LHS	RHS		
422.032	422.640	0.608	Nil	Nil	C	Package-9
422.640	423.350	0.710	Nil	3.75	B2	Package-9
423.350	423.370	0.020	Nil	Nil	C	Package-9
423.370	428.350	4.980	3.75	Nil	B1	Package-9
428.350	428.750	0.400	7.00	Nil	A1	Package-9
428.750	429.120	0.370	3.75	Nil	B1	Package-9
429.120	430.000	0.880	3.75	3.75	B3	Package-9
430.000	431.017	1.017	3.75	Nil	B1	Package-9
431.017	431.140	0.123	3.75	3.75	B3	Package-9
431.140	431.540	0.400	7.00	3.75	D	Package-9
431.540	432.750	1.210	3.75	3.75	B3	Package-9
432.750	433.410	0.660	3.75	Nil	B1	Package-9
433.410	433.810	0.400	7.00	Nil	A1	Package-9
433.810	435.840	2.030	3.75	Nil	B1	Package-9
435.840	436.240	0.400	7.00	Nil	A1	Package-9
436.240	438.770	2.530	3.75	Nil	B1	Package-9
438.770	439.280	0.510	3.75	3.75	B3	Package-9
439.280	440.360	1.080	3.75	Nil	B1	Package-9
440.360	442.785	2.425	3.75	3.75	B3	Package-9
442.785	443.760	0.975	3.75	Nil	B1	Package-9
443.760	444.520	0.760	3.75	3.75	B3	Package-9
444.520	445.000	0.480	3.75	Nil	B1	Package-9

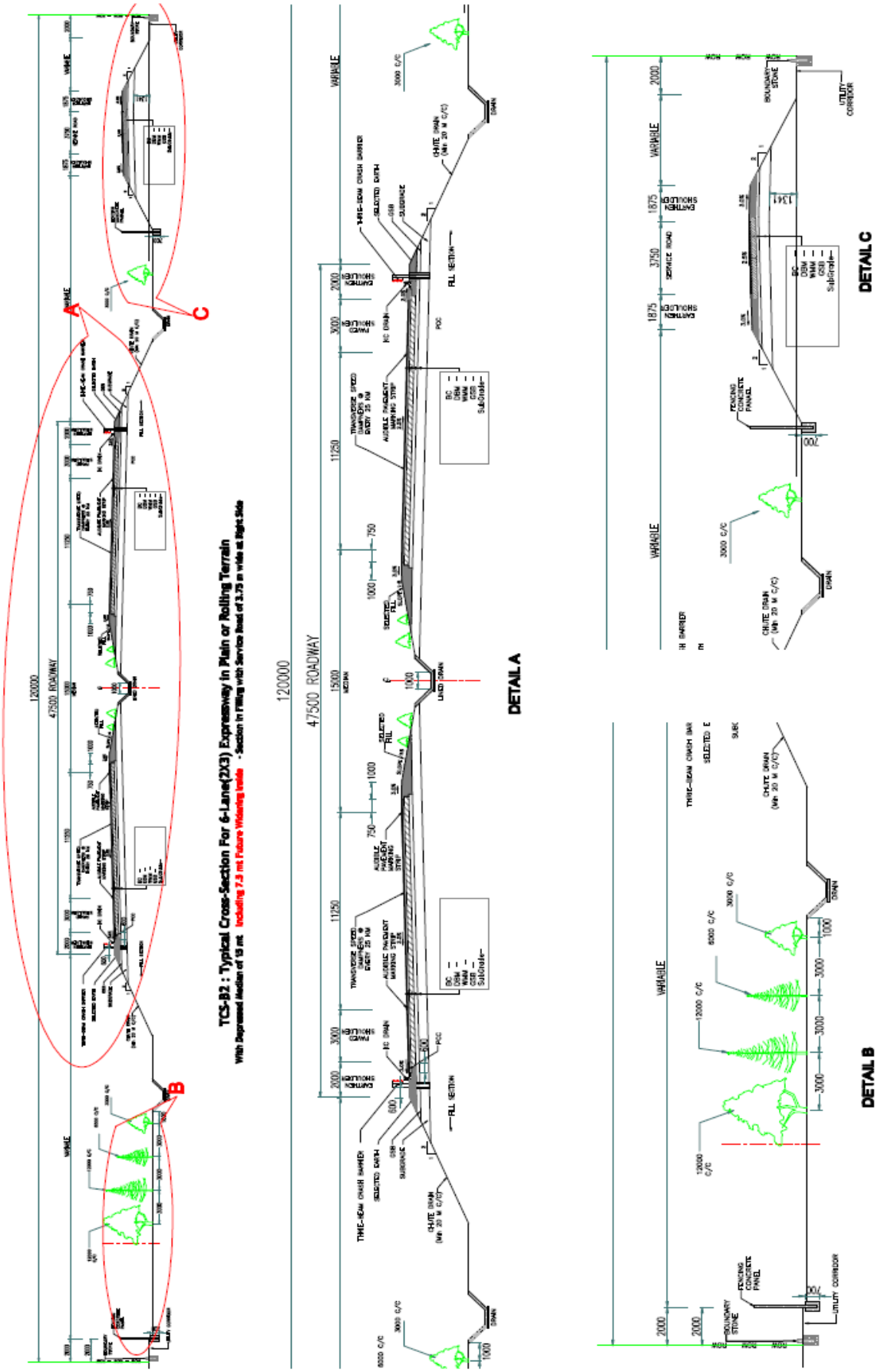
Typical cross-sections mentioned in the above table have been attached below:

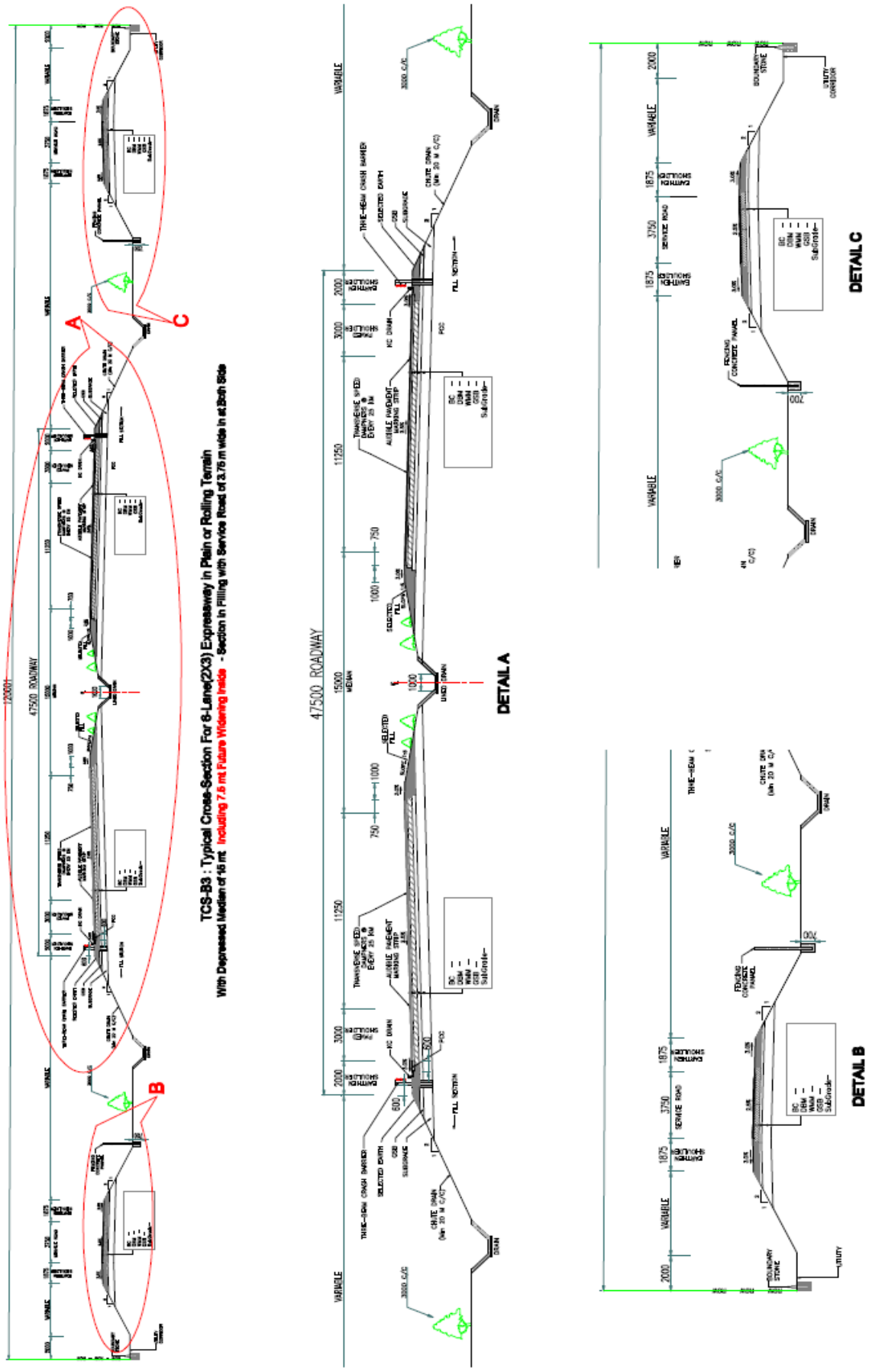

TCS- A1 : Typical Cross-Section For 6-Lane(2X3) Expressway In Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section In Filling with Service Road of 7.00 m wide at Left Side
120000
47500 ROADWAY
DETAIL A
A
B
C

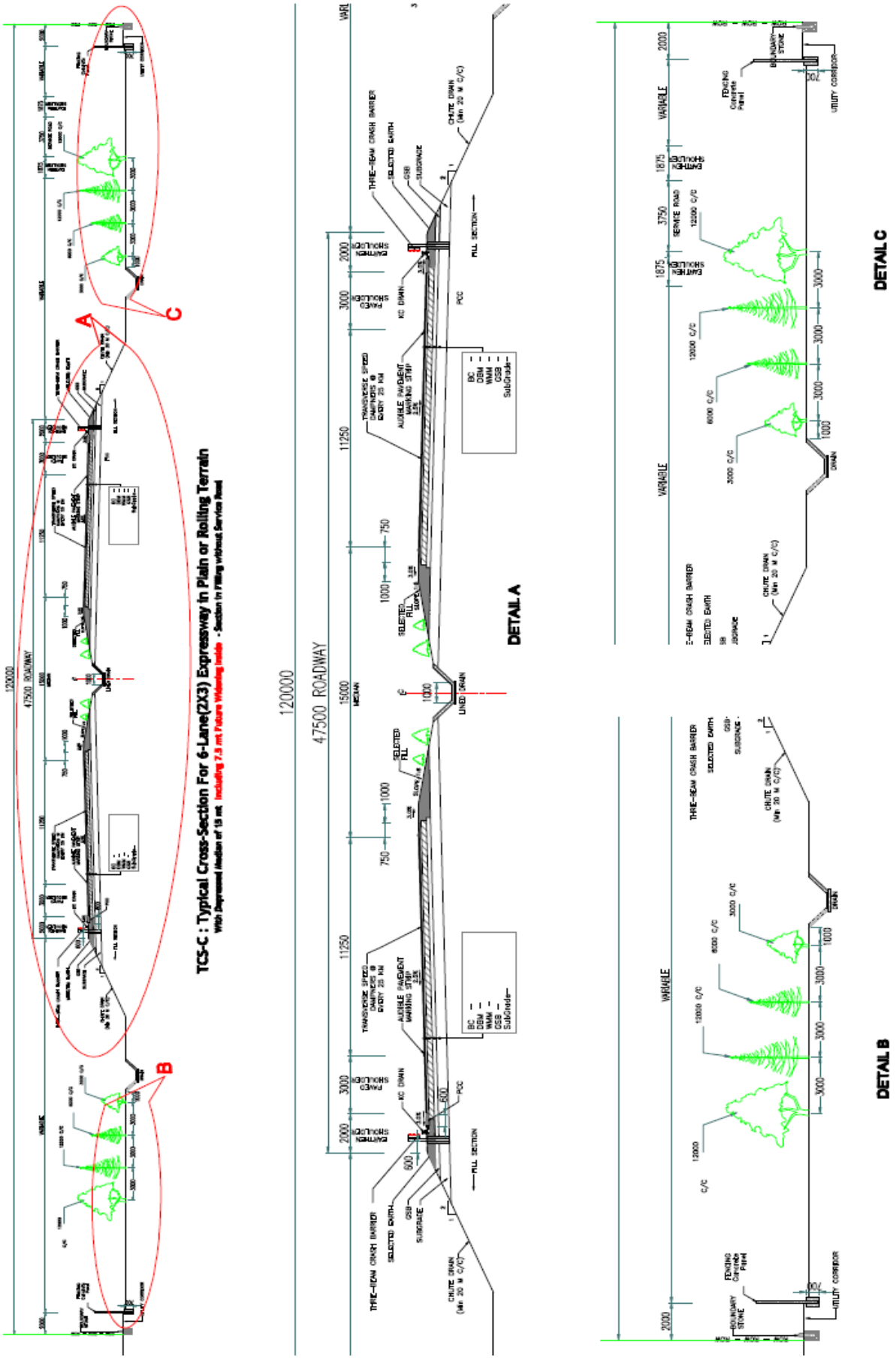

TCS-A2 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 7.00 m wide Right Side
DETAIL A
DETAIL B
DETAIL C
120000
47500 ROADWAY
VARIABLE
A
B
C

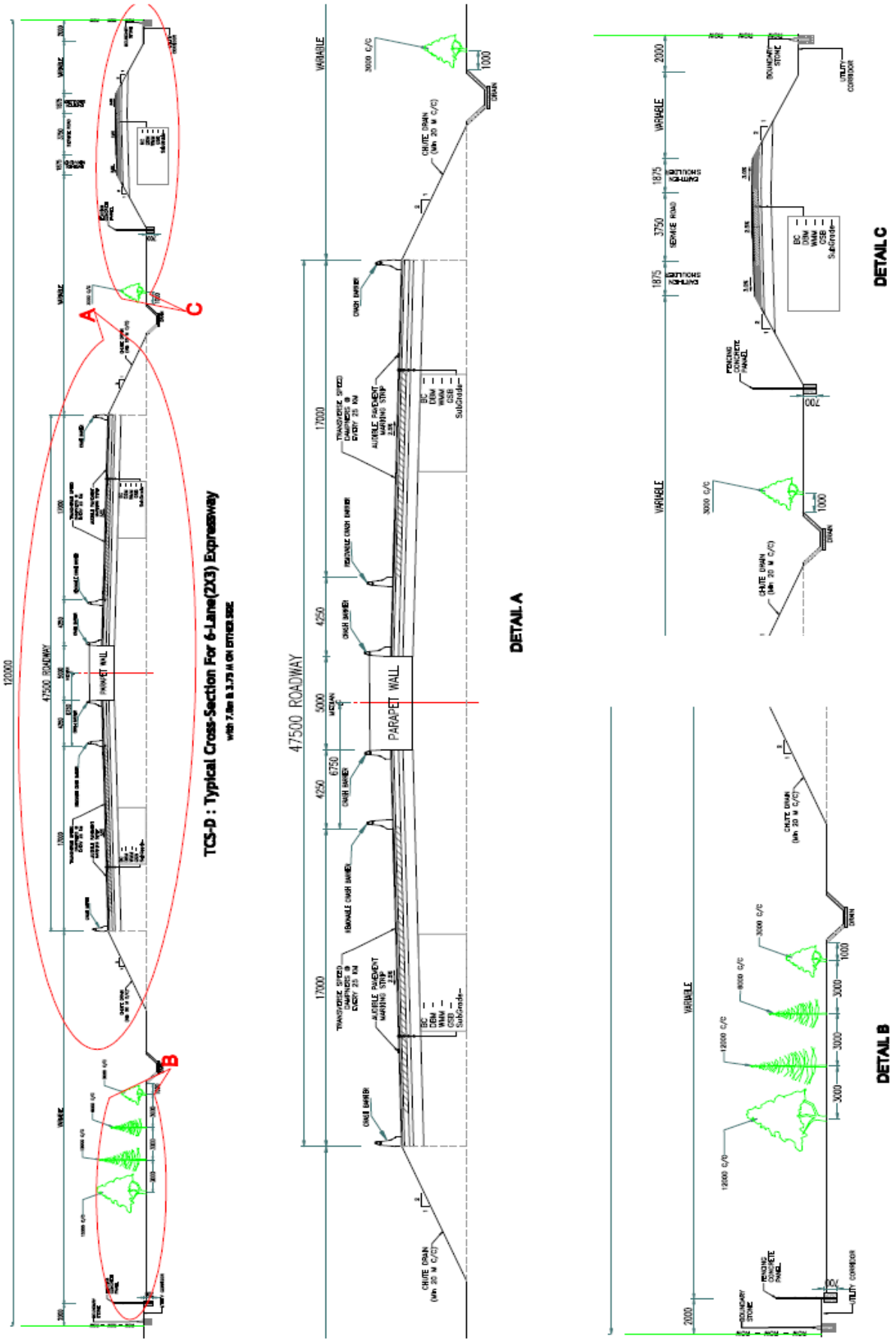

TCS-A3 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 7.00 m wide at Both Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
A
B
C

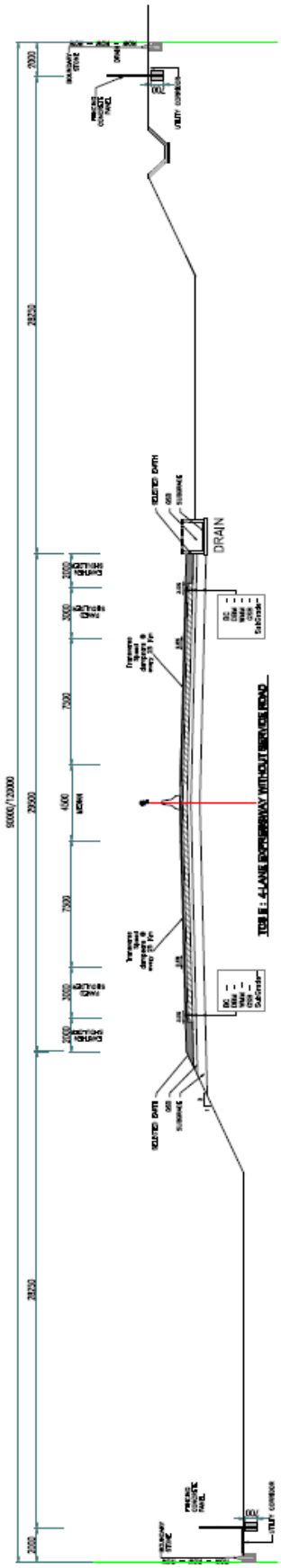

TCS- B1 : Typical Cross-Section For 6-Lane(2X3) Expressway In Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide at Left Side
DETAIL A
DETAIL B
DETAIL C
47500 ROADWAY
120000
VARIABLE
FENCING CONCRETE PANEL
BOUNDARY STONE
UTILITY CORRIDOR
SERVICE ROAD
EARTHEN SHOULDER
THRIE-BEAM CRASH BARRIER
SELECTED EARTH
CHUTE DRAIN (Min 20 M C/C)
RIL SECTION
LINED DRAIN
SELECTED RIL
KC DRAIN
PCC
BC
DBM
WMM
GSB
SubGrade

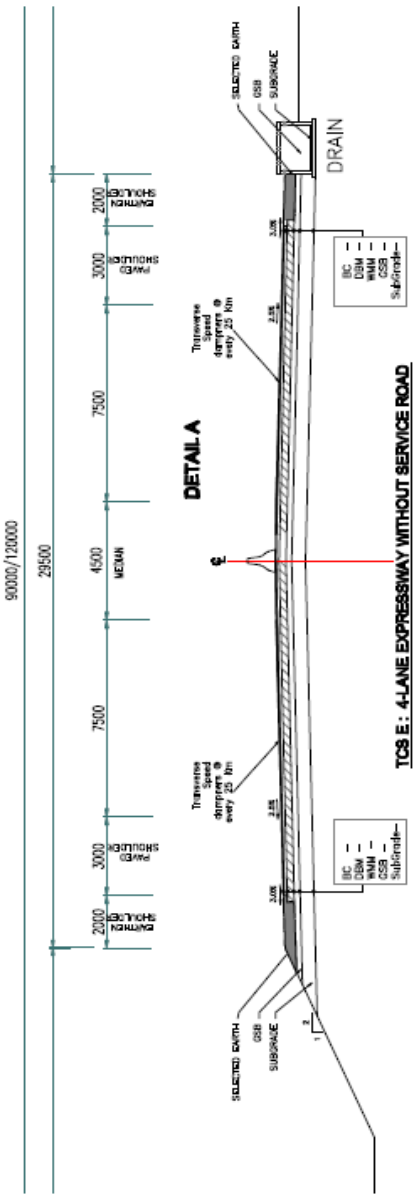

TCS-B2 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 15 mt Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide at Right Side
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
VARIABLE
FILL SECTION
CHUTE DRAIN (Min 20 M C/C)
SELECTED FILL
SUBGRADE
BOUNDARY STONE
UTILITY CORRIDOR
FENCING CONCRETE PANEL
SERVICE ROAD
EARTHEN SHOULDER
PAVED SHOULDER
THRIE-BEAM CRASH BARRIER
TRANSVERSE SPEED DAMPERS @ EVERY 25 KM
AUDIBLE PAVEMENT MARKING STRIP
LINED DRAIN
MEDIAN
A
B
C

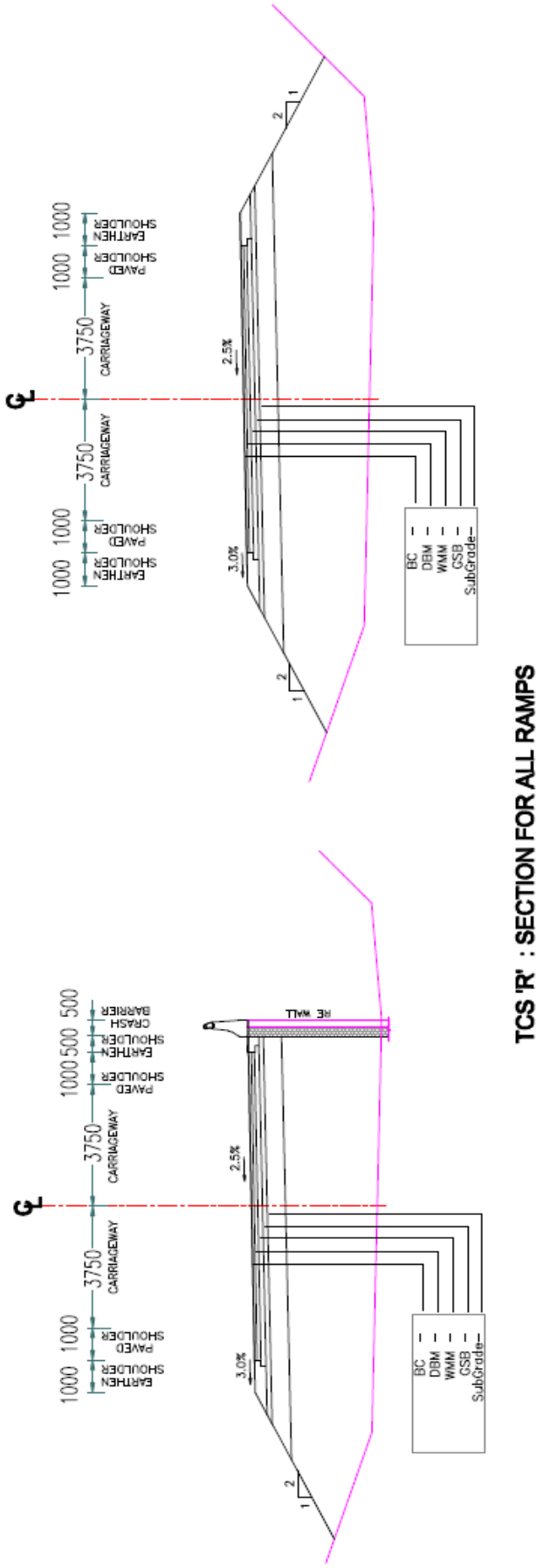

TCS-B3 : Typical Cross-Section For 6-Lane(2X3) Expressway in Plain or Rolling Terrain
With Depressed Median of 16 mt. Including 7.5 mt Future Widening Inside - Section in Filling with Service Road of 3.75 m wide in at Both Side
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C


TCS-C : Typical Cross-Section For 6-Lane(2X3) Expressway In Plain or Rolling Terrain
With Depressed Median of 15 mt. Including 7.5 mt Future Widening Inside - Section in Filling without Service Road
120000
47500 ROADWAY
DETAIL A
DETAIL B
DETAIL C
A
B
C

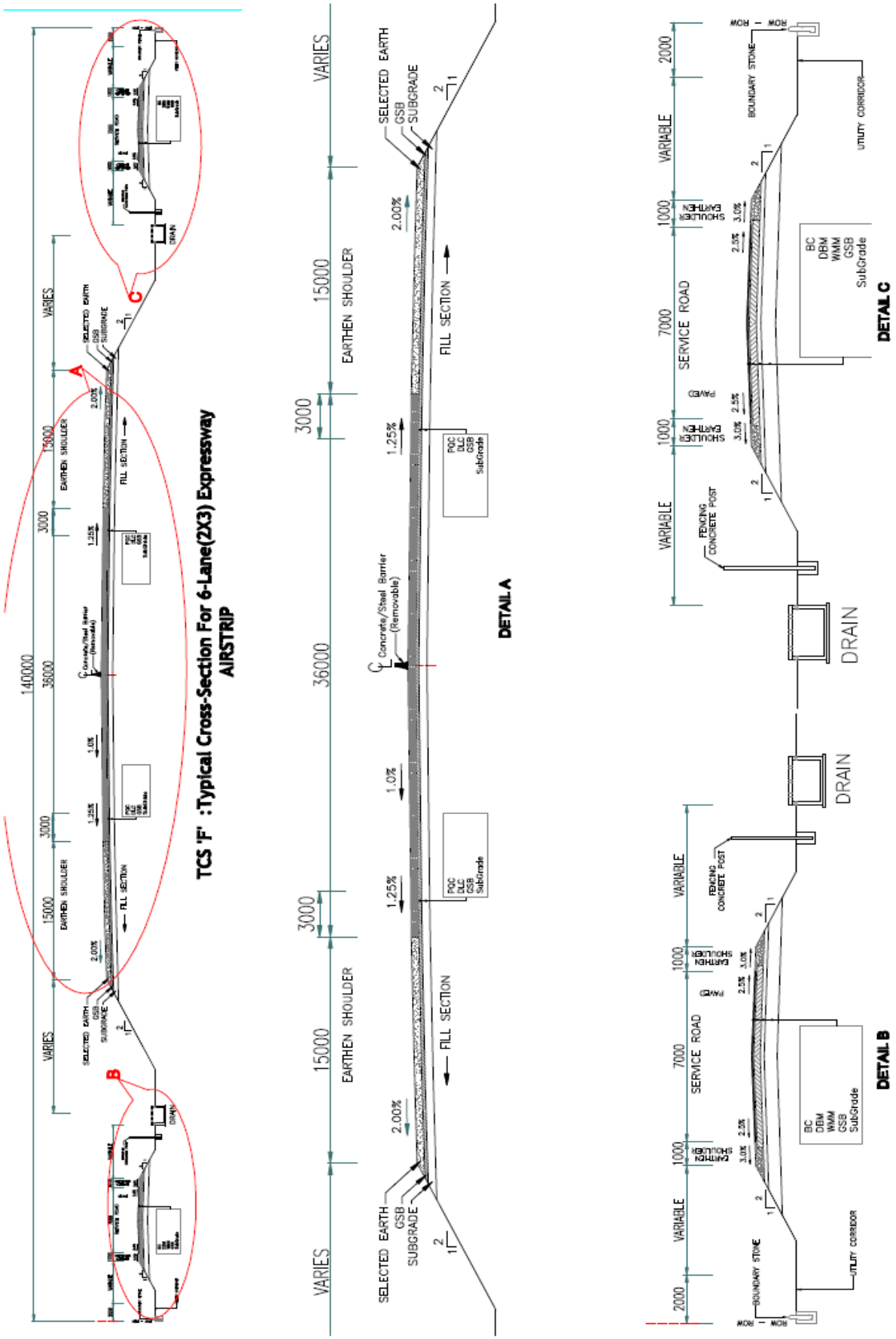

TCS-D : Typical Cross-Section For 6-Lane(2X3) Expressway
47500 ROADWAY
PARAPET WALL
DETAIL A
DETAIL B
DETAIL C
A
B
C


DRAIN
TCS E : 4-LANE EXPRESSWAY WITHOUT SERVICE ROAD


90000/120000
29500
7500
4500
MEIAN
DETAIL A
DRAIN
TCS E : 4-LANE EXPRESSWAY WITHOUT SERVICE ROAD



TCS 'R' : SECTION FOR ALL RAMPS


TCS 'F' :Typical Cross-Section For 6-Lane(2X3) Expressway
AIRSTRIP
VARIES
15000
EARTHEN SHOULDER
3000
36000
FILL SECTION
SELECTED EARTH
GSB
SUBGRADE
2.00%
1.25%
1.0%
DETAIL A
DETAIL B
DETAIL C
VARIABLE
SERVICE ROAD
7000
1000
2000
DRAIN
BOUNDARY STONE
UTILITY CORRIDOR
FENCING CONCRETE POST
BC
DBM
WMM
GSB
SubGrade

5.4 HORIZONTAL DESIGN & VERTICAL DESIGN

The proposed expressway passes mainly through plain terrain. The design standard for plain terrain is adopted for entire expressway. The minimum radius of horizontal curve adopted for the expressway is desirable minimum radius (1000m). Wherever possible, higher radii have been adopted. Horizontal alignment is designed as such to avoid all constraints and have curvilinear alignment to the maximum extend. The horizontal curves with radius of curvature < 4000 m, transition curves are provided on both ends of circular curve. Package wise details of horizontal curves are presented in **Table-5.3.1** below:

Table-5.3.1 Horizontal Curve Report (Package-9)

HIP / Curve No.	Deflection Angle			Element	Start	End	Length (m)	Bearing (dd mm ss)	Hand of Arc	Design Speed (KM/H)	Radius (m)	Super elevation (%)
	Deg	Min	Sec		Chainage (m)	Chainage (m)						
				Start	341700	343692.369	1992.369					
1	340	57	37.7	Arc	343692.37	345021.579	1329.210		Left	120	-4000	-2.500%
				Straight	345021.58	346512.864	1491.285	148 16 3.2				
2	2	47	2.7	Arc	346512.86	346998.778	485.914		Right	120	10000	-2.500%
				Straight	346998.78	349584.393	2585.615	151 3 5.9				
3	357	51	59.2	Arc	349584.39	349956.770	372.377		Left	120	-10000	-2.500%
				Straight	349956.77	351508.431	1551.661	148 55 5.1				
				Transition	351508.43	351728.431	220.000					
4	293	59	20.7	Arc	351728.43	353812.647	2084.216		Left	120	-2000	-2.500%
				Transition	353812.65	354032.647	220.000					
				Straight	354032.65	355243.903	1211.256	82 54 25.8				
				Transition	355243.9	355463.903	220.000					
5	36	50	12.5	Arc	355463.9	356658.335	1194.432		Right	120	2200	-2.500%
				Transition	356658.34	356878.335	220.000					
				Straight	356878.34	360469.277	3590.942	119 44 38.2				
6	351	14	13.8	Arc	360469.28	361310.449	841.172		Left	120	-5500	-2.500%
				Straight	361310.45	365429.196	4118.747	110 58 52				
7	17	34	2.6	Arc	365429.2	368495.283	3066.087		Right	120	10000	-2.500%
				Straight	368495.28	371379.572	2884.289	128 32 54.6				
8	8	36	6.4	Arc	371379.57	372580.607	1201.035		Right	120	8000	-2.500%
				Straight	372580.61	374744.190	2163.583	137 9 1				
9	20	41	46.7	Arc	374744.19	377633.937	2889.747		Right	120	8000	-2.500%
				Straight	377633.94	379161.033	1527.096	157 50 47.7				
10	354	1	4.9	Arc	379161.03	379787.464	626.431		Left	120	-6000	-2.500%
				Straight	379787.46	381341.231	1553.767	151 51 52.6				
11	20	58	49.8	Arc	381341.23	382805.946	1464.715		Right	120	4000	-2.500%
				Straight	382805.95	384863.243	2057.297	172 50 42.3				
12	357	33	22.2	Arc	384863.24	385503.035	639.792		Left	120	-15000	-2.500%
				Straight	385503.04	387241.025	1737.990	170 24 4.6				
13	349	26	50.6	Arc	387241.03	389082.803	1841.778		Left	120	-10000	-2.500%
				Straight	389082.8	390595.288	1512.485	159 50 55.2				
14	5	22	21	Arc	390595.29	390970.359	375.071		Right	120	4000	-2.500%
				Straight	390970.36	391900.000	929.641	165 13 16.2				
					391900						INFINITY	

Package-9 details of vertical curves are presented in **Tables-5.4.1** below:

Table-5.4.9 Vertical Alignment Report (Package-9)

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
1				Grade	390970.359	135.846	390975.186	135.868	0.462				4.827
2	391220.186	137.000	-1.381	Hog Curve	390975.186	135.868	391465.186	134.750		-35489	-0.282	354.887	490.000
3				Grade	391465.186	134.750	391664.822	132.916	-0.919				199.636
4	392258.085	130.652	0.649	Sag Curve	391664.822	132.916	391804.822	132.056		22989	0.435	229.896	140.000
5				Grade	391804.822	132.056	392008.085	131.426	-0.310				203.263
6	393107.391	131.244	1.200	Sag Curve	392008.085	131.426	392508.085	131.500		77075	0.130	770.772	500.000
7				Grade	392508.085	131.500	392649.513	131.979	0.339				141.428
8	394405.856	130.895	1.112	Hog Curve	392649.513	131.979	392849.513	132.018		-31291	-0.320	312.911	200.000
9				Grade	392849.513	132.018	392972.391	131.649	-0.300				122.878
10	395446.738	137.981	-2.000	Sag Curve	392972.391	131.649	393242.391	132.459		22497	0.445	224.972	270.000
11				Grade	393242.391	132.459	393475.000	134.553	0.900				232.609
12	396465.818	130.952	1.300	Hog Curve	393475.000	134.553	393925.000	134.766		-26392	-0.379	263.915	450.000
13				Grade	393925.000	134.766	394315.856	131.620	-0.805				390.856
14	397987.297	130.060	2.000	Sag Curve	394315.856	131.620	394495.856	131.172		16180	0.618	161.799	180.000
15				Grade	394495.856	131.172	394785.562	132.062	0.307				289.706
16	399296.251	130.465	0.686	Sag Curve	394785.562	132.062	394985.562	133.370		28879	0.346	288.784	200.000
17				Grade	394985.562	133.370	395181.738	135.331	1.000				196.176
18	400299.997	133.506	-2.002	Hog Curve	395181.738	135.331	395711.738	135.331		-26500	-0.377	264.999	530.000
19				Grade	395711.738	135.331	395914.192	133.307	-1.000				202.454
20	401104.455	127.031	1.429	Sag Curve	395914.192	133.307	396114.192	132.006		28569	0.350	285.690	200.000
21				Grade	396114.192	132.006	396365.818	131.252	-0.300				251.626
22	402576.031	125.318	1.348	Sag Curve	396365.818	131.252	396565.818	131.952		15385	0.650	153.853	200.000
23				Grade	396565.818	131.952	396917.000	135.463	1.000				351.182
24	403159.683	125.526	0.625	Hog Curve	396917.000	135.463	397447.000	135.463		-26500	-0.377	264.999	530.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
25				Grade	397447.000	135.463	397852.297	131.410	-1.000				405.297
26	404261.675	126.286	1.275	Sag Curve	397852.297	131.410	398122.297	131.410		13499	0.741	134.991	270.000
27				Grade	398122.297	131.410	398397.000	134.157	1.000				274.703
28	405483.600	125.062	1.811	Hog Curve	398397.000	134.157	398927.000	134.157		-26500	-0.377	264.999	530.000
29				Grade	398927.000	134.157	399221.251	131.215	-1.000				294.251
30	407070.196	124.724	2.300	Sag Curve	399221.251	131.215	399371.251	130.230		21858	0.457	218.584	150.000
31				Grade	399371.251	130.230	399729.372	129.106	-0.314				358.121
32	408401.918	126.680	0.988	Sag Curve	399729.372	129.106	399929.372	129.794		15205	0.658	152.050	200.000
33				Grade	399929.372	129.794	400034.997	130.852	1.002				105.625
34	409123.435	127.381	0.690	Hog Curve	400034.997	130.852	400564.997	130.857		-26479	-0.378	264.795	530.000
35				Grade	400564.997	130.857	400754.723	128.959	-1.000				189.726
36	410147.173	127.675	1.306	Sag Curve	400754.723	128.959	400904.723	127.888		26262	0.381	262.626	150.000
37				Grade	400904.723	127.888	400979.455	127.567	-0.429				74.732
38	411308.591	127.728	1.217	Sag Curve	400979.455	127.567	401229.455	128.282		17497	0.572	174.972	250.000
39				Grade	401229.455	128.282	401489.551	130.883	1.000				260.096
40	412339.137	127.394	1.195	Hog Curve	401489.551	130.883	402019.551	130.883		-26500	-0.377	264.999	530.000
41				Grade	402019.551	130.883	402476.031	126.318	-1.000				456.480
42	413362.302	131.765	-1.509	Sag Curve	402476.031	126.318	402676.031	125.666		14836	0.674	148.355	200.000
43				Grade	402676.031	125.666	402795.789	126.083	0.348				119.758
44	414595.024	133.907	-1.907	Hog Curve	402795.789	126.083	402965.789	126.119		-25995	-0.385	259.943	170.000
45				Grade	402965.789	126.119	403009.683	125.985	-0.306				43.894
46	415398.906	130.034	-0.837	Sag Curve	403009.683	125.985	403309.683	126.005		48008	0.208	480.077	300.000
47				Grade	403309.683	126.005	403725.480	127.331	0.319				415.797
48	417443.075	128.793	0.460	Hog Curve	403725.480	127.331	403925.480	127.338		-31660	-0.316	316.596	200.000
49				Grade	403925.480	127.338	404171.675	126.568	-0.313				246.195
50	418403.569	126.611	2.061	Sag Curve	404171.675	126.568	404351.675	127.152		14120	0.708	141.197	180.000
51				Grade	404351.675	127.152	404476.500	128.353	0.962				124.825
52	419369.272	128.193	2.042	Hog Curve	404476.500	128.353	405026.500	128.769		-31019	-0.322	310.193	550.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
53				Grade	405026.500	128.769	405358.600	126.076	-0.811				332.100
54	420211.240	134.580	-0.487	Sag Curve	405358.600	126.076	405608.600	126.312		13805	0.724	138.051	250.000
55				Grade	405608.600	126.312	405995.000	130.176	1.000				386.400
56	420797.160	135.000	-0.625	Hog Curve	405995.000	130.176	406525.000	130.176		-26501	-0.377	265.013	530.000
57				Grade	406525.000	130.176	406915.196	126.274	-1.000				390.196
58	421525.011	131.422	1.591	Sag Curve	406915.196	126.274	407225.196	126.739		13479	0.742	134.789	310.000
59				Grade	407225.196	126.739	407445.000	129.596	1.300				219.804
60	422083.964	134.078	-0.369	Hog Curve	407445.000	129.596	408175.000	129.617		-28139	-0.355	281.389	730.000
61				Grade	408175.000	129.617	408326.918	127.650	-1.294				151.918
62	422775.586	128.349	2.007	Sag Curve	408326.918	127.650	408476.918	126.450		15176	0.659	151.757	150.000
63				Grade	408476.918	126.450	408575.778	126.148	-0.306				98.860
64	424044.306	127.144	0.729	Sag Curve	408575.778	126.148	408725.778	126.150		24372	0.410	243.718	150.000
65				Grade	408725.778	126.150	409048.435	127.149	0.310				322.657
66	424832.000	131.065	-2.000	Sag Curve	409048.435	127.149	409198.435	128.131		21728	0.460	217.278	150.000
67				Grade	409198.435	128.131	409385.000	129.997	1.000				186.565
68	425886.986	127.083	-0.600	Hog Curve	409385.000	129.997	409915.000	129.997		-26502	-0.377	265.020	530.000
69				Grade	409915.000	129.997	410047.173	128.675	-1.000				132.173
70	427338.464	127.172	0.692	Sag Curve	410047.173	128.675	410247.173	127.981		15311	0.653	153.111	200.000
71				Grade	410247.173	127.981	410638.221	129.179	0.306				391.048
72	428359.079	125.755	0.643	Hog Curve	410638.221	129.179	410838.221	129.177		-32547	-0.307	325.468	200.000
73				Grade	410838.221	129.177	411218.591	128.005	-0.308				380.370
74	429540.161	126.612	0.492	Sag Curve	411218.591	128.005	411398.591	128.546		14792	0.676	147.925	180.000
75				Grade	411398.591	128.546	411562.893	130.039	0.909				164.302
76	430534.540	124.178	2.093	Hog Curve	411562.893	130.039	412032.893	130.099		-26232	-0.381	262.316	470.000
77				Grade	412032.893	130.099	412249.137	128.189	-0.883				216.244
78	431357.871	127.193	-0.470	Sag Curve	412249.137	128.189	412429.137	127.675		15063	0.664	150.630	180.000
79				Grade	412429.137	127.675	413004.190	129.469	0.312				575.053
80	432264.550	126.395	0.692	Sag Curve	413004.190	129.469	413104.190	129.972		26113	0.383	261.131	100.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
81				Grade	413104.190	129.972	413152.302	130.306	0.695				48.112
82	433165.753	125.972	1.700	Hog Curve	413152.302	130.306	413572.302	130.057		-27841	-0.359	278.412	420.000
83				Grade	413572.302	130.057	413798.865	128.213	-0.814				226.563
84	434257.558	123.827	1.106	Sag Curve	413798.865	128.213	414048.865	128.446		13784	0.725	137.844	250.000
85				Grade	414048.865	128.446	414345.024	131.407	1.000				296.159
86	434996.187	123.488	0.623	Hog Curve	414345.024	131.407	414845.024	131.640		-26223	-0.381	262.226	500.000
87				Grade	414845.024	131.640	415036.265	129.906	-0.907				191.241
88	436039.000	130.862	-2.000	Sag Curve	415036.265	129.906	415216.265	129.402		14367	0.696	143.670	180.000
89				Grade	415216.265	129.402	415263.906	129.566	0.346				47.641
90	437148.288	125.739	-0.600	Hog Curve	415263.906	129.566	415533.906	129.372		-32276	-0.310	322.768	270.000
91				Grade	415533.906	129.372	416081.043	126.688	-0.490				547.137
92	438255.278	125.038	0.685	Sag Curve	416081.043	126.688	416581.043	126.211		63292	0.158	632.911	500.000
93				Grade	416581.043	126.211	417368.075	128.568	0.300				787.032
94	439577.770	123.126	1.346	Sag Curve	417368.075	128.568	417518.075	129.363		32575	0.307	325.754	150.000
95				Grade	417518.075	129.363	417640.503	130.294	0.760				122.428
96	440352.938	128.753	-2.000	Hog Curve	417640.503	130.294	418125.503	129.563		-26627	-0.376	266.262	485.000
97				Grade	418125.503	129.563	418267.069	128.060	-1.061				141.566
98	441515.556	124.696	-0.607	Sag Curve	418267.069	128.060	418540.069	127.976		13243	0.755	132.429	273.000
99				Grade	418540.069	127.976	418685.650	129.432	1.000				145.581
100	442829.876	126.582	-1.113	Hog Curve	418685.650	129.432	419155.650	129.902		-26112	-0.383	261.117	470.000
101				Grade	419155.650	129.902	419234.272	129.273	-0.800				78.622
102	443960.628	127.068	-1.389	Sag Curve	419234.272	129.273	419504.272	129.869		13225	0.756	132.249	270.000
103				Grade	419504.272	129.869	419721.172	132.562	1.242				216.900
104	445175.000	125.750	-1.841	Hog Curve	419721.172	132.562	420046.172	134.580		-26175	-0.382	261.753	325.000
105				Grade	420046.172	134.580	420146.240	134.580	0.000				100.068
106	446089.066	122.761	0.692	Hog Curve	420146.240	134.580	420276.240	134.264		-26713	-0.374	267.137	130.000
107				Grade	420276.240	134.264	420422.999	133.549	-0.487				146.759

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
108	446200.000	123.871	0.000	Sag Curve	420422.999	133.549	420582.999	133.661		14387	0.695	143.872	160.000
109				Grade	420582.999	133.661	420697.160	134.375	0.625				114.161
110	446200.000	123.871	0.000	Hog Curve	420697.160	134.375	420897.160	135.000		-31977	-0.313	319.765	200.000
111				Grade	420897.160	135.000	420972.738	135.000	0.000				75.578
112	446200.000	123.871	0.000	Hog Curve	420972.738	135.000	421182.738	134.160		-26251	-0.381	262.515	210.000
113				Grade	421182.738	134.160	421410.011	132.342	-0.800				227.273
114	446200.000	123.871	0.000	Sag Curve	421410.011	132.342	421640.011	132.332		14452	0.692	144.521	230.000
115				Grade	421640.011	132.332	421755.574	133.247	0.792				115.563
116	446200.000	123.871	0.000	Hog Curve	421755.574	133.247	421965.574	134.078		-26532	-0.377	265.315	210.000
117				Grade	421965.574	134.078	422033.964	134.078	0.000				68.390
118	446200.000	123.871	0.000	Hog Curve	422033.964	134.078	422133.964	133.894		-27110	-0.369	271.098	100.000
119				Grade	422133.964	133.894	422164.748	133.780	-0.369				30.784
120	446200.000	123.871	0.000	Hog Curve	422164.748	133.780	422324.748	132.711		-26729	-0.374	267.294	160.000
121				Grade	422324.748	132.711	422635.586	129.704	-0.967				310.838
122	446200.000	123.871	0.000	Sag Curve	422635.586	129.704	422915.586	129.805		13948	0.717	139.480	280.000
123				Grade	422915.586	129.805	423079.500	131.510	1.040				163.914
124	446200.000	123.871	0.000	Hog Curve	423079.500	131.510	423624.500	131.510		-26202	-0.382	262.020	545.000
125				Grade	423624.500	131.510	423994.306	127.664	-1.040				369.806
126	446200.000	123.871	0.000	Sag Curve	423994.306	127.664	424094.306	126.989		13718	0.729	137.178	100.000
127				Grade	424094.306	126.989	424246.074	126.516	-0.311				151.768
128	446200.000	123.871	0.000	Sag Curve	424246.074	126.516	424446.074	127.205		15255	0.656	152.553	200.000
129				Grade	424446.074	127.205	424567.000	128.415	1.000				120.926
130	446200.000	123.871	0.000	Hog Curve	424567.000	128.415	425097.000	128.415		-26500	-0.377	264.999	530.000
131				Grade	425097.000	128.415	425281.713	126.567	-1.000				184.713
132	446200.000	123.871	0.000	Sag Curve	425281.713	126.567	425481.713	125.867		15383	0.650	153.834	200.000
133				Grade	425481.713	125.867	425586.986	126.183	0.300				105.273
134	446200.000	123.871	0.000	Hog Curve	425586.986	126.183	426186.986	126.183		-99988	-0.100	999.900	600.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
135				Grade	426186.986	126.183	426357.097	125.673	-0.300				170.111
136	446200.000	123.871	0.000	Sag Curve	426357.097	125.673	426857.097	125.692		82299	0.122	822.978	500.000
137				Grade	426857.097	125.692	427288.464	127.018	0.308				431.367
138	446200.000	123.871	0.000	Sag Curve	427288.464	127.018	427388.464	127.672		14441	0.692	144.411	100.000
139				Grade	427388.464	127.672	427503.000	128.818	1.000				114.536
140	446200.000	123.871	0.000	Hog Curve	427503.000	128.818	428023.000	128.948		-26667	-0.375	266.667	520.000
141				Grade	428023.000	128.948	428294.079	126.372	-0.950				271.079
142	446200.000	123.871	0.000	Sag Curve	428294.079	126.372	428424.079	125.555		20216	0.495	202.159	130.000
143				Grade	428424.079	125.555	428562.840	125.129	-0.307				138.761
144	446200.000	123.871	0.000	Sag Curve	428562.840	125.129	429062.840	125.135		81135	0.123	811.359	500.000
145				Grade	429062.840	125.135	429490.161	126.457	0.309				427.321
146	446200.000	123.871	0.000	Sag Curve	429490.161	126.457	429590.161	127.012		20327	0.492	203.264	100.000
147				Grade	429590.161	127.012	429693.726	127.842	0.801				103.565
148	446200.000	123.871	0.000	Hog Curve	429693.726	127.842	430283.726	126.948		-30960	-0.323	309.598	590.000
149				Grade	430283.726	126.948	430394.540	125.724	-1.104				110.814
150	446200.000	123.871	0.000	Sag Curve	430394.540	125.724	430674.540	125.561		13381	0.747	133.806	280.000
151				Grade	430674.540	125.561	430813.284	126.932	0.988				138.744
152	446200.000	123.871	0.000	Hog Curve	430813.284	126.932	431203.284	127.930		-26624	-0.376	266.248	390.000
153				Grade	431203.284	127.930	431292.871	127.503	-0.477				89.587
154	446200.000	123.871	0.000	Hog Curve	431292.871	127.503	431422.871	126.578		-27673	-0.361	276.732	130.000
155				Grade	431422.871	126.578	431544.100	125.431	-0.946				121.229
156	446200.000	123.871	0.000	Sag Curve	431544.100	125.431	431744.100	124.792		15944	0.627	159.439	200.000
157				Grade	431744.100	124.792	432189.550	126.164	0.308				445.450
158	446200.000	123.871	0.000	Sag Curve	432189.550	126.164	432339.550	127.145		21674	0.461	216.736	150.000
159				Grade	432339.550	127.145	432429.000	128.040	1.000				89.450
160	446200.000	123.871	0.000	Hog Curve	432429.000	128.040	432959.000	128.040		-26499	-0.377	264.992	530.000
161				Grade	432959.000	128.040	433053.253	127.097	-1.000				94.253
162	446200.000	123.871	0.000	Sag Curve	433053.253	127.097	433278.253	126.760		13235	0.756	132.354	225.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
163				Grade	433278.253	126.760	433405.000	127.647	0.700				126.747
164	446200.000	123.871	0.000	Hog Curve	433405.000	127.647	433805.000	127.447		-26668	-0.375	266.681	400.000
165				Grade	433805.000	127.447	434177.558	124.467	-0.800				372.558
166	446200.000	123.871	0.000	Sag Curve	434177.558	124.467	434337.558	124.071		14471	0.691	144.714	160.000
167				Grade	434337.558	124.071	434497.266	124.560	0.306				159.708
168	446200.000	123.871	0.000	Hog Curve	434497.266	124.560	434657.266	124.553		-25811	-0.387	258.104	160.000
169				Grade	434657.266	124.553	434921.187	123.724	-0.314				263.921
170	446200.000	123.871	0.000	Sag Curve	434921.187	123.724	435071.187	123.719		24091	0.415	240.912	150.000
171				Grade	435071.187	123.719	435362.827	124.619	0.308				291.640
172	446200.000	123.871	0.000	Sag Curve	435362.827	124.619	435512.827	125.600		21689	0.461	216.892	150.000
173				Grade	435512.827	125.600	435774.000	128.212	1.000				261.173
174	446200.000	123.871	0.000	Hog Curve	435774.000	128.212	436304.000	128.212		-26500	-0.377	265.006	530.000
175				Grade	436304.000	128.212	436589.063	125.362	-1.000				285.063
176	446200.000	123.871	0.000	Sag Curve	436589.063	125.362	436789.063	124.662		15385	0.650	153.851	200.000
177				Grade	436789.063	124.662	437048.288	125.439	0.300				259.225
178	446200.000	123.871	0.000	Hog Curve	437048.288	125.439	437248.288	125.439		-33329	-0.300	333.289	200.000
179				Grade	437248.288	125.439	437629.220	124.296	-0.300				380.932
180	446200.000	123.871	0.000	Sag Curve	437629.220	124.296	438029.220	124.326		65024	0.154	650.237	400.000
181				Grade	438029.220	124.326	438180.278	124.802	0.315				151.058
182	446200.000	123.871	0.000	Sag Curve	438180.278	124.802	438330.278	125.789		21898	0.457	218.986	150.000
183				Grade	438330.278	125.789	438555.890	128.045	1.000				225.612
184	446200.000	123.871	0.000	Hog Curve	438555.890	128.045	439085.890	128.045		-26499	-0.377	264.985	530.000
185				Grade	439085.890	128.045	439477.770	124.126	-1.000				391.880
186	446200.000	123.871	0.000	Sag Curve	439477.770	124.126	439677.770	123.472		14858	0.673	148.580	200.000
187				Grade	439677.770	123.472	439827.615	123.990	0.346				149.845
188	446200.000	123.871	0.000	Sag Curve	439827.615	123.990	439977.615	125.000		22937	0.436	229.368	150.000
189				Grade	439977.615	125.000	440087.938	126.103	1.000				110.323
190	446200.000	123.871	0.000	Hog Curve	440087.938	126.103	440617.938	126.103		-26501	-0.377	265.006	530.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
191				Grade	440617.938	126.103	440786.536	124.418	-1.000				168.598
192	446200.000	123.871	0.000	Sag Curve	440786.536	124.418	441086.536	123.378		22951	0.436	229.516	300.000
193				Grade	441086.536	123.378	441415.556	124.389	0.307				329.020
194	446200.000	123.871	0.000	Hog Curve	441415.556	124.389	441615.556	124.396		-32937	-0.304	329.370	200.000
195				Grade	441615.556	124.396	441853.270	123.683	-0.300				237.714
196	446200.000	123.871	0.000	Sag Curve	441853.270	123.683	442053.270	123.748		30077	0.332	300.770	200.000
197				Grade	442053.270	123.748	442679.876	126.035	0.365				626.606
198	446200.000	123.871	0.000	Hog Curve	442679.876	126.035	442979.876	125.459		-26944	-0.371	269.440	300.000
199				Grade	442979.876	125.459	443128.849	124.344	-0.748				148.973
200	446200.000	123.871	0.000	Sag Curve	443128.849	124.344	443378.849	124.056		19742	0.507	197.426	250.000
201				Grade	443378.849	124.056	443760.628	126.033	0.518				381.779
202	446200.000	123.871	0.000	Hog Curve	443760.628	126.033	444160.628	125.325		-28792	-0.347	287.919	400.000
203				Grade	444160.628	125.325	444468.998	122.638	-0.871				308.370
204	446200.000	123.871	0.000	Sag Curve	444468.998	122.638	444798.998	122.588		19271	0.519	192.704	330.000
205				Grade	444798.998	122.588	444930.000	123.690	0.841				131.002
206	446200.000	123.871	0.000	Hog Curve	444930.000	123.690	445420.000	123.300		-26616	-0.376	266.163	490.000
207				Grade	445420.000	123.300	445518.676	122.313	-1.000				98.676
208	446200.000	123.871	0.000	Sag Curve	445518.676	122.313	445718.676	121.621		15293	0.654	152.931	200.000
209				Grade	445718.676	121.621	446034.066	122.592	0.308				315.390
210	446200.000	123.871	0.000	Sag Curve	446034.066	122.592	446144.066	123.311		15885	0.630	158.854	110.000
211				Grade	446144.066	123.311	446200.000	123.871	1.000				55.934
212				Grade	446200.000	123.871	0.000	0.000	1.000				-446200.000

5.5 SERVICE ROAD

Width of Service Roads of different widths viz. 3.75 m, 7.0 m & 10 m is given below in **Table-5.4**:

Table-5.4 Package wise Length & Width of Service Roads

Package No.	3.75 m Service Road		7.0 m Service Road		10.0 m Service Road	
	LHS	RHS	LHS	RHS	LHS	RHS
IX	33.79	25.12	3.08	2.01	0	0

5.6 ROADSIDE DRAIN

Package wise lengths and types of Drains are given in table below in **Table-5.5**:

Table-5.5 Package wise Length & Type of Roads Side Drain

Package No.	Length of Drain (m)					Remarks
	Unlined Drain (LHS+RHS)	Lined Drain (LHS+RHS)	Median Drain	Covered Drain (LHS+RHS)	Chute Drain	
IX	42200	63188	51030	-	41920	
Total Length (km)	**42.200**	**63.188**	**51.030**	**-**	**41.920**	

5.7 AIR STRIP

Air Strip has not been provided in this Package.

6. PAVEMENT DESIGN & PAVEMENT PROPOSALS

6.1 PAVEMENT INVESTIGATIONS

In conformity with the provision of the TOR and various standards, the following investigations have been broadly carried during planning and designing stage.

- Axle Load Survey
- Material Investigations

6.1.1 Axle Load Surveys

Several factors such as gross load, tyre pressure, number of wheels and type of wheel configuration, number of repetitions, sub grade soil properties, climatic conditions and type of materials used in pavement, etc. affect the structural design and performance of pavements.

For the design of pavement for the Ganga Greenfield Expressway, the quantum of traffic wheel loads that will be diverted on the project corridor need to be established. For this, the behaviour of axle loading & VDF of commercial vehicles using the project corridor are necessary in determination of realistic pavement design.

To arrive axle loads on to the project corridor, Axle Load surveys have been carried out on primary roads in the Project Influence Area (PIA). Identified Roads in PIA are listed below:

Table- 6.1 Locations of Axle Load Survey

S. No.	Survey Location	Stretch & Road Name	Day & Date of O-D Survey
1	Siwaya Toll Booth	Muzaffarnagar - Meerut	Wednesday, 12thFebruary 2020
2	Nizampur	Meerut - Garhmukteshwar	Friday, 6th December 2019
3	Kurkawali	Hasanpur - Chandausi	Monday, 4th November 2019
5	Nagariya	Aligarh - Etah	Wednesday, 27th November 2019
6	Khankah e Niyaziya	Aliganj - Farrukhabad	Monday, 9th December 2019
7	Samdhan	Farrukhabad - Kannauj	Wednesday, 27th November 2019
8	Bilhaur	Kannauj - Kanpur	Monday, 2nd December 2019
9	Katohan Toll Booth	Fatehpur - Prayagraj	Monday, 16th February 2020
10	Agwanpur	Bijnor - Moradabad	Friday, 29th November 2019
11	Faridpur Toll Booth	Bareilly - Shahjahanpur	Monday, 2nd December 2019
12	Nawada	Chandausi - Budaun	Thursday, 28th November 2019
13	Usawan	Budaun - Farrukhabad	Thursday, 5th December 2019
14	Shahabad	Shahjahanpur - Hardoi	Friday, 29th November 2019
15	Safipur	Bangarmau - Unnao	Wednesday, 4th December 2019
16	Semari	Unnao - Lalganj	Friday, 6th December 2019
17	Andiyari	Unchahar - Prayagraj	Tuesday, 10th December 2019

The vehicles were selected randomly to ensure that the sample collected represents the overall-loading pattern plying on the project expressway. As the pavement design is governed by loading configuration of commercial vehicles, axle load data was collected only for commercial vehicles, which generally cause damage to the pavement. Special care has been taken to avoid any variation in the wheel loads due to camber. The procedure adopted using the weigh pad is as follows:

- A suitable safe site was selected for the diversion of vehicles to avoid traffic congestion and utilization of the equipment.
- The weigh pads were placed on firm ground adjacent to the carriageway, at a spacing to match with the wheel paths of trucks and buses. Each pad is provided with ramps to facilitate vehicle movement onto the pad.
- The driver of the vehicle was directed to position the front wheel(s) on the centre of the pad(s). After waiting for 30 seconds to stabilize the reading, axle load was noted from the inbuilt display unit along with vehicle code to represent type of vehicle.
- Similarly, the rear axle was also positioned and reading noted.

The enumerators recorded the type of the vehicles in the form of vehicle codes, and commodity being carried apart from the load recordings. The raw data and analysis for each of the survey location will be submitted separately.

6.1.2 Material Investigations

6.1.2.1 Objective & Scope of Work

Basic objective of material investigations is to identify the potential sources of construction materials, the borrow areas and their suitability by testing them to establish their physical and engineering- properties of the collected samples from the identified sources as per prevailing codes of practice along the project stretches with reasonable leads, to yield adequate quantity and quality of materials which are suitable for various pavement layers viz. embankment, sub grade, sub base, base and structures etc. The investigations have been done by studying the available information or by local enquiry of people, contractors and material suppliers in the PIA adjacent to roads. The objectives may broadly be defined as below.

- Identification of potential sources of borrow pit soils indicating places and the status of quarries whether in operation or new sources along with identification of naturally available granular material (GSB) if any
- Potential sources of stone quarries
- Sources of water for construction
- Availability of sand
- Availability of steel, cement and bitumen

The investigations of the materials were mainly concentrated on the above guidelines and were initially restricted along the respective road alignments and nearby sources adjoining road sections. When suitable information was not available, the reconnaissance extended towards

further more kilometers where potential sources were found and where access was not a major constraint.

6.1.2.2 Survey Methodology

In particular soils and materials like aggregates, sand surveys are required for following purpose:

- To determine the quantity and physical characteristics of soil for design of embankment and sub grade for pavement.
- To locate sources for aggregates required for pavement and structures and to ascertain their availability and suitability for use.

The field investigations at each section of the project corridor broadly includes:

- Study of available information
- Demarcate the possible borrow areas
- Site inspection and assessment of quantity of potential materials
- Sampling of representative materials and preparation of lead chart with the name and location of borrow area /quarry
- Estimation of approximate potential reserves and other necessary details.

A team of engineers under guidance of Material Engineer have visited site, carried out reconnaissance the area and identified number of quarries for stone, sand, gravel and borrow areas. From the reconnaissance and investigations, it has been observed that sufficient borrow areas are available along the roadside within reasonable lead. The collected samples from the respective source were tested in the laboratory for various physical/engineering properties of the materials as per the relevant Indian standard codes for their suitability in road construction.

6.1.2.3 Various Tests and Test Standards

The following tests were performed on soils, aggregates, sand as per relevant Indian standard codes as presented in the **Table 6.2** below.

Table 6.2: Type of Tests and Test Methods

Sl. No.	Name of the Test	Test Method
Soil		
1	Moisture Content at field	IS 2720, Part-2
2	Grain Size Analysis	IS 2720, Part-4
3	Atterberg Limits	IS 2720, Part-5
4	MDD & OMC Modified Proctor Compaction (Heavy Compaction)	IS 2720, Part-8
5	California Bearing Ratio Test (CBR)	IS 2720, Part-16

Sl. No.	Name of the Test	Test Method
6	Free Swelling Index(FSI)	IS 2720, Part-40
Aggregates		
1	Flakiness Index and Elongation Index	IS 2386, Part-1
2	Specific Gravity and Water Absorption	IS 2386, Part-3
3	Aggregate Impact Value	IS 2386, Part-4 or IS:5640
4	Stripping Value	IS : 6241 or AASHTO T:182
5	Soundness in Sodium Sulphate and Magnesium Sulphate	IS:2386 ,Part-5 or IS:383
Sand		
1	Gradation	IS: 383
2	Fineness Modulus	IS: 383

6.1.2.4 Subgrade Investigations

Pavement sub-grade soil investigations comprise of digging of test pits and collection of material sampling and testing. Physical and mechanical properties of roadway materials and sub-grade soil forms the basis for the design of pavement layers and preparation of most appropriate subgrade proposals for the new alignment (greenfield). For this purpose, various engineering surveys have been carried out as per the relevant MORTH/IRC Codes. This section covers the detailed pavement investigations procedures along with brief summary of field and laboratory test results.

The main objective of pavement investigations for new alignment is to evaluate the strength, condition of the sub-grade for the native/subgrade soil for the greenfield expressway. These characteristics are intended for designing overlay for the intended MSA, and for designing new pavement on Ganga Greenfield Expressway with enhanced durability benefits.

The following field investigations were carried out along with field and laboratory testing for assessment of various engineering properties.

- Sub-grade Investigations through Pavement Test Pits
- Laboratory Testing of Sub-Grade Soils

After the collection of representative samples, various laboratory tests as given in Table-6.3 were conducted for their assessment and suitability in construction.

Sl. No.	Name of the Test	Test Method
1	Moisture Content at Field	IS 2720, Part-2
2	Grain Size Analysis	IS 2720, Part-4
3	Atterberg Limits	IS 2720, Part-5

Sl. No.	Name of the Test	Test Method
4	MDD & OMC Modified Proctor Compaction (Heavy Compaction)	IS 2720, Part-8
5	California Bearing Ratio Test (CBR)	IS 2720, Part-16
6	Free Swelling Index (FSI)	IS 2720, Part-40

Some photographs of test pits are given below which was collected from subgrade along the alignment.

More photos of the sampling have been attached in Material Report.

The results of Soil Test along the project alignment have been attached below in **Table-6.4** below:

Table-6.4 Summary of Lab Test Report of Soil along the alignment

Sr. No.	Existing Chainage in km.	Side	Grain Size Analysis Test (%) As Per IS 2720 (Part-4)			Atterberg Limits (%) IS 2720 (Part-5)			Proctor Density AS Per IS 2720 (Part-8)		F.S.I % AS Per IS 2720 (Part -40)	CBR Value (%) AS Per 2720 (Part-16)	TYPE OF SOIL
			Gravel %	Sand %	Silt & Clay %	LL	PL	PI	MDD gm/cc	OMC %			
1	393 + 300	LHS	5.67	32.58	61.75	41	21.98	19.02	1.94	13.09	25.75	8.1	CI
2	398 + 300	RHS	7.56	39.87	52.57	26.47	17.76	8.71	1.98	10.23	24.5	8.59	CL
3	403 + 300	LHS	9.99	26.58	63.43	34	21.95	12.05	1.96	12.67	26.25	8.43	CL
4	408 + 300	RHS	9.67	31.56	58.77	36	24.69	11.31	1.97	12.56	26.5	8.52	MI
5	413 + 300	LHS	7.52	30.26	62.22	43.21	25.46	17.75	1.89	13.38	26	7.43	CI
6	418 + 300	RHS	7.69	34.78	57.53	39	20.67	18.33	1.95	12.89	25.25	8.82	CI
7	423 + 300	LHS	10.45	37.89	51.66	40.26	20.59	19.67	1.97	12.18	24	9.43	CI
8	428 + 300	RHS	9.56	34.54	55.9	35.98	21.41	14.57	1.96	12.45	26.5	8.64	MI
9	433 + 300	LHS	9.76	29.78	60.46	37.89	21.56	16.33	1.93	12.14	27.25	8.01	CI
10	438 + 300	RHS	9.64	29.58	60.78	38.59	21.46	17.13	1.92	12.46	24.5	7.98	CI
11	443 + 300	LHS	9.54	31.06	59.4	39.52	21.47	18.05	1.91	12.89	23.25	7.89	CI

6.1.2.5 Borrow Area

Works Department and local people have been contacted. Based on the information received and field surveys carried out, the consultants identified the borrow areas which are new ones /existing ones belonging to the government or public. and include certain useful information such as, distance from the project road, location, village name etc. Borrowing soil from these areas would require prior approval of the local authorities' negotiations with private people. Soil samples from these borrow sources have been collected in bulk quantities by excavating test pits down up to 1.0 m to 1.5 m depth from the existing ground surface. The top organic soil layer of approximately 100 mm thickness has been removed before sampling. Representative sample of soil has been collected in bulk, in gunny bags, from major and minor test pits for laboratory testing. Representative samples of Borrow Area soils were collected from the test pits sent to Laboratory for various laboratory tests listed below

The tests performed are:

- Grain size distribution test for each sample.
- Atterberg limits for each sample
- Moisture v/s density relationship (Heavy Compaction) for each sample.
- Four days soaked CBR at three energy levels on each homogeneous group of soils. Soaked CBR at field dry density and 97% of maximum dry density is to be determined from the graphs plotted for CBR verses density at three energy levels. The grouping is established based on similar soil index properties, grain size distribution.

Some photographs of test pits are given below of borrow area sampling along the alignment shown below.

Summary of Laboratory Test Results of Borrow Area Soil Samples is attached below in Table-6.5:

Table-6.5 Laboratory Test Results of Borrow Area Soil

Sr. No.	Existing Chainage in km.	Side	Grain Size Analysis Test (%) As Per IS 2720 (Part-4)			Atterberg Limits (%) IS 2720 (Part-5)			Proctor Density AS Per IS 2720 (Part-8)		F.S.I % AS Per IS 2720 (Part -40)	CBR Value (%) AS Per 2720 (Part-16)	TYPE OF SOIL
			Gravel %	Sand %	Silt & Clay %	LL	PL	PI	MDD gm/cc	OMC %			
1	394+100	RHS	10.68	37.43	51.89	37	22.88	14.12	1.95	12.9	27.64	9.09	MI
2	398+300	LHS	25.67	37.35	36.98	32	20.43	11.57	2.05	9.91	19.28	13.63	CL
3	406+500	RHS	6.35	43.78	49.87	33	20.65	12.35	1.96	12.89	26.74	10.18	CL
4	412+300	LHS	8.28	35.76	55.96	39.23	24.34	14.89	1.95	12.06	23.5	9.52	MI
5	416+600	RHS	5.79	40.52	53.69	36.62	22.54	14.08	1.91	11.8	26	7.49	MI
6	417+500	LHS	7.32	39.88	52.8	37.14	20.24	16.9	1.96	11.56	23	9.23	CI
7	419+000	RHS	9.73	38.3	51.97	33	22.95	10.05	1.99	11.26	21	10.27	CL
8	421+800	LHS	12.15	39.27	48.58	29	20.47	8.53	2	10.15	20	14.29	CL

Sr. No.	Existing Chainage in km.	Side	Grain Size Analysis Test (%) As Per IS 2720 (Part-4)			Atterberg Limits (%) IS 2720 (Part-5)			Proctor Density AS Per IS 2720 (Part-8)		F.S.I % AS Per IS 2720 (Part -40)	CBR Value (%) AS Per 2720 (Part-16)	TYPE OF SOIL
			Gravel %	Sand %	Silt & Clay %	LL	PL	PI	MDD gm/cc	OMC %			
9	423+100	LHS	6.63	35.97	57.4	39.41	18.18	21.23	1.95	12.4	24.5	9.68	**CI**
10	423+600	RHS	6.58	33.18	60.24	40	21.94	18.06	1.94	12.65	25	8.56	**CI**
11	425+300	LHS	7.85	33.79	58.36	41.17	21.2	19.97	1.94	11.67	25.5	9.45	**CI**
12	425+600	LHS	5.18	32.88	61.94	41	23.73	17.27	1.93	12.99	26	7.89	**CI**
13	426+100	RHS	11.34	40.29	48.37	32	18.33	13.67	1.98	10.24	22	12.11	**CL**
14	426+000	RHS	9.68	42.45	47.87	28	20.68	7.32	1.99	10.32	22	10.95	**CL**
15	436+900	RHS	9.81	37.54	52.65	35.24	24.47	10.77	1.97	11.17	23	10.05	**MI**

6.1.2.6 Coarse Aggregate

The objective of this investigation is to identify, inspect and evaluate the aggregate sources, which would supply for the pavement and concrete, quality aggregate for the road construction. During the site visit, aggregate quarries are observed along the alignment. Existing and known quarries/crushing plants and other potential extraction sources of quarry areas in the project vicinity have been inspected. Quarry details of Stone Aggregates & Boulders are attached below in **Table-6.6**.

Table-6.6 Quarry Details of Stone Aggregate and Boulders

Package	Type of material	Stone Aggregate & Boulder								Districts
	Source Point	Kabrai - Granite quarry	Shankargarh - Stone quarry	Mirzapur-Marihan Quarry	Sonbhadra-Dalla stone quarry	km 93 of Bareilly & Bageshwar road	Jamala-Stone Quarry	Bharat Kup-Stone Quarry	Jwalapur/ Haridwar	District HQ
	Proposed Camp Location (km & Village)									
9	418.45 - Village - Algangarh	161	209	340	420	361	198	205	507	Unnao

Summary & Test Result details of Coarse Aggregates is attached in Table-6.7 below:

Table-6.7 Test Result details of Coarse Aggregates

Sr. No.	Location (km/Village)	Coarse Aggregate	Gradation	LAV (%)	AIV (%)	FI & EI (%)	Specific Gravity	Water Absorption (%)
33	**418.45 - Village - Algangarh**	**Kabrai - Granite quarry**	**OK**	18.11	15.25	26.61	2.67	0.72
34		**Jamala-Stone Quarry**	**OK**	16.95	13.88	25.42	2.7	0.69
35		**Bharat Kup-Stone Quarry**	**OK**	18.18	14.82	26.77	2.69	0.72
36		**Meja Stone Quarry**	**OK**	17.83	15.2	28	2.7	0.71

6.1.2.7 Fine Aggregate

For masonry work, sand shall conform to the requirements of IS: 2116.

For plain and reinforced cement concrete (PCC and RCC) or pre stressed concrete (PSC) works, fine aggregate shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attach the embedded steel. Motorized sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386 (Parts I to VIII). The contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Sand/fine aggregate for structural concrete shall conform to the following grading requirements grading requirements as per MORTH Table – 1000-2.

Table 6.8 below shows the location of these sand quarries along with lead to the Project Road.

Table-6.8 Sand Quarry Details

Package	Type of material	Coarse Sand					Districts
	Source Point	Hamirpur	Banda – Ken river	Allahabad-Mahewa ghat quarry	Lal kuan - Gola (UK)	Chaupan	District HQ
	Proposed Camp Location (km & Village)						
9	418.45 - Village -Algangarh	96.2	151	190	360	401	Unnao

The representative Sand samples were collected from mines. Sand sources are generally suitable for fine aggregate materials in bituminous works and Concrete works but would require the removal of deleterious materials and Clay /Silt contents. From the test results it is observed that from all source, sand is as we require as per is 383. However, gradation may vary from location to locations at different bed level. Though there are certain frequency of tests & type of test may be conducted during construction test results shows that sand samples from all sources are falling in zone 2 also bulk density ranging from 2 to 3.5 and hence also suitable for RCC / Masonry work.

Table-6.9 Summary & details of Fine Aggregate test results

Sr. No.	Location (km/Village)	Fine Aggregate	Gradation	Bulking of Sand (%)	Silt of Sand (%)	Specific Gravity
1	**418.45 - Village - Algangarh**	**Hamirpur**	**OK**	10.6	2.27	2.6
2		**Banda**	**OK**	10	1.73	2.58

6.1.2.8 Manufactured Material

The bitumen, cement, steel, etc. are factory manufactured materials used in road projects. Reputed manufacturers are spread at different locations in the vicinity and materials are recommended to be procured directly from them.

6.1.2.9 Water Sources

Detailed survey for potential water sources for use in construction of cement concrete works and other works have been carried out in the vicinity of the project corridor at certain intervals. Water is available from underground water mainly through tube wells and mainly as surface water from major rivers.

6.1.2.10 Fly Ash

Fly Ash and bottom ash are the by-products of combustion of pulverized coal in thermal power plants. Fly Ash is the fine grained dusty material collected from the flue gases using suitable electrostatic precipitators. Bottom ash is the slag which accumulates on the heat absorbing surfaces of the furnace and subsequently falls through the furnace bottom to the ash hopper below. At the ash hopper it is then removed and hydraulically transported to the storage area.

Pond ash refers to the ash collected and stored in the ash ponds by the hydraulic fill method. It is obtained as the mixture of bottom ash and fly ash. Coarser variety of ash in the pond is usually obtained at the inflow point where the slurry from the pipeline is discharged. Finer variety at the out flow point where clean water is decanted.

As per the circular issued by MoEF&CC, The Gazatte of India dated 25th January 2016, pond ash shall be collected within 300km periphery of the project area.

6.2 PAVEMENT DESIGN

6.2.1 Introduction

Pavement design basically aims at determining the total thickness of the pavement structure as well as the thickness of the individual structural components for carrying the estimated traffic loading(MSA) under the prevailing traffic and environmental conditions. Many design methods, from purely empirical to rigorous analytical ones are available, and these are practiced in different parts of the world. The design practices followed in other countries May not be applicable to the Indian traffic and climatic conditions. Latest IRC 37:2018 provisions has been adopted for project pavement design considering the prevailing and horizon year traffic loading the subgrade soils are modified using stabilization technique.

6.2.2 Design Methodology

Pavement design involves 593.947km of Ganga Expressway. The design is based on the parameters as evaluated from field and laboratory investigations, with the objective to ascertain optimal pavement structure. While designing the pavement crust thickness and individual layers for the expressway, requirements of traffic loading and the provisions of the latest codes and UPEIDA guidelines are given consideration. The structural requirements of the pavement for both the roads are governed by:

(i) The total thickness of the pavement and the thickness of individual layers should be designed in such a way that they are not subjected to distress, exceeding those admissible limits in view of the material characteristics and performance factors,

(ii) The pavement layers should be able to withstand repeated applications of wheel loads of different magnitudes under the actual site conditions of sub grade, climate, drainage, and other environmental factors during its design life without causing:

a. excessive permanent deformation (settlement) in the form of rutting and undulations;
b. cracking of bituminous layers; and
c. other structural and functional deficiencies such as potholes, raveling etc.

(iii) Ensure structural and functional performance under varied conditions and factors affecting the performance of the road i.e. soil type, traffic, environment, etc.

6.2.2.1 Pavement Proposals & Design

(a) Based on adopted design methodology, Design Life of 20 years, calculated CBR value of Subgrade, Design Traffic, VDF & MSA values; Package wise total crust provided for main carriageway is tabulated below in **Table 6.10**:

Table-6.10 Package wise Crust Details for Main Carriageway

Proposed Crust For Main Carriageway										
Package No.	Section		Length (m)	Adopted MSA (20 Years)	Design CBR	Crust Composition (in mm)				
	From	To				Subgrade	GSB	WMM	DBM	BC
IX	391.90	445.00	53.10	98	8%	500	200	150	155	40

(b) Service roads have been designed for 5 MSA with design CBR of 8%. The crust composition of service roads is given in Table below:

Table-6.11 Crust Details for Service Road

Proposed Crust For Service Road							
Package No.	Design MSA	Design CBR	Crust Composition (in mm)				
			BC	DBM	WMM	GSB	Subgrade
IX	5	8%	30	50	150	150	500

Package wise Pavement Design of above proposed crust for main carriageway is attached below:

Pavement Design- Package-9

Ganga Expressway - Package - 9							
Stress Table - 2018							
		Va	3.5	Vb	11.5		
Option -3		20 Years - design			Thickness Adopted		
		MSA		98.00	BC	40	
S No	Strain	Alllowable Strain	Computed Strain	Remarks	DBM	155	195
1	€t at BT	1.498E-04	1.49E-04	OK	WMM	150	
2	€v at top of sub grade	3.204E-04	2.99E-04	OK	GSB	200	350

VIEW RESULTS

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No. of layers                3
E values (MPa)          3000.00  185.93   66.60
Mu values                  0.350.350.35
thicknesses (mm)         195.00  350.00
single wheel load (N) 20000.00
tyre pressure (MPa)        0.56
Dual  Wheel
  Z         R       SigmaZ       SigmaT      SigmaR      TaoRZ       DispZ       epZ         epT         epR
195.00     0.00-0.6439E-01 0.5725E+00 0.4659E+00-0.1105E-01 0.3637E+00-0.1426E-03 0.1440E-03 0.9603E-04
195.00L    0.00-0.6439E-01 0.2957E-02-0.3648E-02-0.1105E-01 0.3637E+00-0.3450E-03 0.1440E-03 0.9603E-04
195.00   155.00-0.6235E-01 0.5559E+00 0.3704E+00-0.2812E-01 0.3738E+00-0.1289E-03 0.1494E-03 0.6587E-04
195.00L  155.00-0.6235E-01 0.2962E-02-0.8537E-02-0.2812E-01 0.3738E+00-0.3248E-03 0.1494E-03 0.6587E-04
545.00     0.00-0.1823E-01 0.2091E-01 0.1840E-01-0.2673E-02 0.2882E+00-0.1721E-03 0.1122E-03 0.9393E-04
545.00L    0.00-0.1819E-01 0.1203E-02 0.2818E-03-0.2673E-02 0.2882E+00-0.2809E-03 0.1122E-03 0.9351E-04
545.00   155.00-0.1926E-01 0.2215E-01 0.2043E-01-0.3458E-02 0.2945E+00-0.1837E-03 0.1169E-03 0.1044E-03
545.00L  155.00-0.1926E-01 0.1276E-02 0.6633E-03-0.3459E-02 0.2945E+00-0.2994E-03 0.1169E-03 0.1045E-03
```

7. Hydrological Studies & Drainage Design

7.1 HYDROLOGY FOR BRIDGES

7.1.1 Main Objective

The main objective of the hydrological and hydraulic study is to determine the required size of drainage structures to allow the estimated design flow of the streams to cross the road safely, and to check whether waterways of existing structures are sufficient to transmit the flow without risk so that appropriate decisions could be taken concerning their dimensions.

The hydrological and hydraulic study for the project has been based on:

- Topographic survey data of cross drainage structures.
- Topographic data and maps of streams, upstream and downstream.
- HFL from local enquiries and telltale marks and hydraulic conditions at the existing drainage structures and data provided by C.W.C.

7.1.2 General Description of the Project Site

The project alignment starts from village-Raiyamau (Dist. Unnao) Km 391+900 & terminates at village-Sarso (Dist. Unnao) Km 445+000. The length of the proposed expressway alignment is 53.100 km.

There are numerous rivers & streams crossing the alignment, which are generally flowing from left to right in the direction of increasing chainages.

The elevation of the project road varies from 90 m to 225 m. The normal annual rainfall varies from 933 mm to 980 mm. The monsoon is spread from June to September and the monsoon seasonal rainfall is about 85-90% of the annual rainfall. The mean annual temperature near the sites ranges between 24.7^{0}C to 26.3^{0}C.

7.1.3 Data Collection & Data Analysis

Requirements for Hydrological and Hydraulic Design

The hydrological study aims at estimating the peak discharge of the flood generated by the run-off of rainfall within the catchment area. The hydrological study requires:

- Knowledge of the characteristics of peak rainfall in the regions.
- Knowledge of the characteristics of the catchment areas.
- Topographic data about the stream, upstream and downstream.
- Survey of India toposheets maps to a scale of 1:50,000 and 1:250000 for identification of catchment area and its characteristics.

Data Collection

Topographical surveys have been done at river crossings with a view to obtain the cross sections of the rivers at the centre line of the road and up to a reasonable distance at upstream and downstream. The High Flood Levels (HFL) have been obtained from existing flood marks or ascertained from enquiry with local knowledgeable persons.

The characteristics of the catchment areas have been ascertained from Survey of India toposheets having a scale of 1:50,000 and 1:2,50,000 from which catchment area at the proposed bridge site, length of the stream and fall in elevation from originating point to the point of crossing, could be determined. Slope of the stream has been determined from the contours on the toposheets.

For rivers/streams having catchment area more than 25 sq. km, CWC Report on Flood Estimation Report for Middle Ganga Plain Subzone and Upper Indo-Ganga Plain Subzone has been used for calculating design discharge. This Report has been referred for determining the characteristics of peak rainfall regimes. The report has been jointly prepared by CWC, MOST, Ministry of Railways and IMD and contains all the rainfall data required for estimation of design discharge of 25, 50- and 100-year returns periods by applying the Synthetic Unit Hydrograph approach, the parameters of which have been indicated in the above report.

Return Period and Rainfall

As per IRC: 5 – 2015 (Standard Specifications and Code of Practice for Road Bridges, Section – 1, General Features of Design) the bridges are designed for a return period of 100 years.

The 100-year, 24-hour rainfall for the zone under consideration varies from 280 mm to 320 mm. (Ref: Report on Flood Estimation Report for Middle Ganga Plain Subzone and Upper Indo-Ganga Plain Subzone published by CWC.)

7.1.4 Hydrological Study for Major & Minor Bridges

Design engineers essentially need the design flood of a specific return period for fixing the waterway vis-a-vis the design HFL of bridges depending upon their size and importance to ensure safety as well as economy. IRC: 5-2015, Section – I General Features of Design specify that the waterway of a bridge is to be designed for a maximum flood discharge of 100 years return period.
The following methods have been used to estimate the peak discharge for bridge site:

- Rational Method
- Synthetic Unit Hydrograph Method
- Area Velocity Method
- Method of Transposition using Catchment Area Proportion method

The following method has been used to estimate the design high flood level corresponding to the design flood:

- HEC – RAS Computations

These methods have been discussed in detail as indicated below in subhead of Hydrological Aspect.

7.1.4.1 Hydrological & Hydraulic Design Aspect

a) Estimation of Input Data for Hydrological Analysis

Catchment Area, length of critical point to the structure and slope of fall in river from critical point to structure along with rainfall data is required for estimation design discharge.

On survey of India Topographic map, catchment area is plotted for each bridge and measured. Length of critical point to structure and slope of fall in river from critical point is also measured. 24 hr rainfall for 100 yr return period is also taken from CWC Report No. SB/8/1984 - Flood Estimation Report for sub zone 1(c).

b) Rational Method

$$Q = 0.028 \times P \times f \times A \times I_C$$

Where,

Q	=	Maximum runoff in cumecs
A	=	Catchment area in hectares
Ic	=	Critical intensity of rainfall in cm/ hr.
P	=	Coefficient of run-off for the given catchment characteristics.
f	=	Spread factor for converting point rainfall into area mean rainfall.
Ic	=	(F/T)*(T+1) / (T_c+1)
F	=	Total Rainfall of T hours duration (24 hrs.) in cm, corresponding to 100 yrs return period.
T	=	Duration of total rainfall (F) in hours= 24 hrs.
Tc	=	Time of concentration in hour.

Time of Concentration

Times of concentrations (T_C) are determined on the basis of stream lengths (L_C) and shape of catchment as well as from terrain slope and cover conditions from the toposheets as well as hydrological survey data of stream. The values are found both by Dicken's (Empirical) formulae as well as from time of travel from furthest point of catchment as follows:

Dicken's Formula

$$T_c = [0.87(L^3/H)]^{0.385}$$

Where L is the length of catchment in km and H is the elevation difference in meter in length L.

c) Synthetic Unit Hydrograph (SUH) Approach (Ref. Flood Estimation Report on Middle Ganga Plain Subzone and Upper Indo-Ganga Plain Subzone

This method has been used for those bridges, which cater for more than 25 sq. km of catchment area.

In this method 1 hour, 2 hour and 6-hour Synthetic Unit Hydrograph is determined for an ungauged catchment. Following steps have been followed as suggested in CWC report for determination of discharge by this method.

(i) Physiographic parameters of the ungauged catchment have been determined from toposheets.

Parameter	Definition	Unit
L	Length of longest main stream along the river course	Km
Lc	Length of longest main stream from a point opposite to centroid of the catchment area to dam	Km
A	Catchment Area of River	Km^2
S	Equivalent Stream Slope	m/ km

(ii) SUH parameters have been computed using the following equations:

(a) For Upper Indo-Ganga Plain Subzone

Parameter	Definition	Formula	Unit
q_p	Peak discharge of unit hydrograph per unit area per sq.km. in cumecs	2.030/(L/S^0.5)^649	m^3/km^2
t_p	Time lag from centre of unit rainfall duration to Peak of unit hydrograph in hrs.	1.858/(qp)^1.038	hrs
W_{50}	Width of UH at 50% of peak discharge (Qp) in hrs	2.217(qp)-.990	hrs
W_{75}	Width of UH at 75% of peak discharge (Qp) in hrs.	1.477(qp) -.876	hrs
W_{R50}	Width of UH at 50% of Qp bet. Raising limb and Qp ordinate in hrs.	0.812(qp)-.907	hrs
W_{R75}	Width of UH at 75% of Qp bet. Raising limb and Qp ordinate in hrs.	.606(qp)-.791	hrs
T_B	Base Period of UH in hrs.	7.744(tp)0.779	hrs
T_M	Time from start of raising limb to peak of UH in hrs.	tp + tr/2	hrs
Q_P	Peak discharge of unit hydrograph in hrs.	qp x A	hrs

(b) For Middle Ganga Plain Subzone

Parameter	Definition	Formula	Unit
q_p	Peak discharge of unit hydrograph per unit area per sq.km. in cumecs	0.409/(L/S^0.5)^.456	m^3/km^2
tp	Time lag from centre of unit rainfall duration to Peak of unit hydrograph in hrs.	1.217/(qp)^1.034	hrs
W50	Width of UH at 50% of peak discharge (Qp) in hrs.	1.743(qp)-1.104	hrs
W75	Width of UH at 75% of peak discharge (Qp) in hrs	.902(qp) -1.108	hrs
WR50	Width of UH at 50% of Qp bet. Raising limb and Qp ordinate in hrs.	1.743(qp)-1.104	hrs
WR75	Width of UH at 75% of Qp bet. Raising limb and Qp ordinate in hrs.	.478(qp)-.902	hrs
TB	Base Period of UH in hrs.	16.432(tp)0.646	hrs
TM	Time from start of raising limb to peak of UH in hrs.	tp + tr/2	hrs
QP	Peak discharge of unit hydrograph in hrs.	qp x A	hrs

(iii) The estimated parameters of unit hydrograph in (b) have been plotted and the plotted points were joined to draw synthetic unit hydrograph. The discharge ordinates of SUH at interval of unit hour duration were found out from the equation of the plotted graph. The obtained value of the ordinates is adjusted in order to get proper unit hydrograph shape and area under the unit hydrograph. The unit hydrograph ordinates are summed up and multiplied by the unit hour duration and compared with the volume of 1 cm direct runoff depth over catchment computed by the formula as given below:

$$Q = (A \times d) / (tr \times 0.36)$$

(iv) The design storm duration has been taken as equal to base period of unit graph (TB =1.1* tp).

(v) Point rainfall is read from the given plate in CWC report for 100 year 24 hr rainfall and has been converted to areal rainfall of 100 years and design storm duration.

(vi) The areal rainfall of design storm duration is split into 1-hour rainfall increments using time distribution coefficients.

(vii) Estimation of effective rainfall excess unit has been done after considering design loss rate.

(viii) Base flow has been estimated based upon the catchment area.

(ix) Finally, for 100 year peak discharge, the effective rainfall excess after removing the losses from rainfall increments are arranged against unit hydrograph ordinates such that the maximum of effective rainfall is placed against the maximum UG ordinate, next lower value of effective rainfall against next lower value of UG ordinate and so on. Sum of the product of the above two added together with base flow gives peak discharge.

d) Area Velocity Method/ Slope Area Method

This method has been utilized to calculate the discharge from the stream cross section and stream slope/bed slope at the proposed bridge sites, for bridges. After plotting the cross section of the river, and marking the observed HFL, the cross sectional area (A) and wetted perimeter (P) have been computed. In the absence of the flood slope of the stream, the bed slope of the river has been estimated along its length.

The velocity and Discharge have been calculated using the Manning's formula:

$$V = 1/n * R^{2/3} * S^{1/2}$$

$$Q = A \times V$$

Where,
V = Velocity in m/sec;
R = Hydraulic mean depth in m S = Flood slope/bed slope
n = Co-efficient of rugosity
Q = Peak Discharge
A = Area of cross section

The value of 'n' has been adopted as per soil criteria and river bed characteristics, observed at site and are based on Table 3 in IRC SP-13 which has been tabulated below.

Surface	Perfect	Good	Fair	Bad
Natural Streams				
1. Clean, straight bank, full stage, no rifts or deep pools	0.025	0.0275	0.030	0.033
2. Same as (I), but some weeds and stones	0.030	0.033	0.035	0.040
3. Winding, some pools and shoals, clean	0.035	0.040	0.045	0.050
4. Same as (3), lower stages, more ineffective slope and sections	0.040	0.045	0.050	0.055
5. Same as (3) some weeds and stones	0.033	0.035	0.040	0.045
6. Same as (4), stony sections	0.045	0.050	0.055	0.060
7. Sluggish river reaches, rather weedy or with very deep pools	0.050	0.060	0.070	0.080
8. Very weedy reaches	0.075	0.100	0.125	0.150

The discharge obtained using Slope area method has been used to determine the design HFL including the afflux.

e) Method of Transposition using Catchment Area Proportion Method

The CWC maintains records for the Gauge and Discharge relation for every major river. For such rivers, the other methods such as Rational and Synthetic Unit Hydrograph method does not hold valid. For such cases, the information on the maximum observed flood shall be collected from CWC or other relevant sources, which fall, in vicinity to the proposed bridges on the same river. The annual maximum observed flood is then transposed from the observatory site to the bridge site under consideration using Catchment area proportion method. This transposed discharge at bridge site is then used to determine the high flood level and the relevant hydraulic parameters.

7.1.4.2 Afflux Calculation

Since some of the bridges in the alignment have less clear waterway as compared to natural stream width and also velocities at bridge sites are high due to steep bed slopes, this combined effect causes afflux at bridge sites during flood. Afflux for the bridges has been calculated using Weir and Orifice formulae as described in IRC 5-2015.

As per IRC:5-2015, Cl. 06.6.2 Molesworth formula is given by

$$h = \{V^2/17.88 + 0.01524\} \times \{(A/a)^2 - 1\}$$

h = afflux in meters
V = is the mean velocity to normal HFL of flow in the river prior to bridge construction i.e. corresponding
A = Area of flow section at normal HFL in the approach river section.
a = Area of flow section under the bridge.

7.1.4.3 Development of Stage-Discharge Curve Using HEC – RAS Software

The stage – discharge curve for the bridge sections were determined by HEC-RAS analyses. HEC- RAS is a mathematical model developed by Hydrologic Engineering Centre USA and widely used for River Analyses System. The X-sectional and L-sectional data observed from the field survey at the bridge sites were used as input data for finding the rating curve of the bridge section. The manning's roughness coefficient is an important input data for the HEC-RAS analyses and proper values of 0.035 to 0.04 were provided for the channel and flood plain of the river sections based on the river bed and the river channel. These data were taken from the literatures of open channel hydraulics. The results obtained from the HEC-RAS analyses and water level records have been annexed.

7.1.5 Scour Depth

Various hydraulic parameters e.g. HFL, normal waterway, normal depth of scour under bridges, Maximum scour level at bridge piers and abutments, Froude's number of flow (for scoured waterway under bridges), fluming ratio, afflux etc., are given in detailed sheet attached with **hydrological report**.

Scour Depth

Lacey's equation is adopted for estimating normal scour depth as per IRC: 5

$$R = 1.34\,(q^2/f)^{1/3}$$

Where R is the Lacey's regime scour depth, measured below HFL, q is the design discharge intensity under bridge in cumecs per meter and f is silt factor given by the equation

$$f = 1.76\ (d_{50})^{1/2}$$

Where d50 is the mean sediment size in mm. Normal scour depth based on Lacey's equation and the actual observed depth (equal to the difference between HFL and LBL)/1.27 are compared as per code. Higher of the two values is adopted for design. Silt factor 'f' is found from Lacey's equation corresponding to d50 size of bed materials. Maximum scour level for pier and abutment are calculated using a factor of safety of 2 and 1.27, respectively as per IRC: Code-5. For computing scour depth, design discharge is enhanced by 30% to provide for adequate margin of safety as per provision of IRC: 78 - 2000. The scour depth calculations based upon the silt factor as per surface bed material, are given in hydrological report separately.

7.1.6 Summary & Recommendation

The design discharge has been calculated for 100-year return period flood by the following methods:

- For catchment area greater than 25 sq. km by Synthetic Unit Hydrograph as per CWC Flood Estimation Report
- Area-Velocity Method.
- Rational Method as per IRC:SP-13:2004

The catchment area has been calculated on Survey of India Map on scale of 1:50,000 and 1:1,25,000.

HFL has been established by:

- Local enquiry and Observed Flood Marks, where available.
- HEC – RAS software developed by U.S. Army Corps of Engineers.

The linear waterway calculations have been calculated by Lacey's Perimeter and as per CWC guidelines.

When a new bridge is to be constructed, a designer has all the freedom to provide waterway as required. As per IRC-5:2015 clause 106, waterway (W) should be equal to Lacey's regime waterway (P) given by the equation:

$$P = W = C\ (Q^{1/2})$$

Where,
Q = design flood discharge in m3/s P = Wetted perimeter in meters
W = Linear waterway in meters (for wide river W is almost equal to P)

C = a constant usually taken as 4.8 for regime channels but it may vary from 4.5 to 6.3 according to local conditions.

The code also stipulates that the waterway so found should also be compared with linear waterway at HFL corresponding to design flood discharge and the minimum of the two should be adopted as the clear waterway under the bridge.

7.1.7 Results of the Hydrological Studies

The detailed hydrological and hydraulic calculations have been carried out for all the major and minor bridges. The hydrological analysis for the major and important bridges has been presented in **hydrological report** separately.

7.2 DRAINAGE DESIGN

7.2.1 Introduction

The construction of the expressway embankment will unavoidably obstruct the natural overland flow and flow through the local channels. Suitable bridge / culvert openings have therefore been proposed across natural drainage channels with a view to pass the discharges with minimal disturbances caused to the natural flow regime.

In addition to these bridges / culverts, localized drainage arrangements consisting of longitudinal drains and additional culverts are required to be developed to divert the overland flow (which would otherwise meet the natural stream at some downstream point) intercepted by the expressway embankment into the nearest natural drainage channel. Moreover, these local drainage arrangements have been designed to carry the runoff from the surface of the proposed expressway, too.

As such, development of a drainage system on micro area basis and integration of the same with the overall natural drainage network of the area shall ensure effective drainage of the whole area upstream of the proposed embankment and the expressway as well.

In developing the localized drainage systems, the issues which have been addressed are as follows:

a) Identification of local depressions / channels crossings the proposed alignment and naturally attracting overland flow towards them
b) Assessment of flow direction at those localized areas
c) Identification of local ridges - natural or manmade canals etc.
d) Distances between local depressions and nearest local ridges and corresponding land slope
e) Identification of natural storage areas like ponds, lakes etc.

7.2.2 Components of Road Drainage System and Design Methodology

The road drainage system shall consist of the following:

7.2.2.1 Drainage of Embankment

It is mandatory to design a system to carry runoff from top of embankment safely into the carrier channel. The system shall ensure safe disposal of surface runoff without erosion of earthen shoulder / slope / embankment toe. Considering the project of expressway standards, kerb and chute system for surface water disposal is proposed.

The basic design principles for avoiding accumulation of water on the road surface are:

a) Provision of suitable longitudinal slope

b) Provision of suitable cross slope (both-sides or unidirectional as applicable for the road stretch under consideration i.e. straight, curved, super elevated etc.
c) Provision of GSB layer with sufficient permeability extending up to embankment slope for all sections and provision of horizontal cut-off in waterlogged areas depending on the duration and extent of waterlogging.
d) Provision of shoulder drain (along the edge of shoulder in high embankments) which will empty into chute drains
e) Provision of Median drains for sections where medians wider than 5m. Also wherever the expressway section is in super-elevation in raised median, median drain would be required.
f) Provision of pipe drains to carry accumulated water from catch pits on medians up to the carrier channels / chutes.
g) Provision of chute drains with energy dissipation arrangement in high embankments to safely discharge runoff from embankment top into toe channels. The longitudinal spacing of the chute drains shall be kept at 20 m.
h) Provision of turfing with native vegetation / stone pitching / geotextile for protecting embankment slope from formation of gullies by rain wash.
i) Provision of lined drain between main carriageway and service road. Energy dissipation basin to be interconnected through lined drain. Wherever service road are not present, unlined drain to be provided.

7.2.2.2 Roadside Toe Drains

Roadside toe drains shall be provided to receive discharge from embankment surface and ROW of the embankment and carry it safely to the nearest outfall point ensuring safety to the embankment toe, which is the area most vulnerable to erosion / failure.

Roadside drains shall generally be provided on both sides of the embankment to safely carry the discharge from the embankment without jeopardizing the safety of the toe. For limited stretches, particularly near the approaches to rivers where the existing ground slope is steep enough to carry the upstream discharge up to the rivers, roadside drains shall be discontinued. Otherwise, these drains shall be carried on both sides of the widened embankment.

The alignment of the drains shall depend on the topography of the area and the type of drain selected. For stretches, where the natural ground slope is towards the embankment toe, the drain shall be provided at the toe point and lined suitably. For stretches, where the ground slope is away from the embankment toe, the drains may be provided at the edge of ROW and these drains may not be lined. IRC: SP-42: 2014 permits construction of unlined drains beyond a point where an imaginary line drawn from the shoulder edge at a slope of 4(H): 1(V) intersects the natural ground. However, maintenance of unlined drains is difficult. Unlined Drains are, therefore, not considered for recommendation.

The shape and size of the roadside drains shall be decided on the basis of length of embankment being served by the drain up to the nearest outfall point.

For stretches passing through urban areas, rectangular covered drains shall be recommended for safety reasons.

For rural areas, the drains shall be open and trapezoidal with 1:1 side slope. As the topography in general is quite flat, optimization of the length of drain, bed width and depth of flow shall be necessary to reduce the top width of the drain (land width required for construction of drain). To reduce the length of drain up to nearest outfall and consequently the section, intermediate balancing culverts shall be provided at suitable locations. These drains may also terminate at local roadside ponds, if feasible. The minimum bed width and depth of flow at starting section shall be 500 mm and 300 mm respectively. The sections shall be gradually increased in terms of bed width and depth of flow up to the outfall point.

7.2.2.3 Median Drains

For raised medians in super-elevated sections, concrete drains have been provided in the median. These shall be provided on the entire length of the horizontal curve. These shall facilitate drainage of the surface runoff from the outer carriageway.

Typical cross sections of the proposed road provide the typical arrangement of these drains.

7.2.2.4 Methodology for Design of Drains

The design discharge (25 Year Return Period) for the shoulder drains at high embankment sections and the roadside drains has been estimated on the basis of Rational Formula while the hydraulic design has been done with the help of Manning's Formula.

Steps involved for design of shoulder drains and roadside drains are as follows:

a) Computation of the Average coefficient of runoff (P_{av}) for composite surfaces.

$$P_{av} = (P1*A1+P2*A2)/ (A1+A2)$$

Where, P1, A1 and P2, A2 are the respective runoff coefficients and contributing areas applicable for paved road portion and adjacent built up / agricultural areas.

b) Computation of the Time of Concentration (Tc) has been done taking extreme boundary of the ROW as the remotest point.

Tc = Inlet time (from adjacent land) + Flow time in the drain.

c) Computation of the Catchment area (At) contributing flow to the drain.
At = (width of paved surface + width of adjacent land) * length of road under consideration.

d) Rainfall analysis – 25 year, 24-hr point rainfall has been taken from the Isopluvial Map of the area, as given in CWC Report on Flood Estimation Report for Middle Ganga Plain Subzone and Upper Indo-Ganga Plain Subzone.

e) Based on the above data, drainage discharge is found by using Rational method

$$Q = 0.028\ P\ X\ f\ X\ I_C\ X\ A$$

Where Q= the design discharge in m3/sec, f is the spread factor, taken as 1.0 (for small catchment), P is the mean run-off coefficient, Ic is the design rainfall intensity in cm/hr corresponding to time of concentration (tc) in hour and A is the catchment area in hectares.

8. PROPOSALS FOR STRUCTURES & INTERCHANGES

8.1 GENERAL

The proposed Ganga Expressway is Virgin/Greenfield alignment; hence there is not any existing structure on the alignment. There is not any improvement proposal required hence proposals for only new Major Bridges, Minor Bridges, ROBs, VUPs, LVUPs, SVUPs, PUPs/CUPs, Flyovers, Elevated structures & other Interchanges have been made at required locations with 8 Lane Expressway configuration.

8.2 PROPOSALS FOR MAJOR BRIDGES

There is 1 of Major Bridge proposed on the alignment. The details of the proposed Major Bridge are given in the **Table 8.1**.

Service roads shall be discontinued at major bridge locations.

Deck Width - Overall deck width of is 21.25 m. proposed structures are for dual carriageway with 2 decks separated by open to sky median.

Table -8.1 List of Major Bridges

S. No.	Chainage	Type of Crossing	Type of Structure			Span Arrangement	Width of Structure	Skew Angle, if any	Remarks
			Found-ation	Sub Structure	Super Structure				
1	422+002	Canal+Road	Well	R.C.C.	PSC Box Girder	3 X 20.033	2x21.25	45	Package-9

8.3 PROPOSALS FOR MINOR BRIDGES

There are total 127 numbers of Minor bridges proposed on the alignment. The details of the proposed Minor bridges are given in the **Table 8.2**.

All structures that are proposed will have new 8-lane configurations with dual carriageway separated with median. The structures have been designed to cater 8 lanes vehicular traffic.

Table- 8.2 List of Minor Bridges

S. No.	Chainage	Type of Crossing	Type of Structure			Span Arrangement	Width of Structure	Skew Angle, if any	Remarks
			Found-ation	Sub Structure	Super Structure				
1	392+612	Canal	Raft	Box MNB	Box MNB	1X8	2X21.25	44	Package-9
2	394+132	Stream/ Nallah	Raft	Box MNB	Box MNB	1X10X5	2X21.25	9	Package-9
3	397+182	Canal+Road	Raft	Box MNB	Box MNB	2 x 7.5 x 7.5	2X21.25	49	Package-9
4	401+175	Stream/ Nallah	Raft	Box MNB	Box MNB	1X8X5	2X21.25	0	Package-9
5	402+750	Stream/ Nallah	Raft	MNB	MNB	1X25	2X21.25	0	Package-9
6	407+037	Stream/ Nallah	Raft	Box MNB	Box MNB	1X10X5	2X21.25	0	Package-9
7	408+332	Stream/ Nallah	Raft	MNB	MNB	1 X 20	2X21.25	45	Package-9
8	414+612	Canal+Road	Raft	Box MNB	Box MNB	1x13	2X21.25	24	Package-9
9	420+322	Stream/ Nallah	Raft	Box MNB	Box MNB	2X8X5	2X21.25	0	Package-9

S. No.	Chainage	Type of Crossing	Type of Structure			Span Arrangement	Width of Structure	Skew Angle, if any	Remarks
			Found-ation	Sub Structure	Super Structure				
10	428+544	Canal	Raft	Box MNB	Box MNB	1X8	2X21.25	0	Package-9
11	431+336	Stream/ Nallah	Raft	MNB	MNB	1X30	2X21.25	24	Package-9
12	433+605	Canal+Road	Raft	Box MNB	Box MNB	1x13	2X21.25	0	Package-9
13	436+039	Canal+Road	Raft	Box MNB	Box MNB	1X10	2X21.25	29	Package-9
14	440+437	Gas Pipe Line	Raft	MNB (Portal Frame)	MNB (Portal Frame)	1X9	2X21.25	56	Package-9

8.4 PROPOSALS FOR CULVERTS

Total 79 Balancing Culverts have been proposed on the project expressway. List of culverts is attached below in **Table-8.3**.

Table-8.3 List of Culverts

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
1	392+180	Culvert	2	2	2X21.25	Package-9
2	393+093	Culvert	2	2	2X21.25	Package-9
3	394+717	Culvert	2	2	2X21.25	Package-9
4	395+170	Culvert	2	2	2X21.25	Package-9
5	396+761	Culvert	2	2	2X21.25	Package-9
6	397+550	Culvert	2	2	2X21.25	Package-9
7	398+245	Culvert	3	3	2X21.25	Package-9
8	399+192	Culvert	3	3	2X21.25	Package-9
9	399+630	Culvert	2	2	2X21.25	Package-9
10	400+002	Culvert	3	3	2X21.25	Package-9
11	400+670	Culvert	2	2	2X21.25	Package-9
12	401+580	Culvert	2	2	2X21.25	Package-9
13	402+530	Culvert	2	2	2X21.25	Package-9
14	403+413	Culvert	2	2	2X21.25	Package-9
15	403+850	Culvert	3	3	2X21.25	Package-9
16	404+176	Culvert	3	3	2X21.25	Package-9
17	405+500	Culvert	2	2	2X21.25	Package-9
18	406+430	Culvert	2	2	2X21.25	Package-9
19	407+470	Culvert	3	3	2X21.25	Package-9
20	408+675	Culvert	2	2	2X21.25	Package-9
21	409+270	Culvert	3	3	2X21.25	Package-9
22	410+240	Culvert	2	2	2X21.25	Package-9

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
23	410+819	Culvert	2	2	2X21.25	Package-9
24	410+856	Culvert	2	2	2X21.25	Package-9
25	411+263	Culvert	2	2	2X21.25	Package-9
26	411+531	Culvert	2	2	2X21.25	Package-9
27	412+095	Culvert	2	2	2X21.25	Package-9
28	412+890	Culvert	2	2	2X21.25	Package-9
29	413+700	Culvert	2	2	2X21.25	Package-9
30	414+572	Culvert	2	2	2X21.25	Package-9
31	415+550	Culvert	2	2	2X21.25	Package-9
32	416+134	Culvert	2	2	2X21.25	Package-9
33	416+820	Culvert	2	2	2X21.25	Package-9
34	417+110	Culvert	3	3	2X21.25	Package-9
35	417+302	Culvert	4	3	2X21.25	Package-9
36	418+410	Culvert	3	3	2X21.25	Package-9
37	419+280	Culvert	2	2	2X21.25	Package-9
38	419+590	Culvert	3	3	2X21.25	Package-9
39	421+060	Culvert	5	3	2X21.25	Package-9
40	421+590	Culvert	3	3	2X21.25	Package-9
41	422+720	Culvert	3	3	2X21.25	Package-9
42	423+610	Culvert	2	2	2X21.25	Package-9
43	424+561	Culvert	2	2	2X21.25	Package-9
44	425+468	Culvert	2	2	2X21.25	Package-9
45	426+100	Culvert	3	3	2X21.25	Package-9
46	426+202	Culvert	3	3	2X21.25	Package-9
47	426+835	Culvert	3	2	2X21.25	Package-9
48	427+130	Culvert	2	2	2X21.25	Package-9
49	428+369	Culvert	3	3	2X21.25	Package-9
50	429+300	Culvert	2	2	2X21.25	Package-9
51	430+428	Culvert	3	3	2X21.25	Package-9
52	431+664	Culvert	2	2	2X21.25	Package-9
53	432+060	Culvert	3	3	2X21.25	Package-9
54	433+170	Culvert	2	2	2X21.25	Package-9
55	434+260	Culvert	2	2	2X21.25	Package-9
56	434+650	Culvert	2	2	2X21.25	Package-9
57	435+032	Culvert	2	2	2X21.25	Package-9

S. No.	Chainage	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
			Lateral Clearance (m)	Vertical Clearance (m)		
58	435+480	Culvert	2	2	2X21.25	Package-9
59	436+263	Culvert	3	3	2X21.25	Package-9
60	436+790	Culvert	2	2	2X21.25	Package-9
61	437+430	Culvert	2	2	2X21.25	Package-9
62	438+268	Culvert	3	3	2X21.25	Package-9
63	438+600	Culvert	6	3	2X21.25	Package-9
64	439+265	Culvert	3	3	2X21.25	Package-9
65	439+623	Culvert	3	2	2X21.25	Package-9
66	440+140	Culvert	2	2	2X21.25	Package-9
67	440+870	Culvert	2	2	2X21.25	Package-9
68	441+430	Culvert	3	3	2X21.25	Package-9
69	442+000	Culvert	2	2	2X21.25	Package-9
70	442+485	Culvert	2	2	2X21.25	Package-9
71	442+840	Culvert	2	2	2X21.25	Package-9
72	443+499	Culvert	2	2	2X21.25	Package-9
73	444+463	Culvert	2	2	2X21.25	Package-9
74-75	420+932	Culverts @ Diamond Interchange	2	2	2 Culverts	Package-9
76	420+932	Culverts @ Diamond Interchange	5	3	1 Culvert	Package-9
77	420+932	Culverts @ Diamond Interchange	5	3	1 Culvert	Package-9
78	423+844	HPC @ Way Side Amenities	1X1200		1 Culvert	Package-9
79	424+140	HPC @ Way Side Amenities	1X1200		1 Culvert	Package-9

8.5 PROPOSALS FOR ROBs

One ROB has been proposed as listed in **Table-8.4** below:

Table-8.4 List of ROBs

S. No.	Chainage	Type of Structure			Span Arrangement	Width of Structure (m)	Skew Angle, if any	Remarks
		Foundation	Sub Structure	Super Structure				
1	420+100	Pile	R.C.C.	Bowstring	1X15+1X64.09+1X15	4X12.5	0	Package-9

8.6 PROPOSALS FOR VUPs

Total 50 nos. of VUPs have been proposed as listed in **Table-8.5** below:

Table-8.5 List of VUPs

S.	Chainage	Type of	Structure	Span Arrangement	Width of Structure	Skew	Remarks

No.		Crossing	Type	Lateral Clearance (m)	Vertical Clearance (m)	(m)	Angle, if any	
1	398+662	ODR	Box	2X10	5.5	2X21.25	15	Package-9
2	401+755	ODR	Box	2X10	5.5	2X21.25	20	Package-9
3	423+352	ODR	Box	2X10	5.5	2X21.25	15	Package-9
4	424+000	WSA	Box	2X10	5.5	2X21.25	0	Package-9
5	432+750	MDR	Box	2X10	5.5	2X21.25	48	Package-9
6	438+821	ODR	Box	2X10	5.5	2X21.25	45	Package-9
7	446+625	ODR	Box	2X10	5.5	2X21.25	0	Package-10

8.7 PROPOSALS FOR LVUPs

Total 12 nos. of LVUPs have been proposed as listed in **Table 8.6** below:

Table-8.6 List of LVUPs

S. No.	Chainage	Type of Crossing	Structure Type	Span Arrangement		Width of Structure (m)	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
1	393+700	VR	Box	12	4.5	2X21.25	Package-9
2	406+260	VR	Box	12	4.5	2X21.25	Package-9
3	407+810	VR	Box	12	4.5	2X21.25	Package-9
4	409+650	VR	Box	12	4.5	2X21.25	Package-9
5	417+790	VR	Box	12	4.5	2X21.25	Package-9
6	418+925	VR	Box	12	4.5	2X21.25	Package-9
7	424+832	Road	Box	12	4.5	2X21.25	Package-9
8	427+763	VR	Box	12	4.5	2X21.25	Package-9
9	429+990	VR	Box	12	4.5	2X21.25	Package-9
10	431+017	VR	Box	12	4.5	2X21.25	Package-9
11	440+340	VR	Box	12	4.5	2X21.25	Package-9
12	443+785	VR	Box	12	4.5	2X21.25	Package-9

8.8 PROPOSALS FOR SVUPs

Total 8 nos. of SVUPs have been proposed as listed in **Table-8.7** below:

Table-8.7 List of SVUPs

S. No.	Chainage	Type of Crossing	Type of Structure	Span Arrangement		Width of Structure	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
1	392+840	VR	Box	7	4.0	2X21.25	Package-9
2	396+302	VR	Box	7	4.0	2X21.25	Package-9

S. No.	Chainage	Type of Crossing	Type of Structure	Span Arrangement		Width of Structure	Remarks
				Lateral Clearance (m)	Vertical Clearance (m)		
3	400+300	VR	Box	7	4.0	2X21.25	Package-9
4	404+741	VR	Box	7	4.0	2X21.25	Package-9
5	411+800	VR	Box	7	4.0	2X21.25	Package-9
6	413+212	VR	Box	7	4.0	2X21.25	Package-9
7	415+400	VR	Box	7	4.0	2X21.25	Package-9
8	442+785	VR	Box	7	4.0	2X21.25	Package-9

8.9 PROPOSALS FOR FLYOVERS

Total 1 no. Flyover has been proposed. Details of the same are attached below in **Table-8.8**:

Table-8.8 List of Flyovers

S. No.	Chainage	Type of Crossing	Structure Type			Span Arrangement	Width of Structure	Remarks
			Foundation	Sub Structure	Super Structure			
22	420+932	NH-27	Pile	R.C.C.	PSC I Girder	2x30	2x21.25	Package-9

8.10 PROPOSALS FOR TRUMPETS

Trumpet has not been proposed in this Package. Details of trumpets are as listed below in **Table-8.9**:

Table-8.9 List of Trumpets

S. No.	Chainage	Type of Crossing	Remarks
NIL			

8.11 PROPOSALS FOR DOUBLE TRUMPETS

Double Trumpet has not been proposed in this Package. Details are as given below in **Table-7.10**:

Table-8.10 List of Double Trumpets

S. No.	Chainage	Type of Crossing	Remarks
NIL			

8.12 PROPOSALS FOR DIAMOND INTERCHANGES

One Diamond Interchange has been proposed. Details of Diamond Interchange are given in **Table-8.11**:

Table-8.11 List of Diamond Interchanges

S. No.	Chainage	Type of Crossing	Remarks
1	420+932	NH-27	Package-9

9. PROJECT FACILITIES, ROADSIDE FEATURES & ROAD SAFETY

9.1 PROJECT FACILITIES

The Project Facilities proposed on the expressway shall include:

(a) Toll plazas & Ramp plazas;

(b) Traffic Control Devices, Road Safety Devices and Roadside Furniture;

(c) Lighting / illumination;

(d) Pedestrian facilities;

(e) Landscaping & tree plantation;

(f) Traffic and medical aid posts;

(g) Telecom System

(h) Intelligent Traffic Management System (ATMS/ ITMS);

(i) Wayside Amenities

(j) Toilet Block

Further details are given in the following sec tions:

9.1.1 Toll Plazas & Ramp Plazas

4 Ramp Plazas (2 lanes on each leg) on Diamond Interchange have been proposed along the project corridor. List of the Toll Plazas & Toll Booths is attached below:

S. No.	Location		Remarks
1	420+932	Kanpur - Lucknow	Ramp Plaza

9.1.2 Traffic Control Devices, Road Safety Devices and Roadside Furniture

Traffic Control Devices, Road Safety Devices and roadside furniture shall be provided as per Section-10 and 12 of IRC:SP:99-2013. The details are as follows:

9.1.2.1 Road Signs

Road Signs include roadside signs; chevron signs; overhead signs and kerb mounted signs along the entire Project Expressway and service road.

All road signs shall be of Prismatic Grade Sheeting corresponding to Class 'C' Sheeting described in IRC: 67-2012 and any of the types VIII; IX or XI as per ASTM D-4956-09. The road signs and overhead signs erected on the Project Expressway and service road with regard to requirement of number of signs, type and size of sign, size of letter, color of sign, layout of sign; etc. including signs installations shall conform to Section-10 and Section-12 of "Manual" and IRC: 67-2012. Code of Practice for Road Signs and where the said codes are silent, other codes in the same order of preference shall be used. Chevron signs shall be installed on curves and interchange loops/ramps. In addition to signs prescribed in "Manual" other signs such as signs showing safety slogans, toll free numbers, nearby hospital and police station facilities, lane discipline signs on gantry etc. will also be provided as directed by Authority's Engineer.

The overhead signs shall be placed on a structurally sound gantry or cantilever structure made of tubular structure or steel structure. The final locations shall be finalized in consultation with the Authority's Engineer. The height, lateral clearance and installation of the sign structures shall be as per the MoRT&H/IRC guidelines.

Overhead Signs: Cantilever Type shall be provided at Interchanges as advance direction and exit signs on all arms of interchange.
Additionally, Overhead Gantry Type (4-lane width) is also proposed on each side of main carriageway.
Design and location of route marker signs for Project Expressway shall be as per the IRC: 67-2012.
On cross roads where interchange/slip roads have been provided, necessary information signboards on cross roads on both sides shall also be fixed suitable for the category of cross road.

9.1.2.2 Pavement Marking

Pavement markings shall cover the entire Project Expressway and service roads (on 7.0m wide portions) and shall be as per Section-10 of the "Expressway Manual" and IRC: 35-2015. These markings shall be applied to road carriageway lane; edge lines; continuity line; stop lines; give-way lines; diagonal/chevron markings; zebra crossing and at parking areas, toll booths etc. by means of an approved self-propelled machine which has a satisfactory cut-off valve capable of applying broken lines automatically.
Road markings other than on main carriageway edges (both shoulder and median side) shall be of hot applied thermoplastic materials with glass reflectorizing beads as per relevant sub clauses of MoRT&H specifications;
Raised profile edge lines as per Clause 7.7 of IRC 35 shall be provided on main carriageway edges (both shoulder and median side right lane).
Acrylic water based road marking paint shall be used for kerb, concrete barrier painting, and to display details of structure number; span arrangement etc. on all culverts and bridges with required description as per MoRT&H guidelines.

9.1.2.3 Boundary Stones

These shall be provided for the entire Project Expressway at an interval of 100m c/c as per clause 10.8 of the "Expressway Manual".

9.1.2.4 Hectometer & Kilometer Distance Marker

The arrangement for fixing and placement on expressway for kilometer distance marker shall be as per relevant IRC Codes.

9.1.2.5 Crash Barrier

This shall be provided as per clause 10.7 of section-10 of IRC:SP:99-2013 & Relevant IRC Codes. Retro-reflective (same material as of road signs and Fluorescent yellow / white colour) Stickers (150mm width) shall be provided on alternative vertical posts of W beam barrier throughout.

9.1.2.6 Fencing

As the Expressway is completely access-controlled facility; fencing is its integral part to help enforcement of the acquired access rights. Access control extends to the limits of legal access control on the ramps i.e.; along the ramps to the beginning of the taper on the local road. Precast Pre-tensioned RCC 300 mm wide & 50 mm thick (M30) panels shall be fixed in RCC (M25) posts of minimum size 150mm x 150mm (with 7 Nos. 4mmØ HT wires). RCC posts shall be embedded in M15 grade concrete to a depth of 650 mm below ground having size of 450mm x 450mm. The height of fencing shall be 1.5 m above ground. Chain line fencing of 1.5m height is provided across the road from fencing to embankment at all the VUP/PUP locations so that no cattle can go towards expressway.

On the side where service road is being provided, fence will be placed in between expressway and service road. On the side where service road is not being provided the fence will be placed at ROW edge.

9.1.2.7 Reflective Pavement Markers, Solar Studs and Delineators

Raised pavement markers shall be provided as per Clause 7 of IRC 35 2015 on both should edges and median sides. Relaxation pavement markers and solar studs shall be as per Clause 10.5 and Table 10.4 of manual.

Delineators shall be provided as per clause 10.4 of "Manual". At merging/diverging areas; service areas; ramps of interchanges; bridges and their approaches; the spacing shall be reduced to 30m. The design; location and materials to be used for road delineators shall be as per IRC: 79- 1981.

9.1.2.8 Blinker Lights

Yellow flashing lights using solar power with full alternative power back-up shall be provided to alert the drivers about oncoming interchange; major bridge and toll plazas.

9.1.2.9 Glare Reduction

The devices shall be provided as per clause 10.11 of the "Expressway Manual".

9.1.3 Lighting/Illumination

External and Internal Lighting will be as per Section-15 of the "Expressway Manual" shall be provided. Street Lighting shall be provided at the locations of toll / ramp plaza, interchanges/slip roads and lighting on structures such as major bridges, ROB's, Flyovers, Minor Bridges and Underpasses including high mast at toll plaza, interchange/slip roads. A power connection of appropriate load shall be taken from state electricity department at above locations including all expenses. The use of solar power is optional in lieu of a regular power connection for isolated locations such as Bridges, ROBs, underpasses and flyovers. Provision of adequate capacity Diesel Generator sets as standby arrangement shall be made at Toll / Ramp Plaza, Interchange and Slip road.

9.1.4 Pedestrian Facilities

There is no separate pedestrian facility like FOB etc. SVUPs/LVUPs may be used for pedestrian to cross expressway.

9.1.5 Landscaping & Tree Plantation

Landscaping of road shall be as per IRC SP-21. Four rows of tree on the side where service road is not provided and 2 row of tree on the side of service road shall be provided. Compensatory afforestation shall be undertaken within ROW as prescribed in environment and forest clearances. Landscape treatment shall be provided in the entire open areas near major bridges, at interchanges, toll / ramp plaza, and O & M areas.

Planting along the Project Expressway shall follow a variety of schemes depending upon location requirement as per the IRC: SP: 21-2009. The choice of trees to be planted shall also be made as per IRC:SP:21-2009; "Manual of Landscaping". Local, indigenous species that grow in that area shall be preferred.

On medians and island: planting of dust and gaseous substance-absorbing shrubs shall be provided. The treatment of the highway embankment slopes shall be as per the recommendations of IRC: 56; depending upon the soil type involved and the provisions mentioned elsewhere in this document.

Visibility of any signs; signals or any other devices erected for traffic control, traffic guidance and/or information shall not be obstructed by plantation.

The central island of trumpet and loop area of interchanges has space for attractive landscaping which provide scope for both soft and hard landscape. Special attention will be given that each interchange has a distinct and unique landscape based on some theme. The theme and design of landscaping of each interchange will blend with the local surroundings. Careful selection of plant species will be done in order to match the climatic conditions to merge with the surrounding area. Rainwater/ ground water recharging system should also be integrated with landscaping in order to provide proper drainage to avoid ponding of water. The plantation will be inter-mixed with evergreen species and seasonal flowers. Plantation of flowering species will be done in such a way that each area has different colour pattern. The outer margins of the central islands in the loops of interchange must have low ground covers to avoid any vision obstruction of the drivers to ensure visibility. The central portions of these islands will be provided with objects of any art; creation of pleasing/ attractive land pattern including plantation of trees keeping the aspect of vision in view. Designer lights along the periphery of the islands and central lighting in the form of high masts will be suitably provided for ensuring proper illumination of the area. Different types of water fountains may also be erected at the interchanges. No private advertisements; commercial information; hoardings etc. shall be permitted inside the interchange area. The scheme of landscape for each interchange has to be approved by the Authority's Engineer and the Authority.

9.1.6 Traffic & Medical Aid Post

Provisions as per the codal provisions have been made.

9.1.7 Telecom System

All necessary hardware, equipment, software, optical fiber cable etc. required for Communication System to interconnect Toll Plaza and Ramp Plaza /Toll Booths etc. are proposed and to be provided by the Contractor.

9.1.8 ATMS/ITMS

Implementation of latest Advanced/Intelligent Traffic Management System (ITMS), Highway Incident Control System, Facility Management System (FMS) for the 593.947 km long Ganga Expressway Project has been proposed.

By adopting the ITMS, Authority shall be able to enhance, the efficiency of Enforcement Management, Incident Management, Monitoring & Maintenance Control, Smoothing of Road

Traffic Movement, Efficient Information sharing, processing and dissemination with the stakeholders.

9.1.9 Wayside Amenities

Way Side Amenities have been proposed on 1 location along the project corridor.

S. No.	Chainage	LHS/RHS	Distance between WSA (km)
1	424+000	LHS	46.5

9.1.10 Toilet Block

Separate Toilet Blocks with full facilities for public use shall be provided within the toll plaza for public access. The provisions listed below are

a) 4 Nos. urinals (Ladies) along with wash basin

b) 4 Nos. urinals (Gents) along with wash basin

c) 2 Nos WC in each washroom

d) Drinking Water facilities shall also be provided.

e) Water Supply/Electrical fixtures shall also be provided.

f) Landscaping along with parking space shall also be provided.

10. SOCIAL & ENVIRONMENTAL STUDIES

10.1 SOCIAL IMPACT ASSESSMENT AND R&R STUDIES

10.1.1 Methodology

The action plan is based on the primary and secondary data sources. Secondary data source includes Gazetteer of project districts, maps and Primary Census Abstract (PCA), 2011. A questionnaire was used to conduct census and socio-economic survey.

This Resettlement Action Plan (RAP) report has been prepared as per the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act-2013 (LA and R&R Act – 2013) and is based on data collected from field survey. The primary purpose for preparing Resettlement Action Plan (RAP) is to assess the socio-economic condition of the Project Affected Persons (PAPs) in order to minimize and provide mitigative measures. Since the displacement is indispensable, rehabilitation shall be done in such a manner so that the standard of living of PAPs is restored. Special attention will be paid to the vulnerable groups. RAP has provisions to ensure that PAPs are compensated at replacement value for the assets lost and to enable them to regain or improve their socio-economic status enjoyed prior to the project. The RAP is a live document and will be updated as and when necessary. Implementation of the RAP will be done on data so modified.

10.1.2 Objective of The Study

The objective of social screening is to create a baseline database containing the features and populace in the immediate vicinity of proposed project road as well as the structures likely to be affected by the road widening/Improvement process. Social screening during the feasibility stage helps to avoid, reduce or mitigate likely negative impacts of project action and enhance positive impacts, sustainability and development benefits. The report aims to highlight the social problems and suggests general and typical mitigation measures to alleviate social problems that the project- affected people may face such as loss of livelihood, displacement and loss of access to community facilities through construction of service roads, underpasses and other facilities.

10.1.3 Scope of the study

- Carry out Structure Verification Survey of the structures likely to be affected and Socio-Economic Survey of the Project Affected Persons (PAPs) to get the base line information about the level of impact and to get the base line socio economic status of the PAPs.
- Preparation of Strip Plan showing existing structures likely to be affected along the project roads.
- Conducting Social Impact Assessment including Rehabilitation and Resettlement (R&R) studies.
- Preparation of detailed Land Acquisition (LA) Plans with the help of Village Revenue Maps (RVMs) to undertake the land acquisition along the proposed project corridors.
- Preparation of Land Plan Schedules (LPS) of ownership thereof and costs as per revenue authorities and also based on realistic rates.

- Preparation of Social Impact Assessment (SIA) report and Resettlement Action Plan (RAP) for the Project road.

10.1.4 Social & Rehabilitation Issues

Most of the infrastructure improvements planned for the Urban/Rural areas take place within the existing Right of Way (RoW) except at some of the congested settlements and densely builtup areas where bypasses/change in alignment/grade separation are proposed and at locations where minor improvements are required for accommodating road safety measures. As the proposed project road is entirely a green field alignment except some entry/exit points near the proposed interchanges connecting existing State Highways and National Highways, social screening surveys need to be conducted in the DPR stage. These issues may compound leading to delay of project and escalation of project cost. Hence, in order to face or overcome these consequences, a preliminary idea of Social and Rehabilitation issues need to be acquired and should be considered while selection of corridors. The key social issues considered would be as below.

- Loss of fertile agricultural land;
- Loss of structures used for residential, commercial and other purposes and associated loss of livelihood i.e., loss of livelihood due to impacts on sources of earning;
- Loss of other properties and assets such as boundary walls, hand pumps, bore wells, dug wells, pump houses, ponds etc.;
- Disruption of livelihood due to clearing of RoW particularly, petty shop owners and agriculturists;
- Loss of common property resources such as religious places, Samadhi, graveyard, cremation places, water resources, passenger shelters, etc.

10.1.5 Land Use along the Project Road

The preliminary social assessment was carried out, considering 120m. all along the project road except at the proposed facilities such as Junctions, RoBs, Bridges etc. Most of the land use categories along this section is mainly agriculture land and at some locations it is either Residential. The settlements at the entry/exit point near proposed major/minor interchanges connecting existing State Highways and National Highways through which the proposed alignment is passing where some pucca, semi pucca and kutcha structures are found in very large number along the proposed alignment. These settlements are like as private, government and community assets. The major portion is predominantly either agricultural land or barren land. In general, the inhabitants occupying lands for different activities along the proposed road have land titles. This has implications on the design of the Entitlement Matrix and mitigative measures. Common Property Resources along the sections of the project road include some religious structures, community/village bushy land, grazing lands, water resources, etc.

10.1.6 Negative Social Impact

As the proposed project road is an expressway and passes through total 529 villages, some of these settlements may consist of impact on many pucca, semi pucca and kutcha structures along the proposed alignment (a total length of 593.947 km). However, it is kept in mind while fixing the alignment that minimum structures are affected. Acquisition would be required for the

proposed 8-lane expressway all along the proposed road. As per the preliminary assessment and base line verification survey, many structures are either partially or completely affected. In addition, other assets such as Bore Wells, Wells, Hand Pumps, Pump Houses etc. may also be affected. The land required by the project for the construction of proposed project roads falls under two classifications.

(1) Public land owned by the State Government and administered by other departments such as Revenue Department etc; and (2) Private Land.

10.1.7 Preparation of Land Acquisition Report/ Plan

As part of preparation of Land Acquisition (LA) Report/Plan, firstly after identifying the villages along the entire proposed project road, latest available Village maps were collected from the respective District Survey offices/Village Offices. There after reference points were identified along the project roads at common identifiable locations (both On Village revenue Maps as well as on ground).

The Village Revenue Maps were scanned and superimposed on the topographical data and based on the common reference points collected all along the project road.

As part of the preparation of Land Plan Schedules (LPS), Survey Numbers were identified for which the addition land is to be acquired for proposed improvements. For each survey number details such as type of land, nature of land and other relevant data was collected from the respective Village offices

10.1.8 Issues during preparation of Land Acquisition Plan/Report

Some revenue maps are not in proper shape.

10.1.9 Impact Assessment

Impact Assessment will involve:

(i) Agricultural/Homestead/Commercial Land Impacts;

(ii) Loss of Structures (Residential/Commercial/Other);

(iii) Loss of livelihood due to loss of primary source of income;

(iv) Loss of community infrastructure/common property resources;

(v) Temporary Impacts on agricultural land due to plant site for contractor etc.;

Any unanticipated impacts due to the project will be documented and mitigated based on the spirit of the principle agreed upon in this policy framework.

10.2 ENVIRONMENTAL IMPACT ASSESSMENT, MITIGATION PLANNING, MANAGEMENT PLAN & CLEARANCES

The environmental assessment preparation led to identification of potential environmental hazards and their feasible remedial measures, based on which the environmental mitigation measures have been prepared. The purpose of this report is to identify the legal requirement or otherwise for an Environmental Impact Assessment for the project. The project under assessment is detailed in the accompanying engineers' report.

10.2.1 Objectives of the study

The major objective of this study is to establish present environmental condition along the project corridor through available data / information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. An Environmental Impact Assessment (EIA) study basically includes:

- Establishment of the present environmental scenario
- Study of the specific activities related to the project
- Evaluation of the probable environmental impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan

10.2.2 Scope of work for Environmental Screening

The general approach to be adopted for Environment Screening (ES) includes the following:

- Preliminary reconnaissance surveys to identify environmentally sensitive issues relating to road alignment and influence area and baseline conditions, including regionally and nationally recognized environmental resources and features of the environment and common property resources are such as forests, large water bodies and major physical cultural properties.
- Assessment of the potential impacts of the project on the baseline conditions.
- Recommended migratory measures to offset the identified adverse impacts.
- Stakeholder assessment and consultations along the alignment.
- Identification of the Valued Environmental Components (VECs) considering the baseline information (collected from both secondary and primary sources), the preliminary understanding of the activities proposed in the project and from stakeholder consultations and their requirements.
- Preliminary analysis of impacts identified on the projected site, surroundings and influence area and formulation of management measures/ options/ operations.
- Preparation of scoping for project Environmental Assessment (EA), which will be a direct outcome of the above-mentioned ES, and shall define the boundaries of the project like EA.
- Documentation of the above-mentioned ES in the form of Environmental Screening Report.

10.2.3 Environmental Policies and legislation

Environment policies of the Government of India include legislations related to environment. In the Directive Principles of State Policy, Article 48 says "the state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country"; Article 51-A states that "it shall be the duty of every citizen of India to protect and improve the natural

environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."

Present table shows various Environmental Regulations and legislations relevant to this project, which are the responsibility of a number of government agencies.

Table 8.1: Summary of Relevant Environmental Legislations

Act/Rule/Notification/Policy	Year	Objectives	Responsible Agency
Constitution of India, Article 48,51-A	1950	Article 48A of the directive Principles of State Policy provides for the State's commitment to protect and Article 51A(g) states that to protect and improve the natural environment shall be the fundamental duty of the citizen of India	MoEF&CC; GoI; Department of Forest, GoUP; UPPCB
The Environment (Protection) Act The Environment (Protection) Rules	1986 1986	To protect and improve the overall environment by ensuring that appropriate measures taken to conserve and protect the environment before commencement operations.	MoEF&CC; GoI; Department of Forest, GoUP; UPPCB
Environment Impact Assessment Notification and amendments made thereafter.	2006	To provide environmental clearance to new development activities following environmental impact assessment and Environmental Management Plan	MoEF&CC; GoI; UPPCB
Indian Forest Act Forest (Conservation) Act Forest (Conservation) Rules Forest Conservation Rules (Notification)	1927 1980 1981 2003	To Consolidate the laws related to forest, the transit of forest produce and the duty liveable on timber and other forest produce. Conservation of Forests, Judicious use of forestland for non-forestry purposes; and To replenish the loss of forest cover by Compensatory Afforestation on degraded Forestland and non-forest land. Procedure for submission of the proposals seeking approval for Central Government for diversion of forestland to non-forest purpose	MoEF&CC; Department of Forest, State Govt.
Wild Life (Protection)Act The Wild Life	1972 2002	To Protect wildlife in general and National parks and Sanctuaries in particulars. To protect wild animals, birds and	Chief Conservator of Wildlife Wing, Forest Department, State Govt. National/ State Board for Wildlife

Act/Rule/Notification/Policy	Year	Objectives	Responsible Agency
(Protection)Amendment Act		plants with a view to ensure the ecological and environmental security of the country.	
The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights)Act	2006	Grants legal recognition to the rights of traditional forest dwelling communities, partially correcting the injustice caused by the forest laws. Makes a beginning towards giving communities and the public a voice in forest and wildlife conservation	Ministry of Tribal Affaires, GOI and Department of Tribal Welfare, GoUP
National Forest Policy National Forest Policy(Revised)	1952 1988	To maintain ecological stability through preservation and restoration of biological diversity	Forest Department, GoI and States Govt.
The Water (Prevention and Control of Pollution)Act	1974	To control water pollution by controlling discharge of pollutants as per prescribed standards	CPCB;UPPCB
The air(Prevention and control of Pollution)Act	1981	To control air pollution by controlling emission of air pollutants as per prescribed standards	CPCB;UPPCB Transport Department; State Govt.
Noise Pollution (Regulation and Control) Rules The Noise Pollution (Regulation ad Control)Amendment Rules	2000 2006	To Regulate and Control noise producing and generating sources with the objective of maintaining the ambient air quality standard in respect of noise.	CPCB;UPPCB Transport Department; State Govt.
Biodiversity Act	2002	To provide for conservation of biodiversity, sustainable use of resources fair and equitable sharing of the benefits from use of resources	National Biodiversity Authority/State Authorities
Fly Ash Notification	2011 2016	Mandate use of fly ash in road construction within a radius of 100km.	MoEF&CC
Solid Waste Management Rules (SWM)	2016	For Management and handling of solid waste during construction	UPPCB
Hazardous and Other Wastes (Management & Trans boundary movement)Rules	2016	Protection to the general public against improper handling and disposal of hazardous wastes	UPPCB
Construction and Demolition Waste Management Rules	2016	To provide responsibility of the waste generators for the collection, segregation and other activities involved with the debris management generated during construction	PIU-UPEIDA,UPPCB

Act/Rule/Notification/Policy	Year	Objectives	Responsible Agency
Batteries (Management & Handling) Amendment Rules	2010	Management and handling of used lead batteries i.e. safe disposal of batteries used during construction	UPPCB
E-Waste (Management) Rules	2016	Effective mechanism to regulate generation, collection, storage, transport, import, export, recycling, treatment and disposal of e-wastes	UPPCB
National Environmental Tribunal	1995	To provide for strict liability for damages arising out of any accident occurring while handling any hazardous substance	National Environmental Tribunal
The Motor Vehicle Act Central Motor Vehicle Rules	1988 1989	To consolidate and amend the laws related to motor vehicles. Licensing of driving of motor vehicles, registration of motor vehicles, with emphasis on road safety standards and pollution control measures, standards for transportation of hazardous and explosive materials To check vehicular air and noise pollution.	RTO Office, GoUP, Govt. of Uttar Pradesh
The Ancient Monuments and Archaeological Sites and Remain (Amendment and Validation) Act	1958 2010	To provide for the preservation of ancient and historical monuments and archeological sites and remains of national importance and protection sculptures, carvings and other like objects.	Archaeological Department, GoI; Indian Heritage Society and Indian National Trust for Art and Culture Heritage (INTACH)
The Explosives Act & Rules Explosives Rules	1884 2008	An Act to regulate the manufacture, possession, use, sale, transport, import and export of Explosive (For transporting and storing diesel, bitumen etc.)	Petroleum & Explosives Safety Organization (PESO)
Mines and Minerals (Development and Regulation), Amendment Act UP Minor Mineral Concession Rules	2015 1963	The Mining act has been notified for safe and sound mining activity. For Opening New Quarries for minor minerals like stone, sand ,river sand etc.	District Magistrate, Government of Uttar Pradesh
National Policy of Resettlement and Rehabilitation	2007	For payment of compensation and assistance, different entitlements payment of compensation and assistance, resettlement and rehabilitation of project affected population due to acquisition of lands and structures.	PIU UPEIDA, Competent Authority (Revenue Department)

Act/Rule/Notification/Policy	Year	Objectives	Responsible Agency
Sec 135 and schedule VII of Companies Act Companies (Corporate Social Responsibility Policy) Rules	2013 2014	To provide 2% of the average Net Profits of the Company made during the three immediately preceding financial years.	CSR Committee, UPEIDA
Corporate Environment Responsibility vide MoEF&CC F.No. 22-65/2017-IA.III dated 01.05.2018	2018	Establishing a guideline for compliance with the provisions of Regulations to dedicate a percentage of Company's profits for social projects and Creating opportunities for employees to participate in socially responsible initiatives	SEAC, SEIAA, MoEF&CC
Right to fair compensation and transparency in land acquisition, Rehabilitation and Resettlement Act	2013	Fair compensation for acquisition of immovable assets; Resettlement of displaced population due to LA and economic rehabilitation of all those who are affected due to land acquisition.	Revenue Department. Govt. of U.P.
Uttar Pradesh Policy on direct purchase of land of through mutual agreement	2015	To ensure speedy land purchase in agreement with land owner thus protecting the rights of land owner Land to be purchased in mutual agreement with land owner so that land owner gets the fair compensation for the land and rehabilitation assistance in shortest possible time.	Revenue Department, Govt. of Uttar Pradesh

10.2.4 Environmental Impact Assessment

The Environmental Impact Assessment is a systematic investigation of both positive and negative impacts on the physical, biological socioeconomic environment, which would be caused or induced due to a proposed project. EIA provides a plan to reduce the negative environmental effect of proposed development project through alternative approaches, design modification and remedial measures. Highway construction is a major activity of economic development countries. Road development is major source of damage to the environment, including ecological destabilization, habitat disturbance and damage to flora and fauna. After analysing different parameters and discussing the probable impact suggestion are made regarding the mitigation measures that can be taken at different stages in order to reduce the environmental impacts.

10.2.4.1 Purpose of EIA

The purpose of this Environmental Impact Assessment (EIA) study is to provide information on the nature and extent of environmental impacts arising from the development of the proposed project and related activities with a view to define an Environmental Management Plan (EMP) to minimize adverse environmental impacts.

M/s L N Malviya Infra Projects Pvt. Ltd., Highway Engineering Consultant and Intratech Civil Solutions (Consortium) have been appointed as EIA Consultants to carry out the Environmental Impact Assessment (EIA) study for the proposed project site incorporating baseline data for various Environmental Components, viz, air, water, noise, land and biological along with the parameters of human interest and to prepare Environmental Management Plan (EMP) for mitigation adverse impacts.

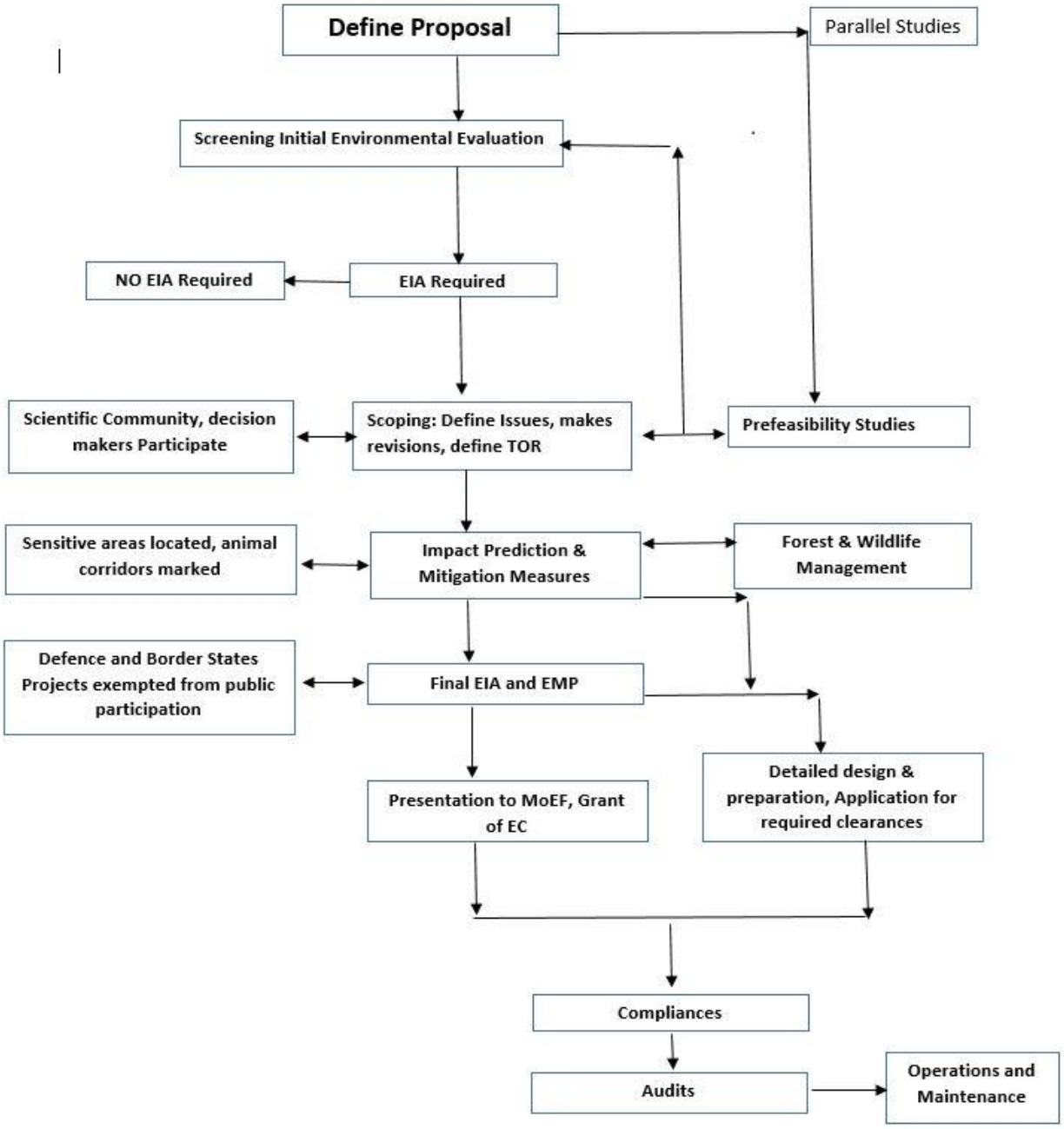
10.2.4.2 Significance of EIA Study

Environmental Impact Assessment (EIA) of a project ensures accountability of all the environmental impacts of the various project activities right from the stages of project initiation. The study incorporates the various environmental issues into planning and design stages of the project. It further guarantees the initiation of the various steps for minimization of the identified project impacts and assures a careful consideration of the different project alternatives. An exhaustive EIA process is inclusive of the various steps as described below:

Screening, Scoping, consideration of alternatives, Baseline data collection, Impact prediction Assessment of alternatives, delineation of mitigation measures and environmental impact statement, Environmental Management Plan Decision –monitors the clearance conditions.

10.2.4.3 Approach & Methodology

The general approach followed for carrying out the EIA for the project is summarized in the enclosed flow chart on the following page.



10.2.5 Environmental Management Plan

Several mitigation measures have been suggested along with the agency responsible for planning, execution, supervision and monitoring of the Environment Management Plan for preconstruction, construction and operation stages to avoid or mitigate the adverse impacts.

Pre-construction Phase

Pre-construction activities include acquisition of land and structures, relocation of utilities, removal of trees, relocation/compensation of common property resources viz. temple, hand pumps, obtaining Environmental Clearance, Consent to Establish from UPSPCB etc. UPEIDA/Concessionaire and concerned departments shall be responsible for those activities.

Construction Phase

Construction activities during this phase include setting up of Construction Camp, setting up of plants namely crusher plant, concrete batching plant, hot mix plant; clearing and grubbing, collection, storage and utilization of topsoil, identification of borrow pit & aggregate quarry (if other than those identified by design consultant), operation of the quarry, plantation on either side of the proposed expressway & at median, environmental protection & monitoring. Concessionaire shall be responsible for obtaining consent for establish and operate of those plants. Concessionaire shall also be responsible for implementation of the environmental protection measures during construction. The Independent Engineer/Authority Engineer shall be responsible for monitoring & supervision of the Concessionaire's activities as per Contract & report it to PIU, NHAI time to time. Project Implementation Unit (PIU), UPEIDA shall be responsible for regulatory compliance.

Operation Phase

Operation phase activities include environmental monitoring and monitoring of survival rate of the plantation etc. The Independent Engineer/Authority Engineer and Concessionaire shall be responsible for those activities.

10.2.6 Environmental Cost

Environmental costs, the costs for mitigation and management measures have been estimated. These costs along with the social costs have to be incurred by the implementing agency to include environmental and social safeguard measures into the proposed project. The environmental cost estimates include Environmental Mitigation Cost + Environmental Monitoring Cost for construction phase (3 years) and operation phase (5 years).

10.2.7 Validity of Environmental Clearance

The prior environmental clearance granted is valid for a period of five years. The regulatory authority concerned may extend this validity period by a maximum period of five years.

10.2.8 Clearance Requirements for the Project

The summary table showing time requirements for agency responsible for obtaining clearance, and a stage at which clearance will required is given below:

S. No.	Type of Clearance	Statutory Authority	Applicability	Project Stage	Approx Time Required	Responsibility
1	Prior Environmental Clearance	MoEF&CC	Applicable	Pre Construction	7-12 months	UPEIDA
2	Permission for Activities near archaeological protected areas	Archaeological survey of India / the state department of Archaeological	NA	Pre Construction	-	-
3	Clearance for working / diversion of sanctuary	Chief Wild Life Warden	NA	Pre Construction	-	-
4	Forest Clearance	State	Applicable	Pre	9-12	UPEIDA

S. No.	Type of Clearance	Statutory Authority	Applicability	Project Stage	Approx Time Required	Responsibility
		Department of Environment & Forest & MoEF		Construction	months	
5	Tree felling permission	Forest department	Felling of trees	Forest department	3 months	UPEIDA
6	NOC And Consents Under Air , Water, EP Acts & Noise rules of SPCB	State Pollution Control Board	For establishing plants	Construction (Prior to work initiation)	2-3 months	Concessionaire / Contractor
7	NOC And Consents Under Air , Water, EP Acts & Noise rules of SPCB	State Pollution Control Board	For operating Hot mix plants, Crushers and batching plants	Construction (Prior to work initiation)	1-2 months	Concessionaire / Contractor
8	Permission to store Hazardous Materials	State Pollution Control Board	Storage and Transportation Of Hazardous Materials and Explosives	Construction (Prior to work initiation)	2-3 months	Concessionaire / Contractor
9	Explosive license	Chief controller of explosives	Storage of explosive materials	Construction (Prior to work initiation)	2-3 months	Concessionaire / Contractor
10	NOC under Hazardous Waste (Management and Handling) Rules, 1989	State Pollution Control Board	Disposal of bituminous wastes	Construction (Prior to work initiation)	2-3 months	Concessionaire / Contractor
11	PUC certificate for use of vehicles for construction	Department of Transport	For all construction vehicles	Construction (Prior to work initiation)	1-2 months	Concessionaire / Contractor
12	Quarry lease deeds and license	Dept. of Geology and Mines	Quarrying and borrowing operations	Construction (Prior to work initiation)	2-3 months	Concessionaire / Contractor
13	NOC for water extraction for construction and allied works	Ground Water Authority	Ground water extraction	Construction (Prior to work initiation)	2-3 months	Concessionaire / Contractor

11. COST ESTIMATES

13.1 GENERAL

The cost estimates for the project are extremely important as its entire viability and implementation depends on the project cost. Therefore, cost estimates and rate analysis of the items have been carried out with due care. The project cost estimates have been prepared considering various items of works associated with the identified proposals.

13.2 METHODOLOGY

The process involved in the preliminary cost estimation has been described under the following sections.

13.2.1 Basic rates

The basic rates of construction items have been analyzed using MoRTH Standard Data Book.

The rates of Bitumen have been adopted based on nearby refinery rates. Circle/District wise SOR/DSR rates have been adopted for Material & Labour.

Rates of each construction item have been analyzed based on study of sources of material involved, Prices of the material and Lead (Distance) of the sources from the project site.

For any item, if rates are not available in SOR/DSR, market rates have been adopted.

13.2.2 Quantification of Items / Quantities

Estimation of quantities & cost of various items has been covered as follows:

S. No.	Item	Activities Involved
1	Site clearance and Dismantling	Tree Cutting, Dismantling
2	Earth Work	Excavation for Roadway, Embankment Construction, Subgrade, Earthen Shoulders, Median Filling
3	Granular Sub Base Courses and Base Courses (Non- Bituminous)	Granular Sub Base, Wet Mix Macadam
4	Bituminous Courses	Prime Coat, Tack Coat, Dense Bituminous Macadam, Bituminous Concrete
5	Box Culverts	Box Culverts along the road for Drainage Purpose & balancing culverts
6	Minor Bridges	Bridges along the road having length between 6 m to 60m
7	Major Bridges	Bridges along the road having length > 60m
8	VUP/LVUP/PUP	Vehicular, Cattle & Pedestrian Underpasses proposed along the road
9	ROB	ROBs proposed along the project road for crossing over the Railway Lines
10	Flyover and NH & SH Crossing	Grade Separators for merging & diverging traffic at selected locations
11	Interchange and Junctions	Grade Separators for merging & diverging traffic at selected locations

S. No.	Item	Activities Involved
12	Retaining Wall	Retaining walls proposed along various stretches, wherever required
13	Drainage & Protective Works	Lined Drain, Unlined Drain, Chute Drain, Median Drain, Turfing, Pitching etc.
14	Traffic signs, Road markings and other road appurtenances	Various road signs, road furnitures, markings & appurtenances required along the project road
15	Toll Plaza	Toll Plazas proposed on the project road
16	Approach to Wayside Amenities, Toilet block & Median Opening	Quantities and cost of materials & activities required for approaches to the Way Side Amenities, toilet blocks & median opening
17	Environmental Cost (Civil Works)	Cost of horticulture & Mitigation measures required for development of project road
18	Miscellaneous Works	Precast Concrete Tiles, Utility Ducts, Temporary Diversions, Lighting, High Masts, Solar Panels, Ambulance, Medical Aid Post, Traffic Aid Posts, Beautification of interchanges etc.
19	ATMS for Access Controlled Expressway,	Installation of ATMS on the project road toll plazas

13.2.3 Centages

Following centages have been added in the cost estimate:

1	Contingency	2.8%
2	Agency Charges	1%
3	Supervision	1.5%
4	Maintenance Cost for 5 years	7%
5	Escalation for First Year	Nil
6	Escalation for Second Year	7.5% on 40% cost
7	Escalation for Third Year	12.5% on 40% cost
8	Labour Cess	1%

13.3 SPECIFICATIONS

The Specifications for various items of work have been assumed to follow the MoRT&H Guidelines for Expressway (2010), MoRT&H Specifications for Road & Bridge Works and Manual of Specifications and Standards for Expressways (IRC: SP:99-2013) published by IRC, Government of India.

13.4 COST ESTIMATES

The Cost Estimates have been prepared for the project expressway. Cost estimates includes cost for 6 (six) lanes expressway and the cost of structures has been adopted for 8 (eight) lanes. The summary of cost estimates for Package-9 of the project road is given in Table 13.1 below:

Table–13.1

Pkg. No.	Chainage (km)		Length	Cost		
	From	To		Civil Cost (Rs)	Civil Cost (Including 12% GST) (Rs)	Capital Cost (Rs)
IX	391.9	445	53.1	₹ 15,445,750,470	₹ 17,299,240,526	₹ 2742,79,99,371

(Package-IX): From Village- Raiyamau (Dist. Unnao) to Village- Sarso (Dist. Unnao) (Km 391.900 to Km 445.000)			
Sr. No.	**Particulars**	**Amount**	**% of Cost**
1	Bill No. 1: Site clearance and Dismantling	37837845	0.245
2	Bill No. 2 : Earth Work	2684519638	17.380
3	Bill No. 3 : Grannular Sub Base Courses and Base Courses (Non- Bituminous)	2768542495	17.924
4	Bill No. 4 : Bituminous Courses	2761902444	17.881
5	Bill No. 5 : Box Culverts	588750131	3.812
6A	Bill No. 6A : Minor Bridges	1144108684	7.407
6B	Bil No. 6B : Major Bridges	429567438	2.781
6C	Bill No. 6C : VUP/LVUP/SVUP	1213448323	7.856
6D	Bill No. 6D : ROB	516960452	3.347
6E	Bill No. 6E : Flyover and NH & SH Crossing	361902270	2.343
6F	Bill No. 6F : Interchange and Junctions	194750475	1.261
6G	Bill No. 6G : Retaining Wall	231476361	1.499
7	Bill No. 7 : Drainage & Protective Works	1115908003	7.225
8	Bill No. 8 : Traffic signs, Road markings and other road appurtunences	773233675	5.006
9	Bill No. 9: Toll Plaza	24181386	0.157
10	Bill No. 10: Approach to Wayside Amenities, Toilet block & Median Opening	133525106	0.864
11	Bill No. 11 : Enviormental Cost (Civil Works)	173656450	1.124
12	Bill No. 12 : Miscellaneous Works	219957760	1.424
13	Bill No. 13 : ATMS for Access Controlled Expressway,	71521533	0.463
a)	**Civil Construction Cost**	**15445750470**	100.00
b)	**GST @ 12%**	**1853490056**	
	Total Civil Cost (a+b)	**17299240526**	
c)	Contingency @ 2 % of Total Civil Construction Cost	308915009	
	Total (a+b+c)	**17608155536**	
d)	Agency Charges @ 1 % of a) Civil Construction Cost	154457505	
e)	Supervision @ 1.5 % of a) Civil Construction Cost	231686257	
f)	Maintenance Cost for 5 years @ 7% of a) Civil Construction Cost	1081202533	
g)	Escalation for First Year		
h)	Escalation for Second Year (7.5% x 40%)	463,372,514	
i)	Escalation for Third Year (12.5% x 40%)	772,287,523	
j)	Labour Cess - 1%	154457505	
	Total Project Cost (a+b+c+d+e+f+g+h+i+j)	**20465619373**	
	Utility Shifting, Land Acquisition & EMP Cost		
	Utility shifting Cost	536411498	
	Land Acquisation Cost	6247164667	
	Enviormental Cost (Non Civil works)	178803833	
	Grand Total	**27427999371**	