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सत्यमेव जयते

GOVERNMENT OF ASSAM

ASOM MALA PROGRAM

Government of Assam

Public Works Roads Department (PWRD)

Project Title: Improvement and Upgradation of Road from from Ghagrabasti to Hawajan [From Ch. 0+000 to Ch. 26+006] and Sonapur to Holongi Airport [From Ch. 0+000 to Ch. 2+130] under Asom Mala

Detailed Project Report Volume I (Main Report)

January, 2025

Fortress Infracon Limited, Mumbai

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ABBREVIATIONS

AADT	-	**Annual Average Daily Traffic**
ADB	-	**Asian Development Bank**
ADT	-	**Average Daily Traffic**
AM	-	**Arrow Marking**
BC	-	**Bituminous Concrete**
BIS	-	**Bridge Information System**
BM	-	**Block Marking**
BOQ	-	**Bill of Quantities**
BTAD	-	**Bodoland Territorial Area District**
CBR	-	**Californian Bearing Ratio**
CDV	-	**Correct Deduct Value**
CE	-	**Chief Engineer**
CPR	-	**Common Property Resources**
CRMB	-	**Crumb Rubber Modified Bitumen**
CRS	-	**Corrosion Resistance Steel**
CSS	-	**Cationic Bitumen Emulsion**
CVC	-	**Classified Volume Count**
CVPD	-	**Commercial Vehicles per Day**
CYCRSHW	-	**Cycle Rickshaw**
DBM	-	**Dense Bituminous macadam**
DCP	-	**Dynamic Cone Penetration**
DGPS	-	**Differential Global Positioning System**
DPR	-	**Detailed Project Report**
EAP	-	**Externally Aided Project**
EIRR	-	**Economic Internal Rate of Return**
EM	-	**Ethnic Minority**
EMP	-	**Environmental Management Plan**
ENPV	-	**Economic Net Present Value**
EPC	-	**Engineering Procurement & Construction**
EPIP	-	**Export Processing Industrial Park**
ESAL	-	**Equivalent Standard Axle Loading**
FEQ	-	**Seismic Loads**

FM	**-**	**Facility Marking**
FOD	**-**	**Footpath Over Drain**
FSI	**-**	**Floor Space Index**
GAD	**-**	**General Arrangement Drawing**
GDP	**-**	**Gross Domestic Product**
GFC	**-**	**Good for Construction**
GIS	**-**	**Geographic information system**
GNP	**-**	**Gross National Product**
GOA	**-**	**Government of Assam**
GOI	**-**	**Government of India**
GPS	**-**	**Global Positioning System**
GSB	**-**	**Granular Sub Base**
GSDP	**-**	**Gross State Domestic Product**
GST	**-**	**Goods and Services Tax**
GVA	**-**	**Gross Value Added**
HDM	**-**	**Highway Development and Maintenance Management System**
HDR	**-**	**High Dynamic Range**
HFL	**-**	**High Flood Level**
HM	**-**	**Hazard Marking**
HS	**-**	**Hard Shoulder**
HT	**-**	**High Tension**
IDC	**-**	**Interest During Construction**
IIDC	**-**	**Industrial Infrastructure Development Centre**
INR	**-**	**The Indian Rupee**
IP	**-**	**Indigenous People**
IRI	**-**	**Information Resources, Incorporated**
IS	**-**	**Indian Standard**
ISI	**-**	**Indian Standards Institute**
JICA	**-**	**Japan International Cooperation Agency**
JPCP	**-**	**Jointed Plain Cement Concrete**
KM	**-**	**Kilometer**
LA	**-**	**Land Acquisition**
LCV	**-**	**Light Commercial Vehicles**
LM	**-**	**Longitudinal Marking**

LMV	**-**	**Light Moving Vehicle**
LOI	**-**	**Letter of Intent**
LOS	**-**	**Level of Service**
MAV	**-**	**Micro air vehicle**
MCE	**-**	**Maximum Considered Earthquake**
MDB	**-**	**Multilateral Development Banks**
MDD	**-**	**Maximum Dry Density**
MDR	**-**	**Major District Roads**
MIDAS	**-**	**Modular Interactive Data Acquisition System**
MJ	**-**	**Mill joule**
ML	**-**	**Mili litre**
MN	**-**	**Millions**
MOEF	**-**	**Ministry of Environment and Forests**
MORTH	**-**	**Ministry of Road Transport and Highways**
MOSPI	**-**	**Ministry of Statistics and Program Implementation**
MSA	**-**	**Million Standard Axles**
MSL	**-**	**Mean Sea Level**
MT	**-**	**Metric Ton**
MW	**-**	**Mega Watt**
NBPZ	**-**	**North Bank Plain Zone**
NDDP	**-**	**Net District Domestic Product**
NGO	**-**	**Non-Governmental Organizations**
NH	**-**	**National Highway**
NHAI	**-**	**National Highways Authority of India**
NHIDCL	**-**	**National Highways and Infrastructure Development Corporation**
NMT	**-**	**Non-Motorized Traffic**
NPV	**-**	**Net Present Value**
NSDP	**-**	**Net State Domestic Product**
OD	**-**	**Origin Destination**
OFC	**-**	**Oxygen Free Copper**
OMC	**-**	**Optimum Moisture Content**
OPC	**-**	**Opportunity Cost of Cargo**
PAP	**-**	**Project Affected Persons**
PCC	**-**	**Portland Cement Concrete**

PCE	**-**	**Passenger Car Equivalents**
PCI	**-**	**Pavement Condition Index**
PCSE	**-**	**Passenger Car Space Equivalency**
PCU	**-**	**Passenger Car Units**
PIA	**-**	**Project Influence Area**
PMGSY	**-**	**Pradhan Mantri Gram Sadak Yojana**
PMS	**-**	**Pavement Management System**
PPP	**-**	**Public Private Partnerships**
PRW	**-**	**Piece Rate Worker**
PSC	**-**	**Pre-Stressed Concrete**
PSU	**-**	**Public Sector Undertaking**
PWD	**-**	**Public Works Department**
PWRD	**-**	**Public Works Roads Department**
RAP	**-**	**Recycled Asphalt Pavement**
RAMS	**-**	**Road Asset Management System**
RCC	**-**	**Reinforced Cement Concrete**
RFCTLAAR	**-**	**Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act**
RFP	**-**	**Reference for Proposal**
ROB	**-**	**Road Over Bridge**
ROW	**-**	**Right of Way**
RP	**-**	**Resettlement Plan**
RPF	**-**	**Resettlement Policy Framework**
R&R	**-**	**Rehabilitation and Resettlement**
RSIS	**-**	**Road Safety Information System**
RUB	**-**	**Road under Bridge**
RUE	**-**	**Road User Effects**
RWFIS	**-**	**Right of way Feature Information System**
SB	**-**	**Sub Base**
SC	**-**	**Scheduled Caste**
SCF	**-**	**Standard Conversion Factor**
SCRIM	**-**	**Sideway-force Coefficient Routine Investigation Machine**
SERF	**-**	**Shadow Exchange Rate Factor**
SH	**-**	**State Highway**

SIDL	**-**	**Superimposed Dead Load**
SMP	**-**	**Social Management Plan**
SNP	**-**	**Structural Number**
SQL	**-**	**Structured Query Language**
SSD	**-**	**Stopping Sight Distance**
ST	**-**	**Scheduled Tribe**
STAAD	**-**	**Structural Analysis and Designing Program**
SWRF	**-**	**Shadow Wage Rate Factors**
TCS	**-**	**Typical Cross Section**
TIS	**-**	**Traffic Information System**
TM	**-**	**Transverse Marking**
TMC	**-**	**Turning Movement Count**
TMT	**-**	**Thermo Mechanically Treated**
TPC	**-**	**Total Project Cost**
TRCT	**-**	**Tractors**
TRL	**-**	**Trailer**
TUG	**-**	**Temperature differences**
TUU	**-**	**Uniform temperature variation**
TVC	**-**	**Traffic Volume Count**
UFC	**-**	**Unified Facilities Criteria**
VDF	**-**	**Vehicle Damage Factor**
VOC	**-**	**Vehicle Operating Cost**
VOTT	**-**	**Value of Travel Time**
WBM	**-**	**Water Bound Macadam**
WMM	**-**	**Wet Mix Macadam**
WPR	**-**	**Work Force Participation**

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EXECUTIVE SUMMARY

Executive Summary

0.1 Project Background

The state of Assam has about 2,530 km of State Highways (SH) and 4,379 km of Major District Roads (MDR) which are being maintained and managed by the Public Works Roads Department (PWRD), Government of Assam (GOA). The GOA has embarked upon the AXOM MALA to objectively develop the SH & MDR network of the State and is planned to be an umbrella program which would have several projects under it funded from various sources.

Public Works Roads Department (PWRD), Guwahati, Assam is engaged in improvement and reconstruction of State Highways (SH) and Major District Roads (MDR) across the state for the improvement of 40 numbers of roads having total length of 1268.10 kms. These roads are grouped in five packages with the view of administrative suitability for Preparation of Detailed Project Report for upgradation of roads in State of Assam.

Chief Engineer, Public Works Roads Department, Government of Assam under AXOM MALA have appointed Fortress Infracon Limited as a Project Consultant vide Work Order No. CE/AXOM MALA/8/2019/11 dated 31st October 2019 to provide consultancy services for the preparation of Detailed Project Report for improvement and reconstruction of roads in Assam State for **Group 3**. The Client has engaged Leading Consultant's LEA Consulting Limited as Program Coordination and Management Consultant (PCMC) to coordinate and manage the contracts of the DPR preparation consultants and review their deliverables.

0.2 Project Objective

The main objective of the consultancy service is to establish the technical, economical, and financial viability of the project and prepare detailed project (DPR) reports for rehabilitation and upgrading of the existing road to 2-lane with paved shoulders configuration with provision of capacity augmentation.

The Project is to be established considering the requirements with regard to rehabilitation, upgrading and improvement based on highway design, pavement design, provision of service roads wherever necessary, type of intersections, rehabilitation and widening of existing and/or construction of new bridges and structures, road safety features, quantities of various items of works and cost estimates and economic analysis.

0.3 Description of Project Road

The project road **Ghagrabasti to Hawajan via Holongi Airport [A28]** falls in the district of Lakhimpur and Sonitpur, passes through various junctions and spreads over the remote locations of the two districts. The project road has been proposed to be implemented in two packages viz., **Package 1 – Ghagrabasti to Mazgaon (Ch. 0+000 to Ch. 13+740 and Ch. 14+800 to Ch. 15+300), Shantipur to Holongi Chariali (Ch. 0+000 to Ch. 2+130)** and **Package 2 – Kokchabari to Hawajan (Ch. 15+300 to 15+900 and Ch. 16+727 to Ch. 26+006).** The portion of the project corridor from Ch. 13+740 to Ch. 14+800 and Ch. 15+900 to Ch. 16+727 comes under ASRP and PMGSY respectively and have been considered as an out-of-scope portion. The total length of the road is 28.136 km whereas the construction length of the project is 26.224 Km.

The project road consists of two alignments wherein the first alignment originates from Ghagrabasti on NH-415 at Y-Junction where left side of the NH-415 goes to Itanagar and the right side to Gohpur. The project road ends at Hawajan on NH-15 making a T-junction. The second alignment initiates near Sonapur on Ghagrabasti to Hawajan section and traverses in the north direction to end at Proposed Holongi Airport. The project road traverses through the settlements of Fatasimalu, Borsala, Barijharr Gaon, Nij Borchola, Balijan, Sitalmari, Singri and Doul Guri before ending at Dhekiajuli. The project road has a single lane configuration with poor to fair condition. Even some sections of the road have non-motorised road.

The entire project stretches passes through two constituency namely, Gohpur and Bihpuria. The section from Ch. 0+000 to Ch. 14+900 falls under the Gohpur Constituency, the section from Ch. 14+900 to Ch. 26+006 falls under Bihpuria Constituency whereas the section from Ch. 0+000 to Ch. 2+130 towards Holongi Airport falls under Gohpur Constituency.

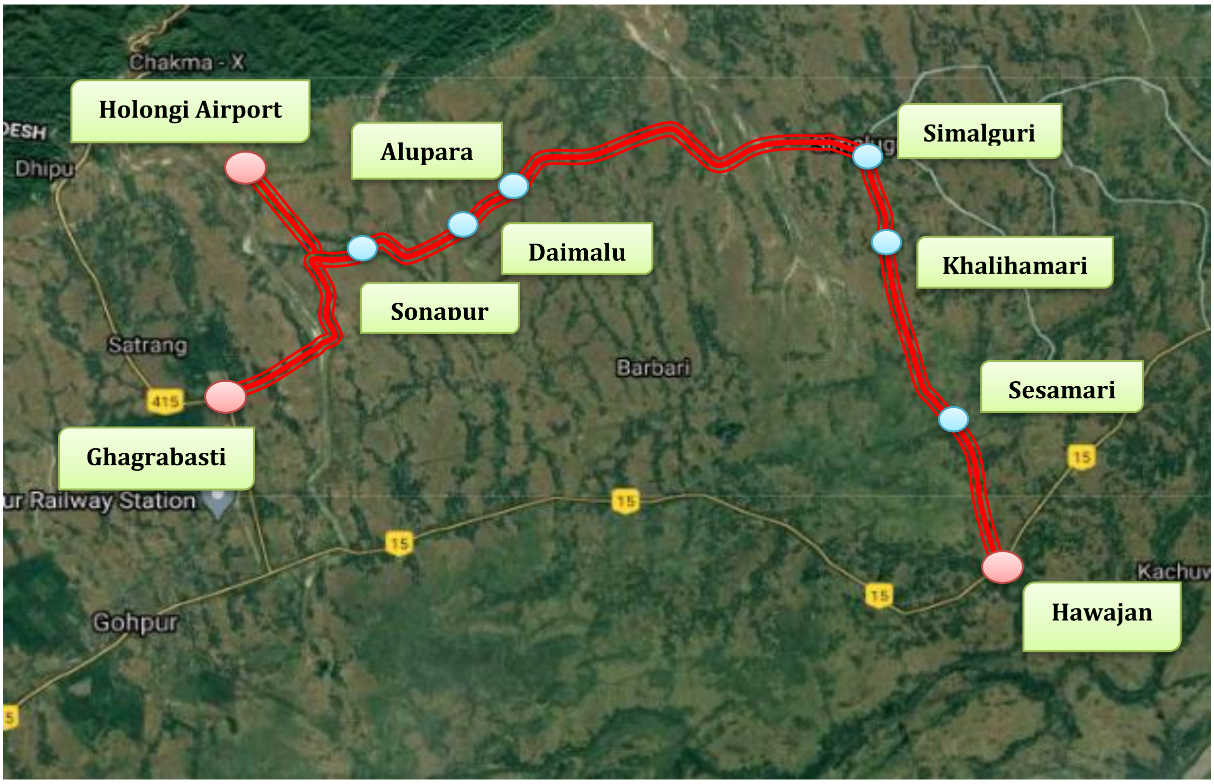


Figure 0-1: Map showing Ghagrabasti to Hawajan & Sonapur to Holongi Airport

0.4 Proposed Alignment of Project Road

The recommended alignment of the project road comprised of retained existing alignment, improved alignment at several locations considering the structures (retained and reconstruction), settlements & existing road geometry and improvement of alignment at few locations.

Realignments are proposed at **Sonapur – Realignment 1** (Existing Ch. Ch. 4+950 to Ch. 6+500), **Salbari – Realignment 2** (Existing Ch. 9+500 to Ch. 10+575), **Alupara – Realignment 3** (Existing Ch. 12+875 to Ch. 14+575), **Niran Chuba – Realignment 4** (Existing Ch. 23+850 to Ch. 24+625). The improvement of existing horizontal alignment is carried out to a possible extent considering the site constraints, deficiency of geometry and structure improvement proposal.

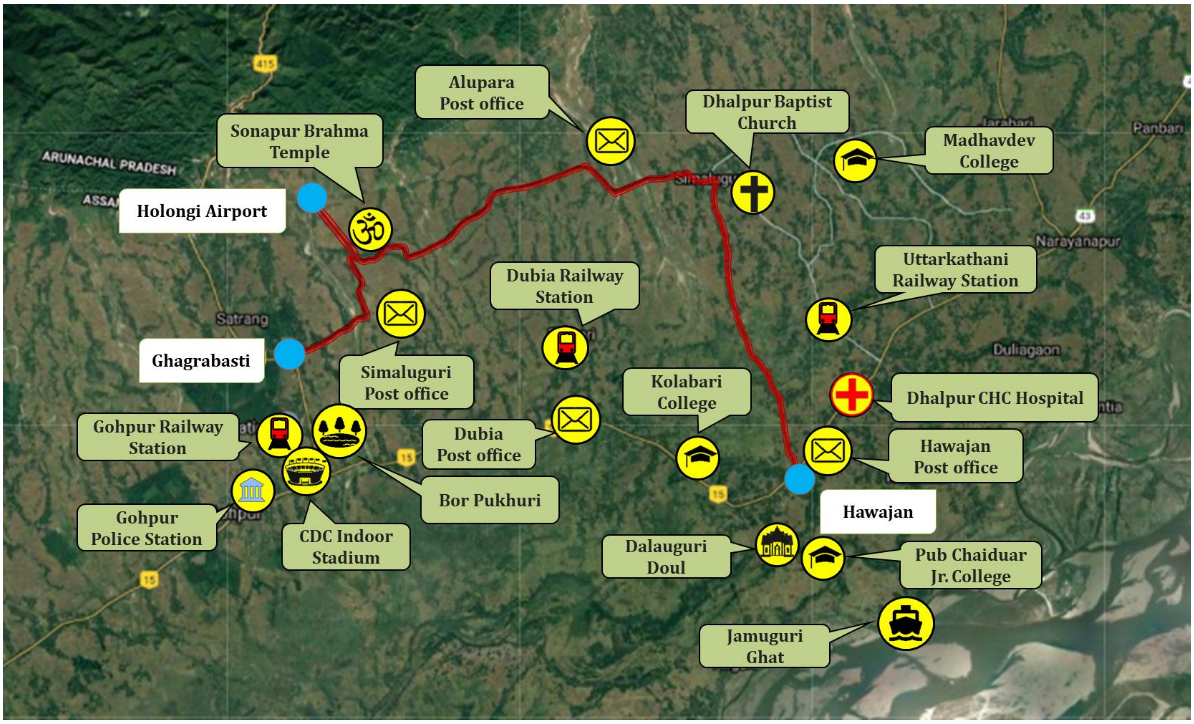


Figure 0-2: Important Locations around the Project Road

Existing alignment is followed at many locations wherever straight portion and horizontal curves of adequate radius prevails. The length of project stretch wherever existing alignment has been retained is 22245 m, the length of project stretch wherever existing alignment retained with improvement is 1640 m and the realignment length of the project stretch is 4255 m.

0.5 Traffic Survey

Traffic Data Collection and projections of traffic volumes are basic requirements for planning of road development and management schemes. Traffic surveys such as mid-block Classified Traffic Volume Counts (TVC) by manual systems, Origin-Destination (OD) surveys are conducted on selected locations and Turning Movement Counts (TMC) are carried out at identified major junctions to understand the existing traffic pattern and to check the adequacy of the number of homogenous sections of the project road. The locations for the surveys were finalized based on the reconnaissance survey.

0.5.1 Traffic Volume

The summary of the average annual daily traffic for the project stretch is given in **Table *0-1*.**

Table 0-1: Annual Average Daily Traffic (AADT) 2024-25

Vehicle Type	Ghagrabasti to Hawajan Road					
	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs
	@ Sonarijan		@ Alupara		@ Sesamiri	
Total Traffic	**1077**	**777**	**1167**	**753**	**2080**	**1281**
Motorized	814	646	677	504	1419	950
Non-Motorized	262	131	491	249	662	331

Source: Consultant Estimates based on Actual Traffic Survey Data

Based on the traffic analysis the recommended Vehicle Damage Factors (VDF) and Million Standard Axles (MSA) values are presented in the following table:

Table 0-2: Recommended VDF & MSA Values

Max VDF Values	MSA Values
2.21	10

0.5.2 Capacity Analysis

The capacity analysis of the project road was done on the basis of level of service for Ghagrabasti to Hawajan via Holongi Airport section. The projected traffic with the corresponding Level of Service for total traffic is presented in ***Chapter 4: Traffic Studies and Demand Forecast.***

At Sonarijan -

As per the projected traffic volume, Sonarijan section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-A by 2052.

At Alupara -

As per the projected traffic volume, Alupara section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-A by 2054.

At Sesamiri -

As per the projected traffic volume, Sesamiri section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-A by 2052.

Hence, due to better road network & connectivity in the state there is a need to improve the proposed project road to cater the growing traffic demand in near future.

0.5.3 Justifications for 2 Lane Road with Paved Shoulders

Based on the traffic volume project will be qualify in future for the two-lane with paved shoulders road. Origin-destination data show that this project road connects/influenced to Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur, Kamrup, Assam, Arunachal, Nagaland, etc. major regions/districts/few states and also to various village roads, major district roads, state highways and national highways. Majorly it connects to NH-15, NH-52A, NH-415, NH-13, Sh-43, SH-45, and MDR's. This project road also connects to the Nagaland and Arunachal Pradesh states borders. It has inter-state connectivity. This road is very much useful for intrastate and interstate passengers and freight traffic movements. The project road is also connecting to the new proposed Holongi Airport. The capacity of project road for Intermediate laning is reaching with LOS-B by 2052 with its current traffic estimates. Hence, considering all these factors it is indicated that in near future project road shall be required a 2 laning widening capacity to cater the future traffic. Therefore, it is required to taken up this project road for 2 laning widening and upgrading to ensure safe and smooth movement of traffic at higher speed.

0.6 Surveys & Investigations

Survey & Investigation includes the survey and analysis of road inventory, visual condition survey, structural evaluation survey, roughness survey, sub grade investigations, material surveys conducted following the relevant Specifications/Codes to generate adequate database for preparing the most appropriate proposal for the rehabilitation / upgrading of the existing road.

Various engineering surveys and investigations for the project road which have been carried out for the project are listed below:

- Road Inventory Surveys
- Pavement Condition Survey
- Traffic Surveys
- Sub grade Investigations
- Topographic Survey
- Roughness Survey
- Soil Investigations

The details of the surveys and investigations are presented in **Chapter 5**: Engineering Survey & Investigations. The summary of the surveys is mentioned below:

Table 0-3: Details of Borrow Area

S. No.	Borrow area Number	Borrow area name village	location	Lead in km	Area available for borrow material	suitability for embankment/ subgrade	Available quantity in Approx cum.	Required quantity in cum
01	BA-1	Purbghagra Majgown	26.9279158N, 93.6316443E	1+000	1423048	Suitable for subgrade and embankment	2134572	1173410.80

Table 0-4: Details of Quarry Sample

Name of the quarry	Name of the crusher	Lead in km	Suitability	Quantity Available in cum	Quantity required in cum
Borgang Stone Quarry	**Borgang Quarry**	55	Suitable for GSB, GSB, WMM, DBM, BC, RCC, PCC, also refer remarks and recommendations given in Aggregate test results sheet	2740464	183356

Table 0-5: Summary of Roughness Values of Project Road

Particular	Roughness Value	IRI	Condition
Maximum	13478	17	Very Poor
Minimum	4623	4	Poor
Average	8491	9	Very Poor

Source: As per Actual Roughness Survey

0.7 Improvement Proposals

The project road is an important connectivity within the Lakhimpur and Sonitpur districts as it connects most of the villages along the road corridor to other regions of the districts. Agricultural activities are major economic drivers of the area. Existing Single lane facility is inadequate to cater the traffic demand and user satisfaction.

- Initially approximate length of project was 24.70 km. However, design chainage length is 28.136 Km.
- Existing alignment is followed for the design purpose and does not have any major deviations except for realignments at 4 locations.
- The project road is proposed to be up-graded to two lanes with shoulder configuration. In settlement areas built-up drains and footpath are proposed.
- Drainage layer is absent in existing pavement which is fundamental cause of road settlement. Moreover, most of the portion of the project has non-mortorized condition. Hence, reconstruction of new pavement is proposed for the entire road with embankment. No overlay is proposed over the road.

0.7.1 Widening Proposal

Entire road length is proposed for widening to 2-Lane with shoulder configuration. Adequate drainage arrangements are also proposed including provision of covered built-up RCC drains in settlement areas. At other locations earthen drains are proposed. The details of the reconstruction schedule are elaborated in ***Table* 0-6**.

Table 0-6: Widening proposal – Two Lane – Flexible Pavement

Lane Configuration	Width (m)					
	Carriageway	Paved Shoulders	Earthen Shoulders	Footpath Over Drain	Space for Drain	Utility Corridor
Package 1 – Ghagrabasti to Mazgaon						
Two Lane with Earthen Shoulders (Open Country) (Type-I)	7.0 (3.5+3.5)	-	3.0 (1.5 + 1.5)	-	-	-
Two Lane with Earthen Shoulders (Open Country - Plain/Rolling Terrain) (Type-II)	7.0 (3.5+3.5)	-	3.0 (1.5 + 1.5)	-	-	-
Package 1 - Shantipur to Holongi Chariali						
Two Lane with Earthen Shoulders (Type-I)	7.0 (3.5+3.5)	-	3.0 (1.5 + 1.5)	-	-	-
Package 2 – Kokchabari to Hawajan						
Two Lane with Paved Shoulder and Footpath Over Drain (Built-Up Area) (Type-I)	7.0 (3.5+3.5)	3.0 (1.5 + 1.5)	-	3.0 (1.5 + 1.5)	-	2.0 (1.0 + 1.0)
Two Lane with Paved Shoulder and Earthen Shoulder (Open Country) (Type-II)	7.0 (3.5+3.5)	3.0 (1.5 + 1.5)	2.0 (1+1)	-	3.0 (1.5 + 1.5)	2.0 (1.0 + 1.0)
Two Lane with Paved Shoulder and Earthen Shoulder (Open Country - Plain/Rolling Terrain) (Type-III)	7.0 (3.5+3.5)	3.0 (1.5 + 1.5)	2.0 (1+1)	-	3.0 (1.5 + 1.5)	2.0 (1.0 + 1.0)
Two Lane with Paved Shoulder and Earthen Shoulder - LHS Retaining Wall and RHS Gabion Wall (Open Country - Plain/Rolling Terrain) (Type-IV)	7.0 (3.5+3.5)	3.0 (1.5 + 1.5)	3.0 (1.5+1.5)	-	-	2.0 (1.0 + 1.0)
Two Lane with Paved Shoulder and Earthen Shoulder - LHS Retaining Wall (Open Country - Plain/Rolling Terrain) (Type-V)	7.0 (3.5+3.5)	3.0 (1.5 + 1.5)	2.0 (1+1)	-	1.5 (0 + 1.5)	1.0 (0 + 1.0)
Two Lane with Paved Shoulder and Earthen Shoulder - LHS Retaining Wall and RHS Gabion Wall	7.0 (3.5+3.5)	3.0 (1.5 + 1.5)	3.0 (1.5+1.5)	-	-	2.0 (1.0 + 1.0)

Lane Configuration	Width (m)					
	Carriageway	Paved Shoulders	Earthen Shoulders	Footpath Over Drain	Space for Drain	Utility Corridor
(Open Country - Plain/Rolling Terrain) (Type-VI)						

Source: Typical Cross Section

It is recommended to widen the section as per the above-mentioned widening proposals. The details of the reconstruction schedule are elaborated in ***Table 0-7***.

Table 0-7: Reconstruction Schedule

Design Chainage		Length (m)	Proposal	Widening Scheme
From	From			
Ghagrabasti to Mazgaon (PKG-1)				
0+000	0+075	75	Concentric	2L+ES
0+075	0+098	23	Retained Minor Bridge	
0+098	2+000	1902	Concentric	2L+ES
2+000	2+130	130	Realignment	2L+ES
2+130	2+230	100	Under Construction Bridge	
2+230	2+410	180	Concentric	2L+ES
2+410	2+460	50	Under Construction Bridge	
2+460	4+775	2315	Concentric	2L+ES
4+775	5+332	557	Realignment	2L+ES
5+332	5+342	10	Proposed Minor Bridge	
5+342	6+200	858	Realignment	2L+ES
6+200	6+770	570	Concentric	2L+ES
6+770	6+978	208	Realignment	2L+ES
6+978	6+990	12	Proposed Minor Bridge	
6+990	7+312	322	Realignment	2L+ES
7+312	7+342	30	Proposed Minor Bridge	
7+342	7+554	212	Realignment	2L+ES
7+554	7+566	12	Proposed Minor Bridge	
7+566	7+750	184	Realignment	2L+ES
7+750	9+125	1375	Concentric	2L+ES
9+125	10+050	925	Realignment	2L+ES
10+050	12+300	2250	Concentric	2L+ES
12+300	13+740	1440	Realignment	2L+ES
13+740	14+800	1060	OUT OF SCOPE	
14+800	15+000	200	Realignment	2L+ES
15+000	15+225	225	Concentric	2L+ES
15+225	15+235	10	Proposed Minor Bridge	
15+235	15+300	65	Concentric	2L+ES

Design Chainage		Length (m)	Proposal	Widening Scheme
From	From			
Mazgaon to Hawajan (PKG-2)				
15+300	15+840	540	Concentric	2L+PS+ES
15+840	15+900	60	Concentric	2L+PS+ES
15+900	16+727	827	Out of Scope	
16+727	16+740	13	Concentric	2L+PS+ES
16+740	16+785	45	Concentric	4L
16+785	16+850	65	Taper from Tcs-I to Tcs-II	
16+850	16+950	100	Concentric	2L+PS+ES
16+950	17+700	750	Concentric	2L+PS+ES
17+700	18+200	500	Concentric	2L+PS+ES
18+200	18+405	205	Concentric	2L+PS+ES
18+405	18+605	200	Concentric	2L+PS+ES
18+605	20+500	1895	Concentric	2L+PS+ES
20+500	20+700	200	Concentric	2L+PS+ES
20+700	21+075	375	Concentric	2L+PS+ES
21+075	21+464	389	Concentric	2L+PS+ES
21+464	21+471	7	Level crossing	
21+471	22+000	529	Concentric	2L+PS+ES
22+000	22+350	350	Concentric	2L+PS+ES
22+350	22+370	20	Concentric	2L+PS+ES
22+370	22+375	5	LHS access road	
22+375	22+675	300	Concentric	2L+PS+ES
22+675	22+800	125	Concentric	2L+PS+ES
22+800	22+900	100	Concentric	2L+PS+ES
22+900	22+960	60	Concentric	2L+PS+ES
22+960	22+990	30	Concentric	2L+PS+ES
22+990	22+995	5	RHS access road	
22+995	23+008	13	Concentric	2L+PS+ES
23+008	23+020	12	Proposed Minor Bridge	
23+020	23+200	180	Realignment	2-lane + PS +ES
23+200	23+284	84	Realignment	2-lane + PS +ES
23+284	23+332	48	Proposed Minor Bridge	
23+332	23+623	291	Realignment	2-lane + PS +ES
23+623	23+638	15	Proposed Minor Bridge	
23+638	23+825	187	Realignment	2-lane + PS +ES
23+825	23+850	25	Concentric	2L+PS+ES
23+850	23+880	30	Concentric	2L+PS+ES
23+880	24+000	120	Concentric	2L+PS+ES
24+000	25+000	1000	Concentric	2L+PS+ES
25+000	25+700	700	Concentric	2L+PS+ES
25+700	25+890	190	Concentric	2L+PS+ES
25+890	25+955	65	Taper from Tcs-II to Tcs-IX	

Design Chainage		Length (m)	Proposal	Widening Scheme
From	From			
25+955	26+006	51	Realignment	4-L +ES
Sonapur to Holongi Chariali Airport Road				
0+000	1+814	1814	Concentric	
1+814	1+822	8	Retained Minor Bridge	
1+822	2+130	308	Concentric	

0.7.2 Junction Improvements

3 major and 7 minor junctions are proposed for development in the view of traffic safety. Details of 3 major junctions considered for improvement are presented in ***Table 0-8***.

Table 0-8: Details of Major Junction

Sl. No.	Chainage	Description	Designed Proposal
1	0+000	T Intersection	Improvement as per type design for intersection on National Highway
2	16+725	4-leg Intersection	At Grade Intersection as per IRC SP 73
3	26+006	T Intersection	Improvement as per type design for intersection on National Highway

0.7.3 Bus Shelters and Bus Bays

10 new bus shelters have been proposed at different locations along the project corridor.

0.8 Bypass and Realignment Proposals

The recommended alignment of the project road comprised of retained existing alignment, improved alignment at several locations considering the structures (retained and reconstruction) and realignments to improve the geometry of alignment at certain locations.

The project road alignment starts from existing Ch. 0+000 at Ghagrabasti and follows the alignment up to Ch. 2+000. At this point **Realignment-1** is proposed from Ch. 2+000 to 2+130**.** **Realignment-2 at Sonapur** is proposed that starts from existing Ch. 4+775 to Ch. 5+332 and 5+342 to 6+200. Total length of Realignment - 2 is 1.415 km. From Ch. 6+200 the alignment follows existing alignment upto Ch. 6+770.

After that, the **Realignment-3 at Salbari** is proposed that starts from existing Ch. 6+770 to Ch. 6+978 and from Ch. 6+990 to 7+312 and 7+342 to 7+554 and ch. 7+566 to 7+750. Total length of Realignment-3 is 0.936 km. From Ch. 7+750 to 9+125 the alignment follows existing alignment.

The **Realignment-4** is proposed from Ch. 9+125 to 10+060**.** **Realignment-5 at Alupara** is proposed that starts from existing Ch. 12+300 to Ch. 13+740 and from Ch.14+800 to 15+000. Total length of Realignment-5 is 1.640 km.

0.9 Pavement Design

Based on the existing pavement conditions, entire project road was identified for reconstruction using flexible pavement. Flexible Pavement has been designed considering a design period of 10 years for Bituminous Layer and 20 years for Granular Layer with Design CBR value of 7% for entire stretch.

The proposed thickness of the different layers computed according to the guidelines of IRC: 37- 2018 for flexible pavement.

Table 0-9 represents the pavement composition proposed for the project stretch.

Table 0-9: New Flexible Pavement Composition

Road Section	Design Traffic (10th Year)	Design Traffic (20th Year)	Design CBR (%)	Pavement Composition (As Per IRC: 37-2018)	Specification
Ghagrabasti to Hawajan via Holongi Airport	10 MSA	10 MSA	7	BC - 40mm	PMB 70
				DBM – 60mm	VG 30
				WMM – 250mm	-
				GSB – 200mm	Grading V

Source: Pavement Design

0.10 Service Road/Slip Road

One slip road has been proposed along the entire project stretch.

0.11 Bridges and Structures

Based on the structures inventory, hydraulic adequacy calculations, adequate number of balancing structures are proposed, structural stability / condition of structure and overall development plan, reconstruction is proposed. The summary of all the structures on the entire road stretch are mentioned in ***Table* 0-10**.

Table 0-10: Structure Improvement Summary

Structure Details	Existing no. of Structures	Retained with Minor repairs	Reconstruction				Newly Proposed	Total no. of Structures
			Box Culvert	Minor Bridge	Pipe Culvert			
					Single Vent	Two Vent		
Major Bridge	2	-	-	-	-	-	-	-
Minor Bridge	13	3	-	6	-	-	2	11
Slab Culvert	10	-	10	-	-	-	-	10
Pipe Culvert	22	-	22	-	-	-	-	22
Box Culvert	8	-	6	2	-	-	-	8
LUVP	-	-	-	-	-	-	1	1
Total	55	3	38	4	-	-	7	52

Source: Structure Inventory & Condition Survey

Two major and two minor bridge are under construction and are not considered under improvements.

0.12 Road Safety Measures

Road traffic signages, road markings, safety devices and junction improvement are provided as per IRC standards from road safety measures aspect.

- Cautionary / Warning sign boards at turning/bend, structure, junction, school and built-up locations.
- Regulatory Sign Board at speed restrict location and junctions.
- Informatory sign board at junctions, villages and existing facility locations.
- Gantry sign location at start and end point of the proposed road
- Chevron Board at curve locations.
- Hazard marker at structure, crash barrier location and island locations.

0.13 Environmental Assessment

The project corridor is an existing road located in the Lakhimpur and Sonitpur Districts of Assam. It is connecting 19 settlements and passes through mostly plain terrain. The existing ROW varies from 7m to 40m, there are 11 minor bridges, 22 existing pipe culverts, 10 existing slab culverts and 8 existing box culverts.

The proposed improvement will have impacts on topography and change in land use in the region. Loss of agricultural land and productive soil is also anticipated due to additional land acquisition. The improvement of the proposed road in the brownfield area involves cutting, filling, and the need to cut vegetation along most of the project road length. Land clearing will involve cutting off 1652 trees. The loss of trees will be compensated by planting 16520 trees (1:2 ratio) as compensatory afforestation. In order to improve the environment, additional measures are proposed during construction for (a) sanitation and housekeeping at the labour/ construction camps (b) provision of water supply (c) hygiene and provision of toilet facilities, (d) sewerage and waste disposal (e) first aid, (f) maintenance of buildings and facilities (g) identification of debris disposal sites, (h) rehabilitation of quarry and borrow pits and (i) Precautionary measure taken during construction with respect to Covid-19.

The identified environmental issues and suggested mitigation measures with institutional arrangements for implementation are given in the Environmental Management Plan (EMP) in **Volume IV A**.

- An environmental mitigation measure budget of **INR 2,66,21,160** has been estimated for the implementation of the environmental management plan. The proposed improvement of the project road is expected to cause some environmental impacts, but it is not expected to cause any significant impact. The project does not require environmental clearance as per EIA Notification, 2006 and amendments made thereunder. The project road also does not require NOC from the Standing Committee of National Board for Wildlife.

0.14 Social Assessment

This social assessment along the project road has been carried out by keeping a consideration for minimum resettlement impact through feasible engineering designs. However, there will be some adverse social impact which will be properly mitigated through resettlement provisions.

0.15 Cost Estimate

The cost estimate was prepared based on the following methodology:

- Quantities of various components are worked out based on preliminary engineering.
- Rate analysis template published by MORTH is used.
- Unit rates considered are as per "Schedule of Rates for the year 2018-19, published by Public Works Road department, Assam"
- Unit rates for key materials (Cement, Reinforcement, etc.) have been collected and used from SoR.

Table 0-11: Total Project Cost

ABSTRACT OF COST		
Sr.No.	**Description**	**Amount (INR)**
	Road Works	
1	A) Site Clearance and Dismantling	48,20,528.00
	B) Earthwork	8,89,10,577.00
	C) Bus bays, junction improvement including widening for auxiliary lanes	4,47,208.00
	D) Sub-Base and Base Courses (GSB, WMM)	19,91,56,852.00
	E) Bituminous Course	12,75,78,884.00
	F) Concrete pavement	-
	G) Service Road	-
2	**Structures**	
	A) Culverts (Pipe/Box culverts)	9,06,74,682.00
	B) Bridges (Major/Minor/ROB/RUB/VUP/Foot Over)	8,31,19,409.00
	C) Repair and Rehabilitation of Poor Bridges	18,02,067.00
	D) Retaining wall	-
	E) Bus Shelter	23,22,948.00
3	**Drainage and Protection Work**	
	A) RCC Drain	-
	B) Protection Work	-
	C) Others	-
4	**Traffic Sign and Road Appurtenances**	
	A) W Beam Crash barrier & Flexible Crash Barrier, Wire Rope Safety Barrier	1,68,04,321.00
	B) Traffic Signs	52,66,009.00
	C) Pavement Marking	79,38,238.00

ABSTRACT OF COST		
Sr.No.	**Description**	**Amount (INR)**
	D) Pedestrian Guard Rail	-
	E) Paver block	-
	F) Others (km stones, studs, solar blinkers, delineators, RPC, Street Light etc.)	83,93,945.00
5	**Environmental Mitigation Cost**	8,29,030.00
6	**Total Civil Cost (1+2+3+4+5)**	**63,80,64,698.00**
7	Price adjustment @ 4% Per Annum on 6 *(18 months)*	3,82,83,882.00
8	**Total (6+7)** (Price adjustment + Civil Work Cost)	**67,63,48,580.00**
9	GST, Assam building and other construction workers welfare cess (13%) on 8	8,79,25,315.00
10	Provisional Sum for Day Work (including Tax @13%)	59,98,447.00
11	Contingencies @ 5% on (6+Taxes)	3,60,50,655.00
12	Tree Cutting Cost, Afforestation, Training and Administrative charges (including GST12%)	8,17,35,301.00
13	Forest Clearance Cost (as per actual)	5,53,62,779.00
14	Utility Shifting Cost (as per actual) (including GST)	2,11,27,581.00
15	Land Acquisition and R&R Cost (as per actual)	22,19,78,116.00
16	Maintenance Cost after construction (0.5% for 1st year,1% for 2nd year, 1% for 3rd year, 1% for 4th year and 1.5% for 5th year) on Cost put tender	3,60,50,655.00
17	**Total Project Cost**	**1,22,25,77,429.00**
	Cost per KM w.r.t (with Taxes)	**4,40,44,784.00**
	Cost per KM w.r.t (Put tender cost+17) Including taxes	**4,62,47,023.00**
	Cost per KM w.r.t 18 (including all cost) (18/L)	**7,46,84,021.00**
	Cost put to tender (Including taxes)	**72,10,13,109.00**

Package 2 – Kokchabari to Hawajan		
Sr. No.	**Description**	**Amount (INR)**
	Road Works	
1	A) Site Clearance and Dismantling	71,53,349.00
	B) Earthwork	13,06,41,295.00
	C) Bus bays, junction improvement including widening for auxiliary lanes	45,79,138.00
	D) Sub-Base and Base Courses (GSB, WMM)	17,12,32,383.00
	E) Bituminous Course	12,93,87,986.00
	F) Concrete pavement	-
	G) Service Road	-
2	**Structures**	

Package 2 – Kokchabari to Hawajan		
Sr. No.	**Description**	**Amount (INR)**
	A) Culverts (Pipe/Box culverts)	3,73,59,340.00
	B) Bridges (Major/Minor/ROB/RUB/VUP/Foot Over)	12,51,37,606.00
	C) Repair and Rehabilitation of Poor Bridges	12,39,448.00
	D) Retaining wall	-
	E) Bus Shelter	11,61,474.00
3	**Drainage and Protection Work**	
	A) RCC Drain	1,98,14,171.00
	B) Protection Work	4,03,95,679.00
	C) Others	4,85,760.00
4	**Traffic Sign and Road Appurtenances**	
	A) W Beam Crash barrier & Flexible Crash Barrier, Wire Rope Safety Barrier	1,25,29,351.00
	B) Traffic Signs	37,57,722.00
	C) Pavement Marking	47,22,429.00
	D) Pedestrian Guard Rail	82,14,700.00
	E) Paver block	-
	F) Others (km stones, studs, solar blinkers, delineators, RPC, Street Light etc.)	49,95,139.00
5	**Environmental Mitigation Cost**	8,14,144.00
6	**Total Civil Cost (1+2+3+4+5)**	**70,36,21,114.00**
7	Price adjustment @ 4% Per Annum on 6 *(24 months)*	5,62,89,690.00
8	**Total (6+7)** (Price adjustment+Civil Work Cost)	**75,99,10,804.00**
9	GST, Assam building and other construction workers welfare cess (13%) on 8	9,87,88,405.00
10	Provisional Sum for Day Work (including Tax @13%)	59,99,125.00
11	Contingencies 5% on (6+Taxes)	3,97,54,593.00
12	Tree Cutting Cost, Afforestation, Training and Administrative charges (including GST12%)	1,19,32,622.24
13	Forest Clearance Cost (as per actual)	-
14	Utility Shifting Cost (as per the present) (including GST12%)	1,27,42,370.00
15	Land Acquisition and R&R Cost (as per actual)	28,14,48,445.60
16	Maintenance Cost after construction (0.5% for 1st year,1% for 2nd year, 1% for 3rd year, 1% for 4th year and 1.5% for 5th year) on Cost put tender	3,97,54,593.00
17	**Total Project Cost**	**1,25,03,30,958.00**
	Cost per KM w.r.t (with Taxes)	**8,04,83,031.00**
	Cost per KM w.r.t (Put tender cost+17) Including taxes	**8,45,07,182.10**
	Cost per KM w.r.t 18 (including all cost) (18/L)	**12,65,64,527.00**
	Cost put to tender (Including taxes)	**79,50,91,859.00**

0.16 Economic Analysis

The results of economic analysis for the project road are presented in terms of economic internal rate of return (EIRR) and net present value (NPV) at 12% & 9% discount rate. A project with an EIRR equal or above 12% or 9% is treated as economically feasible for implementation. The result is presented in ***Table* 0-12**.

Table 0-12: Sensitivity of Economic Returns

Option	Discount Rate	Base Case		Base Cost Plus 15% and Base Benefits		Base Cost and Base Benefits Minus 15%		Base Cost Plus 15% and Base Benefits Minus 15%	
		EIRR (%)	NPV (In Million)	EIRR (%)	NPV (In Million)	EIRR (%)	NPV (In Million)	EIRR (%)	NPV (In Million)
I 2LPS	*12%*	24.5	1965	22.1	1750	21.7	1455	19.4	1239
II 2LES		25.3	2017	22.8	1809	22.4	1506	20.1	1298
I 2LPS	*9%*	24.5	3208	22.1	2984	21.7	2503	19.4	2279
II 2LES		25.3	3261	22.8	3045	22.4	2556	20.1	2340

Source: Consultant's Analysis

The project is found to be economically feasible for the proposed improvement of upgradation to two lane with paved shoulders considering that the EIRR of 21.60% in base case and 17.0% is worst case, which is above the benchmarked IRR of 12% and 9% respectively.

0.17 Road Asset Management Plan

The proposed process of asset management system will begin with site condition investigation for all the road asset. All the recorded road asset condition data are processed and converted into the predefined RAMS format. The process of asset management system is also proposed with public issues interface system. The public issues received shall be sent for investigation and validation. If authentic, then it would be considered into the RAMS format but if found false then it would be discarded. This data then goes as an input to the Road asset management system. The road asset management system then serves as a data base for all the recorded road assets and shall locate every individual road asset when and where required via its GIS interface. The output obtained from RAMS then goes as an input into HDM4 (an analytical software) and HDM4 as an output gives the maintenance plan which also includes the cost of maintenance for the road asset.

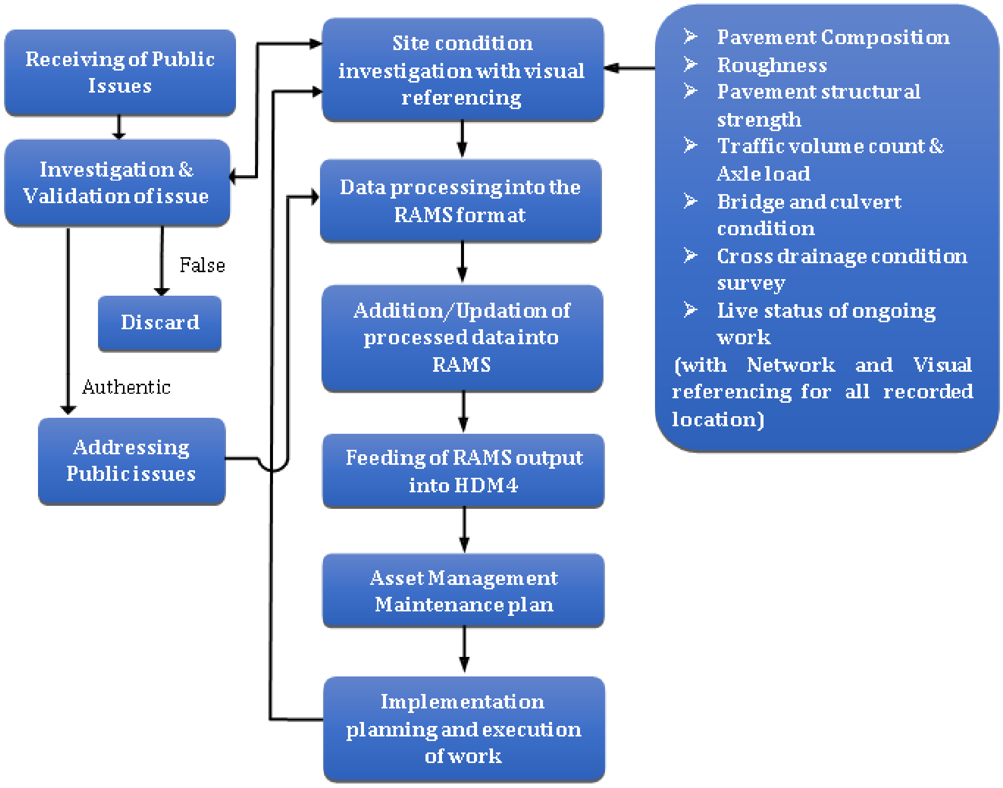


Figure 0-3: Road Asset Management Process

0.18 Conclusions and Recommendations

- This project road has a wider connectivity to various regions like Lakhimpur, Sonitpur, Kamrup, etc and also to Nagaland and Arunachal Pradesh states borders. The project road is also connecting to the new proposed Holongi Airport, 15 km away from Itanagar. The implementation of proposed road project will help intrastate and interstate passengers and freight traffic movements, also imbibe smooth vehicular movement and shall significantly improve ease of transit.
- The project road has wider connectivity to some of NH's and SH's like NH-15, NH-52A, NH-415, NH-13, SH-43, SH-45 and MDR's.
- The present condition of the pavement is fair to bad. It is suggested that road should be considered under reconstruction in order to comply with the safety concerns.
- Moreover, the project road is basically aimed at improving rural connectivity, facilitating safer and more efficient access to livelihood and socio-economic opportunities for the local communities in the districts and region. With the development proposal of the project is found to be economically viable, it can cater for the traffic demand for at least 20 years after construction and improve the connectivity of agricultural and commercial locations of Assam.

CHAPTER 1

INTRODUCTION

1 Introduction

1.1 Background

Assam is the largest state among the North Eastern states of India in terms of population and acts as gateway for the entire North Eastern (NE) states i.e. Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and shares its border with the state of West Bengal and two countries viz. Bangladesh and Bhutan. Its fiscal and economic situation has been improving since last decade, efforts of the government has helped the state to accelerate its Gross State Domestic Product (GSDP). Its geographical location demands huge thrust on the development of road infrastructure in the region thereby enhancing the region's economy. Road infrastructure assets are the key factors of economic development, mobility and social equity for any region or nation. They are not only costly to build but also expensive to maintain in order to adequately meet the public expectations. The key issue is how to manage existing assets in a way that it delivers maximum benefit to public with the limited financial resources. The answer is Road Asset Management System (RAMS) which offers a comprehensive and structured approach to the delivery of the community benefits through management of road networks.

The Government of Assam intends to objectively develop State's road infrastructure for fueling economic growth, by providing transportation and rural connectivity, and also by providing good quality inter-state and international connectivity, making it at par with other replicable Asian economies. The Government of Assam has formulated the "Assam Vision 2030" in line with the UN Sustainable Development Goals (SDG) and the National Development Agenda. The Government of India has also embarked upon 'Act East Policy' and it aims to make Assam the hub of economic activities in South Asia region.

Public Works Roads Department (PWRD), responsible for managing the secondary, urban and rural road network in Assam, had initiated several projects in the state to boost its infrastructure and Assam State Road Project (ASRP), was one of them. Development and implementation of a computerized road asset management system (RAMS) for the maintenance and management of the state road network was one of the key mandates of ASRP. Consequently, such a system was developed and implemented during 2015-18 to meet the needs of PWRD and is called the Assam Road Asset Management System (ARAMS). The ARAMS application was envisioned to assist the PWRD to rationalize and aid the decision-making for planning/ programming of road maintenance and rehabilitation activities and to estimate the long-term funding requirement for preserving the road assets at an acceptable service level, thereby safeguarding their asset value.

It was observed that years of underfunding and perennial neglect to maintenance has dilapidated the State Highways (SH) and Major District Roads (MDR) network. The SHs & MDRs have remained as the 'neglected middle', as compared to NHs which were being improved by MoRTH and Rural Roads which are being constructed largely under PMGSY by Ministry of Rural Development (MORD), GOI. Most SHs & MDRs have poor riding quality, weak pavements, and inadequate capacity. Nearly 35% of SH & MDR have remaining life less than 2 years. The SH & MDR network now needs fast reconstruction and capacity augmentation.

To preserve and improve the secondary network in a serviceable condition is a challenging task for the state. The region is geographically dispersed and experiences a long rainy season thereby submerging a considerable part of network.

The road network traffic demand has increased considerably since the last decade. Between 2001 and 2011 the Assam population grew by around 17%, while during the same period of time the number of motor vehicles on Assam roads is estimated to have grown by 160% (16% per year) and the road network has grown by around 4% per year. 33% of present network needs capacity augmentation/ widening. It is expected to increase to 46% in 3 years and 61% in 10 years.

To improve the secondary road network objectively, the Government of Assam has initiated a flagship program named as Axom Mala. It is planned as a long term programme for fueling economic growth as well as improving the road infrastructure towards achieving the Assam Vision 2030 and Sustainable Development Goals. The programme has been developed based on a long-term plan developed using the Road Asset Management System. It would be an umbrella program with funding from State Government and multilateral development banks. The objectives of the program include:

1) To improve the SH & MDR network in the next 15 years for fueling economic growth and bringing the state road infrastructure at par with Southeast Asian countries;
2) To provide quality inter-linkage roads between the National Highways and the rural roads network as well as facilitate seamless multi-modal transportation; and
3) To interconnect economic growth centers with quality developing quality transportation corridors and improve inter-state connectivity. The Axom Mala will be an umbrella program with funding from State Government and multilateral development banks like ADB, AIIB, etc.

The project road works will generally involve geometric improvement in terms of horizontal and vertical alignment improvement, as well as widening to two lanes with or without paved shoulders depending on necessity and feasibility. Roads to be improved would mostly follow the existing alignment, but at some stretches realignments or new alignments would be adopted for improving the roads. New RCC bridges would be constructed wherever required and existing structurally weak bridges in poor condition would be rehabilitated. Road safety audits will be carried out and counter measures to improve safety would be adopted. Economic analysis would be carried out for each project road to ensure viability of road improvements works.

The State Government has initiated implementation of program by starting 5 works contracts valued at Rs. 375 crores from its own budgetary resources. More importantly, it identified about 1320 km of priority SH & MDR for improvement under Axom Mala for which DPR preparation has been initiated.

The DPRs for the road improvement and widening works would include the detailed engineering designs. It would include environmental assessments as per the applicable Government of India guidelines. It would also include Environmental Management Plans (EMP) to mitigate environmental damages along with compensatory afforestation for roadside trees to be felled, meeting the policies and guidelines of funding agencies. Furthermore, the DPRs would include social assessments as per the regulations. It would include land acquisition plans for improving horizontal alignment and widening the roads, prepared based on revenue records. Moreover, it would include resettlement and rehabilitation plans for project affected persons. An entitlement matrix would be prepared for compensation to be paid to affected persons and families.

Preparation of DPRs would further include shifting of utilities along the road, including electrical poles and water supply pipes. The cost estimates would be prepared based on joint inspection at work site with the concerned organizations like Power department, Public Health Engineering Department, etc. The pre-construction works involving land acquisition and utility shifting are planned to be started after DPRs are approved so that encumbrance free site is available to the contractor at the time of award of the work.

1.2 Objective of Consultancy Services

The main objective of the consultancy service is to establish the technical, economical, and financial viability of the project and prepare detailed project (DPR) reports for rehabilitation and upgrading of the existing road to 2-lane with paved shoulders configuration with provision of capacity augmentation.

The Project is to be established taking into account the requirements with regard to rehabilitation, upgrading and improvement based on highway design, pavement design, provision of service roads wherever necessary, type of intersections, rehabilitation and widening of existing and/or construction of new bridges and structures, road safety features, quantities of various items of works and cost estimates and economic analysis.

1.3 Scope of Consultancy Services

The scope of Consultancy services as set out in the TOR includes the following major tasks for the PPR and DPR stages of works.

- Traffic studies including traffic surveys and Axle load survey and demand forecasting for next 20 years;
- Road inventory and condition surveys;
- Inventory and condition surveys for culverts and bridges
- Detailed topographic surveys using Total Stations and DGPS;
- Soil investigations, sub-grade characteristics and strength, subsoil and geotechnical investigations.
- Pavement investigations, pavement deflection measurement;
- Identification of sources of construction materials;
- Detailed design of all culverts, ROBs, Grade separators, under/over passes and other structures including, preparation of GAD and construction drawings.
- Identification of the type and the design of intersections;
- Design of roadside drainage system.
- Economic analysis;
- Construction/contract packaging and implementation schedule.
- Strip plan indicating the scheme for carriageway widening, location of all existing utility services (both over and underground) and the scheme for their relocation, cutting of trees, tie-in with on-going/sanctioned works of MORT&H/ Assam PWD / other agencies
- Environmental and Social Impact Assessment Studies and preparation of Environmental Management Plan (EMP) and Social Management Plan (SMP) for the project affected people as per the requirements and policy of the GOI and GOA R&R Policy. Public consultation, including consultation with communities located along the roads, NGOs working in the area, other stakeholders and relevant Govt. departments at all the different stages of assignment.
- Land acquisition plans and schedules including reports and documents required for land acquisition in accordance with the applicable Land Acquisition Act or as per the procedure adopted for the project by the client.
- Preparation of detailed project report, cost estimate, construction drawings, rate analysis, detailed bill of quantities, bid documents for execution of civil works. All ready to implement “good for construction” drawings shall be prepared.
- The consultant shall study the possible locations and design of wayside amenities required such as bus bays, truck lay byes and plan arboriculture along the highway

- Road safety audit shall be carried out. Aspects to be checked shall inter alia include safety and operational implications of proposed alignment, junction designs, road width, deviations from standards and action taken, provision of pedestrians and slow-moving vehicles, etc.

1.4 Stages of Completion

In developing the Work Plan for completing the assignment, the activities have been considered under three stages as follows:

Stage 1 - **Inception Report**

Stage 2 - **Preliminary Project Report (PPR)**

Stage 3 - **Detailed Project Report (DPR)**

The stages will generally follow a sequence, though each stage is inter-related and inter-dependent on one another. The related reports for each stage will be submitted to the PWRD Assam as stipulated in the TOR.

1.5 Reporting Requirements

Detailed Project Report (DPR) document is the 3rd Stage report of a three-stage study of the project. The Detailed Project Report (DPR) constitutes of the following Volumes fulfilling requirement of TOR Clause No. 6.

Volumes		**Title**
Volume – I	:	Main Report
Volume – IA	:	Appendices to Main Report
Volume – II	:	Design Report (Two Parts)
	:	Part – 1: Roads
	:	Part – 2: Culverts, Bridge & other Structures
Volume IIA	:	Appendix to Design Report (Three Parts)
	:	Part – 1: Roads
	:	Part – 2A: Culverts, Bridge & other Structures
	:	Part – 2B: Sub-Soil Exploration Report
Volume – III	:	Materials Report
Volume – IVA	:	Environmental Assessment and Environmental Management Plan (EMP)
Volume – IVB	:	Social Assessment and Resettlement Action Plan (RAP)
Volume – V	:	Technical Specifications
Volume – VI	:	Rate Analysis
Volume – VII	:	Cost Estimates
Volume-VIII	:	Bill of Quantities
Volume – VIIIA	:	Quantities Calculation Backup

Volume – IXA	:	Drawing Volume: Road Works
Volume – IXB	:	Drawing Volume: Bridge Works
Volume – X	:	Bidding Documents
Volume – XI	:	Project Clearances
Volume – XII	:	Proposed Work Program and Construction Schedule

1.6 Structure of this Report

This report is constituent "Volume – I: Main Report" of the Detailed Project Report (DPR) documents. The contents of **Volume – I: Main Report** is as follows:

Chapters		Title
		Executive Summary
Chapter 1	-	Introduction
Chapter 2	-	Project Description
Chapter 3	-	Socio-Economic Profile of the Project Area
Chapter 4	-	Traffic Studies and Demand Forecast
Chapter 5	-	Engineering surveys and Investigation
Chapter 6	-	Design standards and specifications
Chapter 7	-	Proposed Road Features and Improvements
Chapter 8	-	Engineering Design
Chapter 9	-	Environmental Assessment and EMP
Chapter 10	-	Social Assessment and RAP
Chapter 11	-	Cost Estimate
Chapter 12	-	Economic Analysis
Chapter 13	-	Road Safety Audit
Chapter 14	-	Implementation Schedule
Chapter 15	-	Long Term Asset Management Plan
Chapter 16	-	Conclusions and Recommendations

CHAPTER 2

DESCRIPTION OF EXISTING PROJECT ROAD

2 Description of Existing Project Road

2.1 General

This chapter purports the essential features of the existing project road namely **Ghagrabasti to Hawajan via Holongi Airport [A28].** It presents a summarized view of the existing location, condition, importance and developments in and around the existing road. It also provides a glimpse of the critical locations like forest and wildlife, if any, around the road.

The project work for the proposed road consists of improvement of **Ghagrabasti to Hawajan (Part I - L: 26.006 Km) and Sonapur to Holongi Airport (Part II - L: 2.130 Km) District: Sonitpur & Lakhimpur.** ***Table*** 2-1 shows the details of the project road stretch considered for the Detailed Project Report.

Table 2-1: Details of Project Road

Sr. No.	Group	Corridor No.	Project Road Stretch	Design Length (km)
1	**III**	A28 (Part I)	Ghagrabasti to Hawajan	26.006
2	**III**	A28 (Part II)	Sonapur to Holongi Airport	2.130

However, the project road has been proposed to be implemented in two packages viz., **Package 1 – Ghagrabasti to Mazgaon (Ch. 0+000 to Ch. 13+740 and Ch. 14+800 to Ch. 15+300), Shantipur to Holongi Chariali (Ch. 0+000 to Ch. 2+130)** and **Package 2 – Kokchabari to Hawajan (Ch. 15+300 to 15+900 and Ch. 16+727 to Ch. 26+006).**

The roads covered under Group 3 as per the revised grouping are mentioned in **Table** 2-2***.***

Table 2-2: Details of Group 3 project roads

Sr. No.	Corridor No.	District Name	Name of the Road	Start Point	End Point	Road Length (Km) as per RFP
1	A11_1	Darrang	Dalgaon Borchola to Dhekiajuli via Gupteshwar Temple	Dalgaon	Dev Pukhuri	14.30
2	A11_3	Sonitpur	Dalgaon Borchola to Dhekiajuli via Gupteshwar Temple	Dhupguri	Dhekiajuli	27.459
3	A11_4	Sonitpur	Dalgaon Borchola to Dhekiajuli via Gupteshwar Temple	Kalisthan	Dipota	27.278
4	A13_2	Darrang	Salmara Andherighat Khoirabari Tangla Harisinga Deolguri	Barbari	Andherighat	7.10
5	A14_1	Darrang	Sipajhar Tangla	Sipajhar	Dolong Ghat	20.00
6	A17_2	Sonitpur	Rowat to Missamari via Hugrajuli, Batasipur Railway Station including 3 Major RCC Bridges	Kanakata	Phuloguri	33.30

Sr. No.	Corridor No.	District Name	Name of the Road	Start Point	End Point	Road Length (Km) as per RFP
7	A22	Lakhimpur & Dhemaji	Dhakuakhana Butikur Tiniali Telijan	Dhakuakhana	Telijan	33.30
8	**A28**	**Sonitpur & Lakhimpur**	**Gohpur Dholpur Road via Arunachal Highway, Daimalu, Alupara, and Simaluguri including 2 Major RCC Bridges over River Kokila**	**Ghagrabasti**	**Hawajan**	**24.70**
9	A30_1	Dibrugarh	Moran to Disang Kinar Bangali	Moran	Disang Kinar Bangali	82.30
10	A30_2	Dibrugarh	Disang Kinar Bangali to Kathalguri via Naharkatia Bypass	Disang Kinar Bangali	Kathalguri	
11	A31_2	Lakhimpur	Majuli to Bhogalmara via Dhunaguri	Dhunaguri	Bhogalmara	9.30
Total						**252.90**

2.2 Description of Project Road

The project road **Ghagrabasti to Hawajan via Holongi Airport [A28]** lies in the district of Sonitpur and Lakhimpur, passes through various junctions and spreads over the remote locations of the two districts. **Lakhimpur** is the administrative district in the state of Assam bounded on the North by Siang and Papumpare District of Arunachal Pradesh and on the East by Dhemaji District and Subansiri River whereas Majuli District stands on the Southern side and Biswanath District is on the West. **Sonitpur** lies on the plains between the foothills of the Himalayas and the valley of the Brahmaputra which forms its southern border.

The project road consists of two alignments wherein the first alignment originates from Ghagrabasti on NH-415 at Y-Junction where left side of the NH-415 goes to Itanagar and the right side to Gohpur. The project road ends at Hawajan on NH-15 making a T-junction. The second alignment initiates near Sonapur on Ghagrabasti to Hawajan section and traverses in the north direction to end at Proposed Holongi Airport. The road is well surrounded by SH's and NH's like NH-15, NH-415, NH-13, SH-43, SH-45. The project road experiences a good portion of agricultural area on both sides of road with main crop sown being rice. A number of Common Property Resources like schools, colleges, temples are observed along the project alignment depicting the religious and social status. The project road has a single lane configuration with poor to fair condition.

Figure 2-1 bestows a pictorial representation of all the project roads of Group 3.

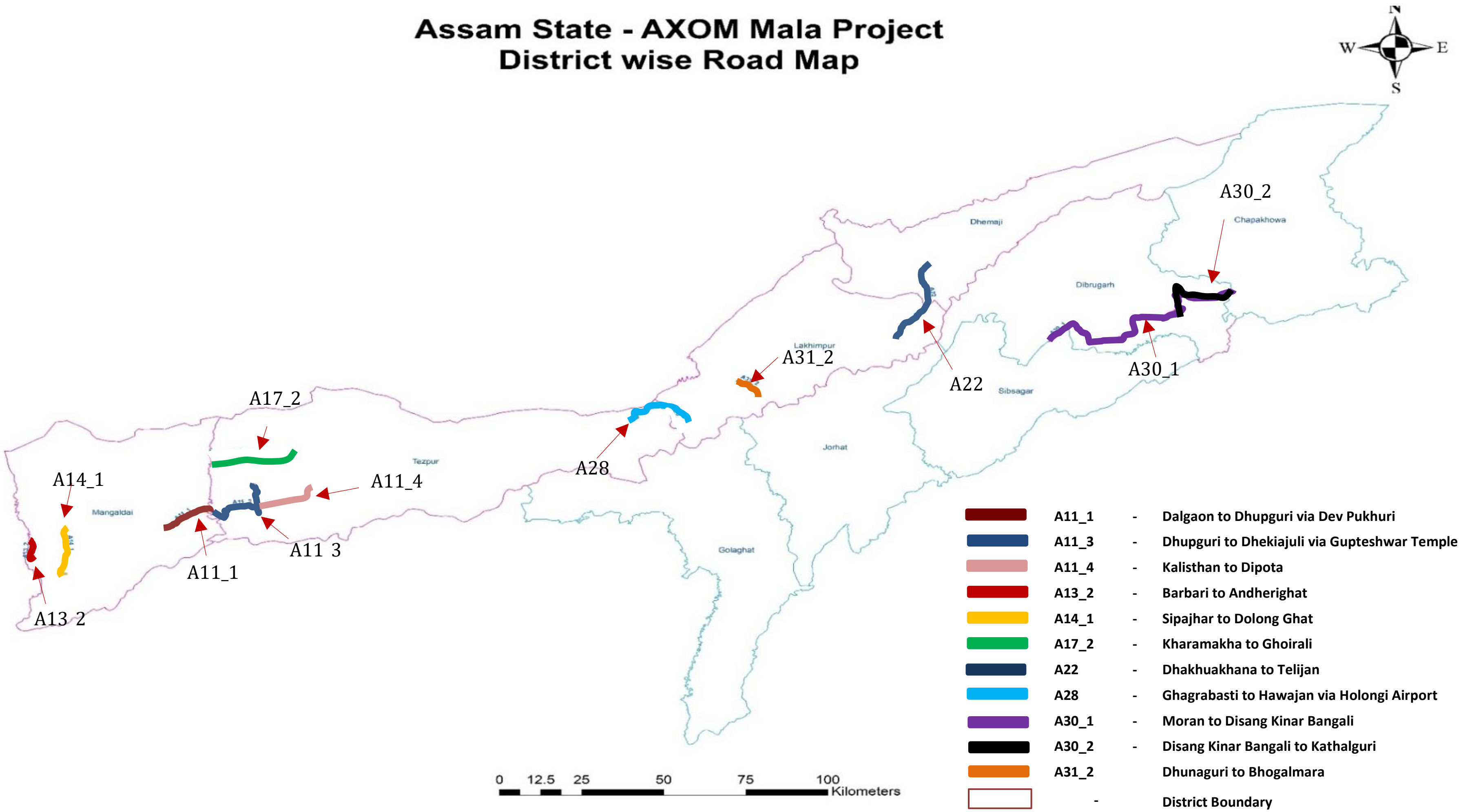


Figure 2-1: Map representing project roads under Group 3

2.3 Existing Alignment

The Project Road from **Ghagrabasti to Hawajan via Holongi Airport** has a total length of is 28.136 km (Part I – 26.006 km & Part II – 2.130 km). The section **Ghagrabasti to Hawajan** starts from Ghagrabasti and proceeds in the North-east direction meets a major bridge over Solangi river and then traverses through a number of settlements Sonapur, Alupara, Daimalu and Simaluguri. After Simaluguri, the road moves in south direction passing through some more settlements like Khalihmari and Sesamiri before ending at Borthekerabari village on NH-15. Roads coming from various nearby villages like Nalbari, Kalmouguri, Kalika Guri, Nowguli joins the project road at various junctions. The section from **Sonapur to Holongi Airport** initiates near Sonapur and traverses in the north direction to end at Proposed Holongi Airport. The project road has a single lane configuration with poor to fair condition. Even some sections of the road have non-motorised road. Carriageway of the existing road is of Bitumen with some portions near Sonapur and Alupara have paver block surfaces. The pictorial representation of the project road is provided in ***Figure*** 2-2***.***

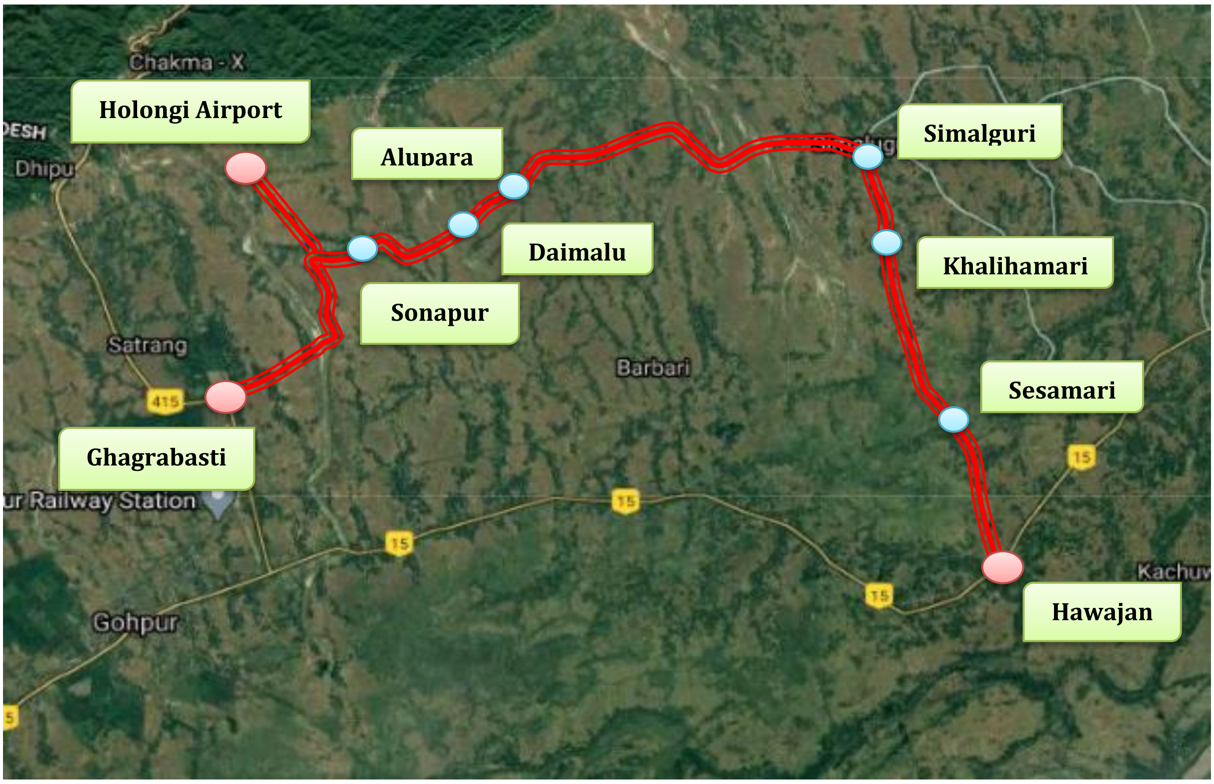


Figure 2-2: Settlements along Ghagrabasti to Hawajan & Sonapur to Holongi Airport

2.4 Location

The project road Ghagrabasti to Hawajan is located in Lakhimpur and Sonitpur District. The alignment of the project road connects several villages along its stretch. The project road mainly traverses through the settlements of Ghagrabast, Nalbari, MC Sonapur, Madhya Sonapur, Sonapur, Narenguri, Sonarijan, Hoijangbari, Thoribari, 2 No. Bijaypur, Alaipur, Salbari, Doimalu, Alupara, Simaluguri, Sesamiri, Futabhug, Niran Chuba, Khalihamari, Borthekerabari before ending at Hawajan. The project road has its connectivity to several NH and SH like to NH-15, NH-52A, NH-415, NH-13, SH-43, SH-45.

2.5 Terrain, Soil Type and Geology

The district is mainly a flat alluvial tract; in its southern part, a few scattered 'inselbergs' of gneissic rocks not exceeding 90 to 140 m., high above mean sea level, lie along the north bank of the Brahmaputra. In the northern front along the base of the foot-hills of the eastern Himalayas, from where the alluvial plain gradually slopes down to the Brahmaputra, there are several low-lying mounds made up of unsorted river terraces. Some parts of the district are hills, covered with long grass jungle interspersed here and there with patches of rice fields.

Acidity is a general characteristic of the soil of the district and more so in the older alluvial soil. New alluvial soils representing the lands of the river banks are less acidic. There are often neutral and even alkaline. The phosphoric content is good in the river side of the Brahmaputra where tea is grown. Acidic alluvial soils are suitable for cultivation of tea. Heavy clay with high percentage of nitrogen in low land areas give a good return of rice, while sand looms above inundation level give a good yield of crops. Overflowing of the rivers replenishes the soil every year by depositing silt. The potash (k20) content is low in some soils and moderate in others.

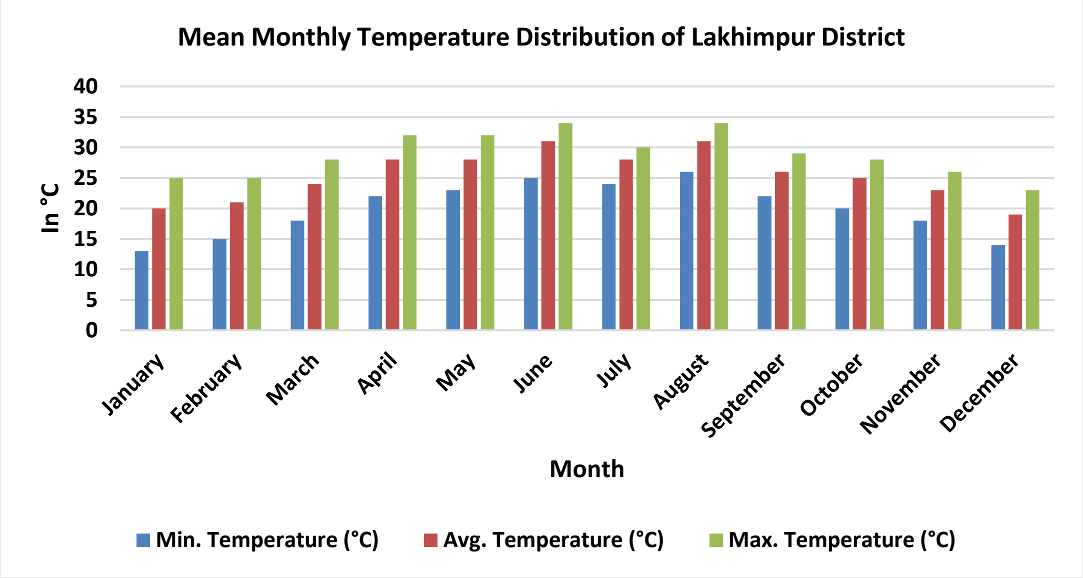
2.6 Climate

As the entire road stretch passes through Lakhimpur & Sonitpur district, information related to climate is studied for both Lakhimpur & Sonitpur districts.

2.6.1 Annual Temperature

Lakhimpur:

The high temperature is experienced during South-West monsoon season which generally starts in the month of June and last till the beginning of the month of October every year. The cold season starts from the early part of November till late February. The winters are generally cold and foggy. The mean temperature (°C) data for Lakhimpur district reveals that June is the hottest month with mean temperature reaching up to 34°C while December is the coldest month of the year when mean temperature dips down to 14°C. The mean maximum annual temperature as recorded in Lakhimpur is 29°C while mean minimum annual temperature is 20°C. ***Figure*** 2-4 represents the Mean monthly Temperature Distribution in Lakhimpur district for 2019.

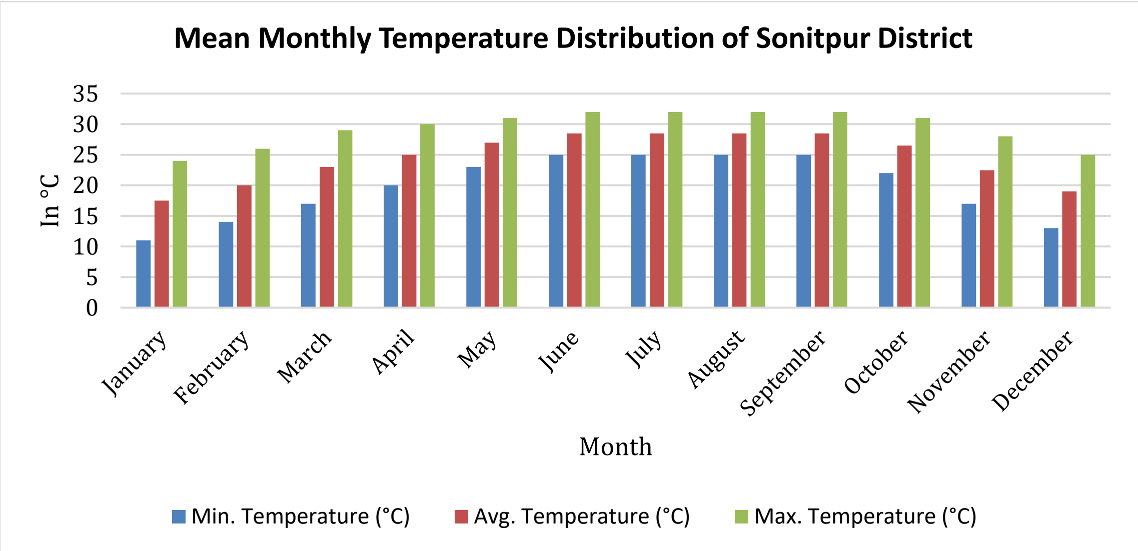


Source: www.worldweatheronline.com

Figure 2-3: Mean Monthly Temperature Distribution details - Lakhimpur

<u>Sonitpur:</u>

The mean temperature (°C) data for Sonitpur district reveals that June is the hottest month with mean temperature reaching up to 32°C while December is the coldest month of the year when mean temperature dips down to 13°C. The mean maximum annual temperature as recorded in Sonitpur district is 28°C while mean minimum annual temperature is 17°C. ***Figure*** 2-4 represents the Mean monthly Temperature Distribution in Sonitpur district.



Source: NOAA.gov

Figure 2-4: Mean Monthly Temperature Distribution details – Sonitpur

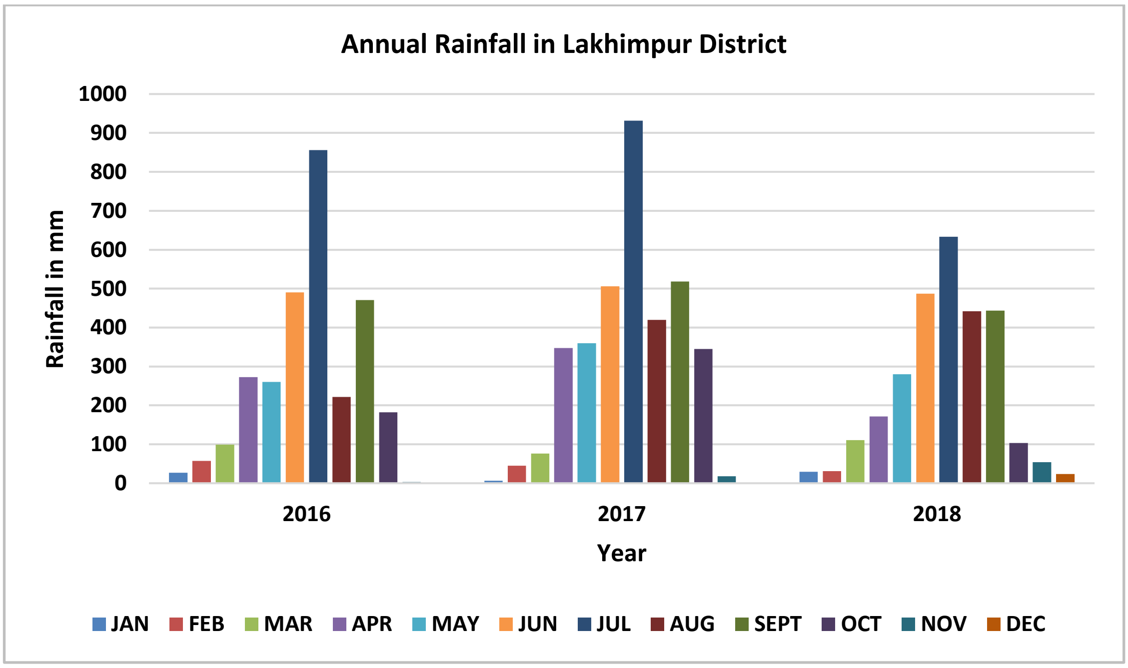
2.6.2 Annual Rainfall

Lakhimpur:

The absence of dry hot summer is the characteristic feature of the climate of Lakhimpur district. High humid temperature and exorbitant rains during summer, like the other districts of Assam, are experienced. The climatic feature of February March is usually dry and windy. April to May is a period of thunderstorm and heavy cyclonic rainfall. Rainfall occurs almost throughout the year. The South-West monsoon arrives and blows over the district by about the beginning of June every year.

Lakhimpur is situated in the high rainfall zone with annual average rainfall of 2809.90 mm received in the year 2018. The district normally receives 2 percent of rainfall in Winter Season (January-February), 20 percent in Summer Season (March-May), 55 percent in Monsoon Season (June-September) and 22 percent in Post-Monsoon Season (October-December). ***Source:*** *India Meteorological Department website (www.imd.gov.in)*

Figure 2-6 depicts the details related to the Annual Mean Rainfall received by Lakhimpur district from 2016 to 2018.



Source: India Meteorological Department website (www.imd.gov.in)

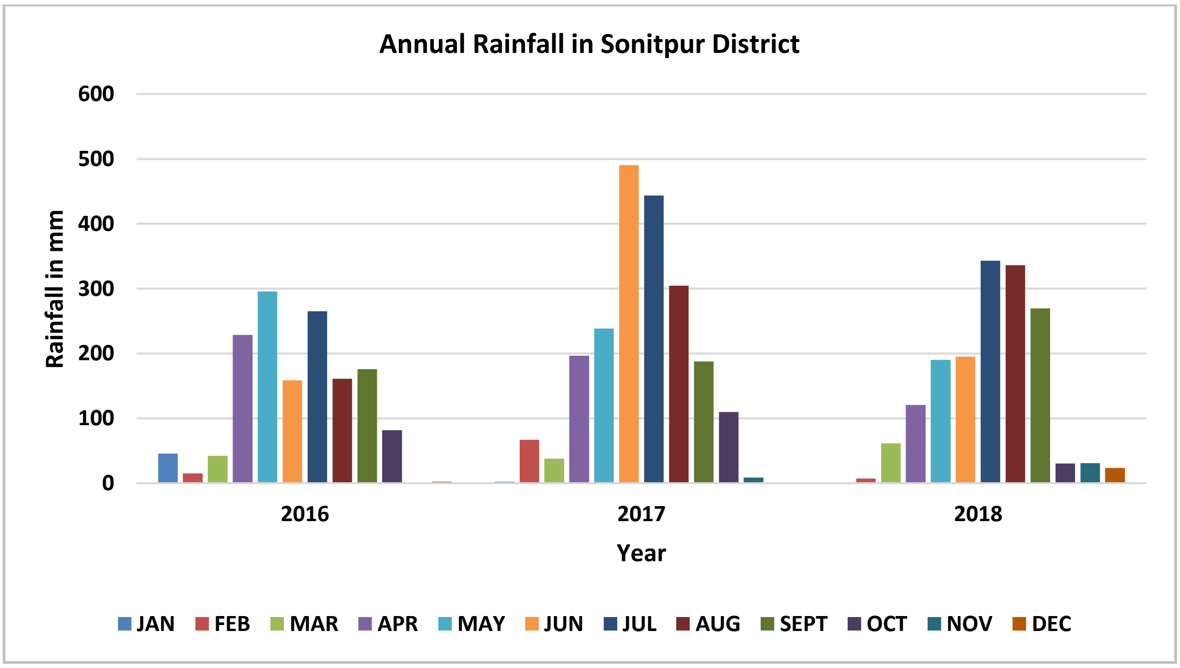
Figure 2-5: Annual Rainfall details – Lakhimpur

Sonitpur:

Sonitpur District falls in the Sub-Tropical climatic region and enjoys Monsoon type of climate. Summers are hot and humid. Summer rain is heavy, which is both a boon and a bane for the people. A boon, for it provides natural irrigation to the fields; and a bane, as it causes the rivers to overflow their banks and cause floods. Winters extend from the month of October to February and are cold and generally dry. It gets quite chilly in late December and early January, on account of snowfall in the upper reaches of Arunachal Pradesh.

Sonitpur is situated in the high rainfall zone with annual average rainfall of 1608.3 mm received in the year 2018. The district normally receives 2 percent of rainfall in Winter Season (January-February), 23 percent in Summer Season (March-May), 70 percent in Monsoon Season (June-September) and 5 percent in Post-Monsoon Season (October-December). ***Source: India Meteorological Department website (www.imd.gov.in)***

Figure 2-6 depicts the details related to the Annual Mean Rainfall received by Sonipur district from 2016 to 2018.



Source: India Meteorological Department website (www.imd.gov.in)

Figure 2-6: Annual Rainfall details – Sonitpur

2.7 Land Use

The land-use pattern in the project section has a major share of settlements and agricultural area. The abutting land use patterns observed along the project road are as given in **Table 2-3.**

Table 2-3: Land use pattern

Type of Land	Ghagrabasti to Hawajan (Part - I)		Sonapur to Holongi Airport (Part - II)	
	Length (Km)	Percentage (%)	Length (Km)	Percentage (%)
Agricultural	12.65	49.80	1.55	72.09
Barren Land	0.00	0.00	0.00	0.00
Built Up	1.75	6.89	0.00	0.00
Forest	0.00	0.00	0.00	0.00
Semi Built Up	11.00	43.31	0.60	27.91

Source: Road Inventory Survey

2.8 Roadside Development – Villages & Towns

The project road **Ghagrabasti to Hawajan via Holongi Airport [A28]** initiates from Ghagrabasti and traverses through several important villages which are deemed important. The settlements like Ghagrabast, Nalbari, MC Sonapur, Madhya Sonapur, Narenguri, Sonarijan, Hoijangbari, 2 No. Bijaypur, Alaipur, Doimalu, Alupara, Simaluguri, Sesamiri, Futabhug, Niran Chuba, Khalihamari, Borthekerabari village have been given due consideration while designing the project road as these villages have been considered as important settlements along the project road.

The list of villages and towns on the sides of project highway, identified as important during Reconnaissance Survey and Inventory of project road are presented in ***Table*** 2-4***.***

The identified settlements have been given careful consideration before deciding on the appropriate cross-section, and other related improvement proposals earmarked for the project.

Table 2-4: Important Settlements Abutting Project Highway

Existing Chainage		Length (in m)	Name of Settlement
From	To		
0+000	1+200	1200	Ghagrabasti
1+200	2+550	1350	Nalbari
2+550	4+350	1800	MC Sonapur
4+350	5+400	1050	Madhya Sonapur
5+400	5+950	550	Narenguri
5+950	6+400	450	Sonarijan
6+400	7+000	600	Hoijangbari
7+550	7+900	350	2 No. Bijaypur
7+900	9+100	1200	Alaipur
9+800	12+100	2300	Doimalu
12+100	14+900	2800	Alupara
14+900	15+980	1080	2 No. Bikrampur
15+980	18+540	2560	3 No. Simaluguri
18+540	19+960	1420	1 No. Sesamiri
19+960	20+900	940	2 No. Sesamiri
20+900	21+040	1840	Futabhug
22+740	23+840	1100	Niran Chuba
23+980	24+450	470	2 No. Khalihamari
24+450	26+010	1560	Borthekerabari

Source: Road Inventory Survey and Revenue Village Maps

2.9 Existing Traffic

Based on the classified volume count traffic survey the commercial vehicles per day for the location (Alupara & Sesamiri) Ghagrabasti to Hawajan Road are calculated and CVPD for both directions at Ghagrabasti to Hawajan project road are presented in the following ***Table*** 2-5***.***

Table 2-5: CVPD (Both Directions) on Ghagrabasti to Hawajan Road

Commercial Vehicle Per Day (CVPD) Both Directions AADT							
Location	Buses	LCV	2 Axle Truck	3 Axle Truck	MAV	Total Vehicles	Total PCUs
Alupara-Ghagrabasti to Hawajan & Hawajan to Ghagrabasti (BOTH DIRECTION)	00	01	01	00	00	**02**	**05**
Sesamiri- Ghagrabasti to Hawajan & Hawajan to Ghagrabasti (BOTH DIRECTION)	00	05	00	00	00	**05**	**08**

Source: Consultant Estimates based on Traffic Survey

2.10 Broad Features & Preliminary Technical Assessment of Existing Road

2.10.1 Carriageway

The project road has a single lane configuration. The Carriageway is a mix of Earthen, Bituminous and Paver Block type with the condition being mostly good to very poor. A major portion of the road surface is worn out. The road also passes through several Green Field areas throughout its stretch. The shoulder is constructed with earthen materials and the width of the carriageway is 3m. The details of existing lane configuration are presented in ***Table* 2-6.**

Table 2-6: Details of existing lane configuration

Lane configuration	Total length (Km)	Length (Km.)	Percentage (%)
Ghagrabasti to Hawajan (Part I)	**26.006**		
Single Lane		22.350	85.94
Intermediate lane		0	0
Two Lane without paved Shoulders		0	0
Two Lane with paved Shoulders		0	0
Sonapur to Holongi Airport (Part II)	2.130		
Single Lane		2.130	100
Intermediate lane		0	0
Two Lane without paved Shoulders		0	0
Two Lane with paved Shoulders		0	0

Source: Road Inventory Survey

Large section of the project road either has non-motorised earthen road or passes through Greenfield Area.

2.10.2 Shoulders

The soft shoulders are generally in good to very poor condition with width being 0.5m mostly.

2.10.3 Pavement

Pavement Condition was determined through visual pavement condition survey and summary is presented in ***Table* 2-7**.

Table 2-7: Pavement Condition Summary

Ghagrabasti to Hawajan		
Chainage		Condition (G/F/P/VP)
From	To	
0+000	0+150	P
0+150	2+050	G
2+050	2+150	VP
2+250	2+400	VP
2+450	2+550	VP
2+550	4+350	P
4+350	5+100	VP
5+100	5+600	Greenfield Area
5+600	5+950	VP
5+950	6+150	Greenfield Area
6+150	7+300	VP
7+300	7+550	P
7+550	7+850	Greenfield Area
7+850	9+150	VP
9+150	9+800	Greenfield Area
9+800	10+700	VP
10+700	12+250	G
12+250	13+050	P
13+050	14+000	VP
14+100	14+450	VP
14+450	14+900	Major Bridge Under Construction
14+900	15+300	VP
15+300	16+200	G
16+200	17+000	Out of Scope section
17+000	23+250	P

Ghagrabasti to Hawajan		
Chainage		Condition (G/F/P/VP)
From	To	
23+250	24+000	Greenfield Area
24+000	26+250	VP
Sonapur to Holongi Airport		
0+000	2+130	VP

G –Good, F- Fair, P-Poor, VP-Very Poor *Source: Road Inventory Survey*

From the road inventory survey as well as reconnaissance survey it was observed that the road surface is in poor to very poor condition. It was also observed that there is existence of Paver Block roads at certain sections of the project road which seems to be in good condition. However, it can be easily identified that the existing pavement layer beneath the bituminous surface is undergoing distress. Due to absence of the most important granular sub base layer and non-treatment of the existing pavement layer, the distress will appear on the bituminous surface in due course of time. After Field observation, it is recommended to go for reconstruction with GSB and new pavement layer.

Figure 2-7 shows the highly distressed road along the project corridor respectively.

Figure 2-7: Photo of Highly Distressed Road along the stretch

2.10.4 Horizontal Geometry of Project Road

The horizontal alignment of the project road is straight with few curves which needs to be improved during geometric design catering to the design speed and a realistic compatibility within the available ROW, for some stretches land acquisition is considered for widening and geometric design. Concentric Widening is being followed throughout the project road. Minimum as well as absolute design speed has been maintained for the entire project road. All the horizontal curves have been designed with a desirable minimum radius of 230m and 155m respectively. However, at certain locations because of major site constraints, it is not possible to improve the horizontal alignment in accordance with design speed and road safety measures and possible geometric improvement have been considered at these locations.

2.10.5 Drainage

No drainage channels are present along the project corridor.

2.10.6 Submergence Locations

No Submergence locations are present along the project stretch.

2.10.7 Nalah, Stream & Water Bodies abutting the project road

The project road alignment experiences several water bodies in the form of Ponds. There is a presence of 8 number of ponds along the complete stretch of project alignment.

Table 2-8: Nalah, Stream and Water Bodies Location

Sr. No	Existing Chainage		Name of Nalah/Stream/Water Body
	To	From	
Ghagrabasti to Hawajan (Part - I)			

Sr. No	Existing Chainage		Name of Nalah/Stream/Water Body
	To	From	
1	6+850	7+000	Pond LHS
2	12+000	12+050	Pond LHS
3	18+800	18+850	Pond LHS
4	19+900	19+950	Pond RHS
5	21+300	21+350	Pond RHS
6	21+450	21+500	Pond (Both Side)
Sonapur to Holongi Airport (Part II)			
7	0+850	0+900	Pond RHS
8	2+100	2+150	Pond RHS

Source: Road Inventory Survey

2.10.8 Major & Minor Intersections

Project road passes through the rural settlements. Also, project road crosses & connects to the various important and lateral roads along the entire length. 3 major and 6 minor Junctions are observed along the project road. The details of the junctions are presented in

Table 2-9.

Table 2-9: Details of Junctions

Sr. No.	Design Chainage	Junction Type	Location	Major/ Minor Junction	Name of Place	
					L	R
Part I – Ghagrabasti to Hawajan						
1	0+000	T	Ghagarabasti	Major	Gohpur	Borbali

Sr. No.	Design Chainage	Junction Type	Location	Major/ Minor Junction	Name of Place	
					L	R
2	2+550	T	Naya Ghagra	Minor	-	Rangajan
3	4+350	4 Leg	Sonapur	Minor	Santipur	Dholpur
4	6+370	T	Gohpur	Minor		Rangajan
5	13+745	4 Leg	-	Minor	Alupara	Goraimari Shatra
6	15+915	T	Bikrompur	Minor	Letekujan	
7	16+725	4 Leg	Lakhimpur	Major	Simaluguri	Ganakdoloni
8	26+006	T	Hawajan	Major	Lakhimpur	Guwahati
Part II – Sonitpur to Holongi Airport						
9	2+130	T	Hollongi Chariali	Minor	Towards NH-52	Papum Pare

Source: Road Inventory Survey

2.10.9 Height of Existing Road Surface from Adjoining Ground Level

The project road is constructed mostly on embankment. The embankment height and its approximate extent along the project road are given in ***Table* 2-10.**

Table 2-10: Embankment details

Embankment height (m)	Length (Km)		Percentage (%)	
	Left	Right	Left	Right
Ghagrabasti to Hawajan (Part I)				
< 0.5	3.70	4.70	16.48	20.94
0.5 – 1	9.85	8.65	43.88	38.53
1 – 2	6.90	7.95	30.73	35.41
> 2	2.00	1.15	8.91	5.12
Sonapur to Holongi Airport (Part II)				
< 0.5	0.35	0.10	16.28	4.65
0.5 – 1	1.50	1.30	69.77	60.47
1 – 2	0.30	0.75	13.95	34.88
> 2	0.00	0.00	0.00	0.00

Source: Road Inventory Survey

2.10.10 Existing Right of Way (RoW)

Based on the information collected from Land Circle Office, it was observed that the available ROW of the project road varies from 7m to 40m (max) and the same has been considered for evolving the design. The available clear right of way based on the inventory is as given in ***Table* 2-11.**

Table 2-11: Row Details

Existing Chainage		Length (in m)	Existing RoW (in m)	Village Name	
From	To			LHS	RHS
0+000	1+200	1200	7	Ghagrabasti	
1+200	2+550	1350	7	Nalbari	
2+550	4+350	1800	7	MC Sonapur	
4+350	5+400	1050	7	Madhya Sonapur	
5+400	5+950	550	7	Narenguri	
5+950	6+400	450	7	Sonarijan	
6+400	7+000	600	7	Hoijangbari	
7+000	7+550	550	7	Thoribari	
7+550	7+900	350	7	2 No. Bijaypur	
7+900	9+100	1200	7	Alaipur	
9+100	9+800	700	7	Salbari	
9+800	12+100	2300	7	Doimalu	
12+100	14+900	2800	7	Alupara	
14+900	15+880	980	20	2 No. Bikrampur	
15+880	15+980	100	40		
15+980	16+840	860	10	3 No. Simaluguri	
16+840	17+100	260	32		
17+100	17+360	260	28		
17+360	18+400	1040	28		
18+400	18+540	140	24		
18+540	19+000	460	28	1 No. Sesamiri	
19+000	19+960	960	32		
19+960	20+900	940	20	2 No. Sesamiri	
20+900	21+040	140	16	Futabhug	
21+040	21+160	120	12		
21+160	21+280	120	16		
21+280	21+680	400	12		
21+680	22+100	420	8		
22+100	22+380	280	10		
22+380	22+460	80	12		
22+460	22+740	280	10		
22+740	23+840	1100	28	Niran Chuba	

Existing Chainage		Length (in m)	Existing RoW (in m)	Village Name	
From	To			LHS	RHS
23+840	23+980	140	28	1 No. Khalihamari	
23+980	24+450	470	28	2 No. Khalihamari	
24+450	26+010	1560	20	Borthekerabari	

Source: As per village maps

The available clear right of way based on the revenue map is as given in ***Annexure 2-2: Existing RoW as per Revenue Village Maps.***

2.10.11 Available RoW at Built-up Area/Settlement Locations

Based on the information collected from Land Circle Office and the road inventory survey carried out by the consultant, it was observed that available ROW at Built-up area of the project road varies from 7 m to 40 m (max). The available clear right of way based on the inventory is as given in ***Table*** 2-12***.***

Table 2-12: Available RoW for Built-up Area

Existing Chainage		Length (in m)	Existing RoW (in m)	Name of Settlement
From	To			
0+000	1+200	1200	7	Ghagrabasti
1+200	2+550	1350	7	Nalbari
2+550	4+350	1800	7	MC Sonapur
4+350	5+400	1050	7	Madhya Sonapur
5+400	5+950	550	7	Narenguri
5+950	6+400	450	7	Sonarijan
6+400	7+000	600	7	Hoijangbari
7+550	7+900	350	7	2 No. Bijaypur
7+900	9+100	1200	7	Alaipur
9+800	12+100	2300	7	Doimalu
12+100	14+900	2800	7	Alupara
14+900	15+880	980	20	2 No. Bikrampur
15+880	15+980	100	40	
15+980	16+840	860	10	3 No. Simaluguri
16+840	17+100	260	32	
17+100	17+360	260	28	
17+360	18+400	1040	28	
18+400	18+540	140	24	
18+540	19+000	460	28	1 No. Sesamiri
19+000	19+960	960	32	
19+960	20+900	940	20	2 No. Sesamiri

Existing Chainage		Length (in m)	Existing RoW (in m)	Name of Settlement
From	To			
20+900	21+040	140	16	Futabhug
21+040	21+160	120	12	
21+160	21+280	120	16	
21+280	21+680	400	12	
21+680	22+100	420	8	
22+100	22+380	280	10	
22+380	22+460	80	12	
22+460	22+740	280	10	
22+740	23+840	1100	28	Niran Chuba
23+980	24+450	470	28	2 No. Khalihamari
24+450	26+010	1560	20	Borthekerabari

Source: Village maps & Highway Design

2.10.12 Existing Earth Retaining Structures (Retaining Wall & Breast Wall)

There is no existing retaining wall & breast wall along the project road from Ghagrabasti to Hawajan via Holongi Airport.

2.10.13 Existing Bridges & Culverts

There are 2 major bridges and 13 existing minor bridges along the project road. There are 22 pipe culverts, 15 slab culverts and 8 box culverts present along the project corridor. The list of the existing bridges and culverts along the project road stretch are mentioned in ***Table* 2-13** and ***Table*** 2-14***.***

Table 2-13: List of Culverts

Sl. No.	Location (km)	Type of Structures	Span Arrangement and Total Ventway (No. x Length)	Width of Culvert (m)
Part I – Ghagrabasti to Hawajan				
Pipe Culverts				
1	0+575	Pipe Culvert	2 x 900mm	6.1
2	0+992	Pipe Culvert	3 x 1200mm	10.15
3	2+050	Pipe Culvert	NV	NV
4	2+064	Pipe Culvert	1 x 1000mm	7.65
5	3+847	Pipe Culvert	1 x 900mm	7.5
6	4+110	Pipe Culvert	1 x 1000mm	10.15

Sl. No.	Location (km)	Type of Structures	Span Arrangement and Total Ventway (No. x Length)	Width of Culvert (m)
7	5+952	Pipe Culvert	1 x 900mm	7.5
8	6+724	Pipe Culvert	2 x 900mm	7.5
9	6+777	Pipe Culvert	1 x 900mm	7.5
10	7+165	Pipe Culvert	1 x 900mm	7.5
11	8+214	Pipe Culvert	1 x 600mm	7.6
12	9+113	Pipe Culvert	1 x 600mm	7.6
13	10+569	Pipe Culvert	1 x 900mm	7.6
14	11+328	Pipe Culvert	1 x 900mm	10.15
15	12+467	Pipe Culvert	2 x 1200mm	10.15
16	12+543	Pipe Culvert	1 x 1000mm	10.1
17	12+810	Pipe Culvert	1 x 1000mm	10.3
18	15+316	Pipe Culvert	1 x 1000mm	10.3
19	15+449	Pipe Culvert	1 x 1000mm	10.15
20	15+738	Pipe Culvert	1 x 1000mm	10.15
21	16+460	Pipe Culvert	1 x 1000mm	10.15
22	19+092	Pipe Culvert	1 x 1000mm	10.1
Slab and Box Culverts				
1	1+350	Slab Culvert	1 x 3.2	7.05
2	4+339	Slab Culvert	1 x 3.5	5.45/6.10
3	4+375	Slab Drain	1 x 0.95	4.80
4	5+505	Skew Slab Culvert	1 x 2.75	4.6/5.3
5	9+800	Slab Culvert	1 x 1	7.65
6	9+903	Slab Culvert	2 x 1.7	5.50
7	10+321	Slab Culvert	1 x 2.5	6.00
8	10+936	Slab Culvert	1 x 1.5	6.00
9	12+064	Slab Culvert	1 x 3	6.85
10	15+045	Slab Culvert	1 x 3.45	6.35
11	16+509	Box Culvert	1 x 2	12.00

Sl. No.	Location (km)	Type of Structures	Span Arrangement and Total Ventway (No. x Length)	Width of Culvert (m)
12	22+064	Box Culvert	2 x 3	8.10
13	22+204	Box Culvert	1 x 3	8.10
14	24+612	Box Culvert	1 x 3	8.20
15	25+727	Box Culvert	2 x 3	8.15
Sonapur to Holongi Airport				
1	1+000	Box Culvert	1 x3	7.50
2	1+500	Box Culvert	1 x 3	7.50
3	2+125	Box Culvert	1 x 2	7.50

Source: Structure Condition & Inventory Survey

Table 2-14: List of Bridges

Sr. No.	Design Chainage	Name of River / Bridge	Bridge No.	Total Length of Bridge	Span Arrangements	Structure type	Bridge Type
Part I – Ghagrabasti to Hawajan							
1	0+087	Local Nallah	49	22.5	1 x 22.5	Slab Type	Minor
2	2+187		43	Under Construction			
3	2+430		42	Under Construction			
4	5+337	Local Nallah	37	6.5	2 x 3.25	Slab Type	Minor
5	6+984	Local Nallah	32	28	Timber Bridge		Minor
6	7+327	Local Nallah	30	28.35	Timber Bridge		Minor
7	7+550	Local Nallah	29	15	1 x 14.3	Slab Type	Minor
8	13+882		16	Under Construction			
9	14+387		15	Under Construction			

Sr. No.	Design Chainage	Name of River / Bridge	Bridge No.	Total Length of Bridge	Span Arrangements	Structure type	Bridge Type
10	15+230	Local Nallah	13	7.3	2 x 3.65	Slab Type	Minor
11	15+832	Local Nallah	11	6.7	2 x 3.35	Slab Type	Minor
12	23+014	Local Nallah	5	9	1 x 9	Slab Type	Minor
13	23+308	Local Nallah	4	25.1	1 x 25.1	Slab Type	Minor
14	23+308	Local Nallah	3	12.4	1 x 12.4	Slab Type	Minor
Part II – Sonapur to Holongi Airport							
15	1+818	Local Nallah	1	8	1 x 8	Slab Type	Minor

Source: Structure Condition & Inventory Survey

2.10.14 Existing Rail-Road Level Crossings, ROB's & RUB's

The road alignment passes through one rail-road level crossing. The road alignments do not pass through any ROB's or RUB's throughout the stretch. The details of the rail-road level crossing is mentioned in ***Table* 2-15**.

Table 2-15: Details of Railroad Level Crossing

S. No.	Existing Chainage	Place
1	22+290	Futabhug

2.11 Industrial Area Abutting Project Area

There is no designated industrial area along the project road.

2.12 Utilities

Utilities such as electrical poles and transformers are located along the project road. Low Tension lines also cross the project road in many locations. Trees are also seen on both sides along the project stretch. The details of utilities are given in ***Table* 2-16**.

Table 2-16: Details of Utilities

Sr. No	Type of Utility	No. of Utilities	
		Part I	Part II
1	Tree No	LHS: 799 & RHS: 858	LHS: 17 & RHS: 34
2	Electric Poles	LHS: 158 & RHS: 269	-
3	Telephone Poles	LHS: 1 & RHS: 1	-
4	Transformers	LHS: 8 & RHS: 6	-
5	Bus stop	LHS: 1 & RHS: 0	-
6	Fencing/Compound Wall (m)	2862/694	-
7	HT wire crossing	-	-
8	Critical structures	21	-

Source: Road Inventory Survey

2.13 National parks/ Wildlife Sanctuaries/ Bird Sanctuaries

The protected area network of Assam includes 5 National Parks and 18 wildlife sanctuaries covering an area of 0.40 million ha constituting 4.98% of the geographical area. The state has three Tiger Reserves, namely Kaziranga, Manas, and Nameri. Kaziranga National Park and Manas National Park are on the list of World Heritage sites.

As per the approved Protected Areas map received from the PCCF office, Guwahati vide Letter No. CE/AXOM MALA/12/2019/40 during the initial survey, the project road does not pass through any notified protected area or lie within a 10 km radius of any protected area.

Reserve Forest:

As per the approved Reserve Forests map received from the PCCF office, Guwahati vide Letter No. CE/AXOM MALA/12/2019/40 during the initial survey, the project road passes through the Gohpur Reserve Forest, from Ch. 0+385 to Ch. 14+930 & Ch. 0+000 to Ch. 2+114.

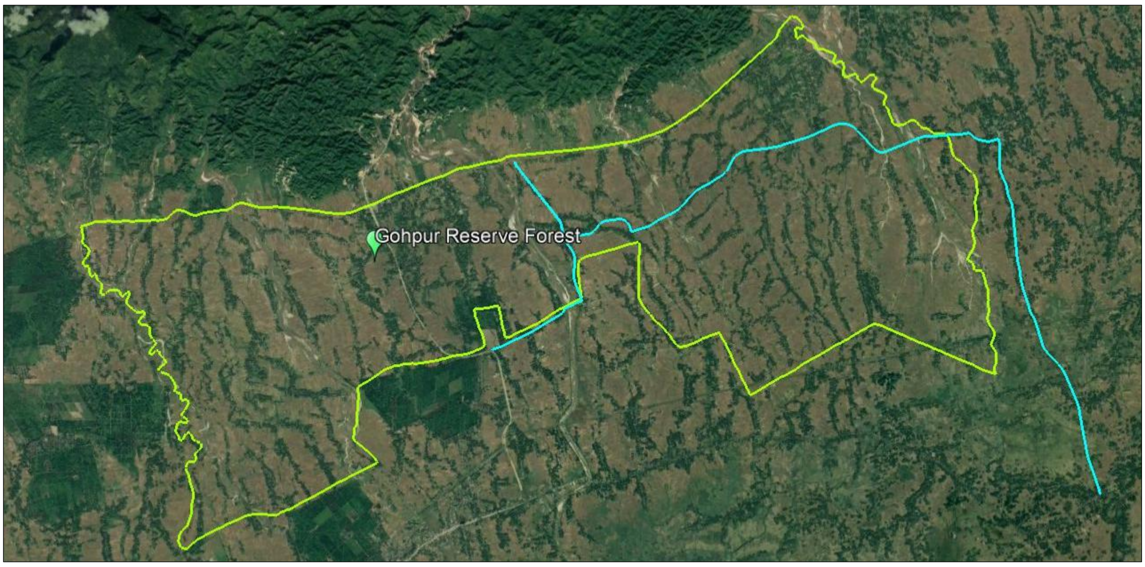


Figure 2-8: Map showing A28 project road passing through Gohpur Reserve Forest

2.14 Sensitive Receptors

Common Property Resources like schools and religious places are observed along the project alignment. The details of the Sensitive Receptors are mentioned in ***Table*** 2-17 .

Table 2-17: List of sensitive receptors along the project road

Sr. No.	Receptor	Side	Chainage (Km)	Approx. Distance from Road Edge (m)
1	Temple	Left	0+010	10
2	School	Right	4+050	20
3	Temple	Left	4+600	15
4	Temple	Left	5+900	20
5	Temple	Left	6+350	15
6	School	Left	6+400	15
7	Temple	Left	6+900	10
8	School	Left	9+100	20
9	School	Left	10+850	20
10	Church	Left	17+350	30
11	School	Left	18+400	20
12	Temple	Right	18+850	20
13	Temple	Right	19+800	15
14	School	Left	20+450	20
15	Temple	Left	21+250	20
16	School	Left	21+550	20
17	School	Right	22+550	15
18	Temple	Left	24+050	10
19	Namghar	Left	23+750	20
20	Temple	Left	25+200	30

CHAPTER 3

SOCIO-ECONOMIC PROFILE OF THE PROJECT AREA

3 Socio-Economic Profile of the Project Area

3.1 Basic Approach

The primary purpose of Socio-economic analysis is to provide an overview of the State's socio-economic setup and the relative status of the Project influence area within the State. Data to be considered include demographic aspects, macro-economic indicators and sectorial production of agriculture and allied activities, manufacturing, mining and service sectors including infrastructure. The profile provides the present scenario, the past performance and the perspective growth of the economy, population and urbanization. The profile depicts the spatial distribution of economic activities and provides basic inputs for estimating future growth in Transport demand, on the basis of perspective economic growth rates and transport demand elasticity. Secondary data available with different state government departments have been collected and analyzed for preparation of socio-economic profile.

3.2 Introduction

Project road comprises of road stretch between Ghagrabasti to Hawajan (Part – I) & Sonitpur to Holongi Airport (Part – II). A major portion of project stretch passes through village and agricultural area. At present the project road is promoted by Public Works Road Department (PWRD), Assam.

This Chapter provides a socio-economic profile of the state and the relative status of the project influence area within the state. The aspects covered include demography, employment pattern, state income and major economic sectors including transport infrastructure. The profile discusses presents a broad assessment of the perspective growth of the economy as a basis for estimating the future growth in transport demand.

3.3 Delineation of Project Influence Area (PIA)

Traffic surveys were done along the project corridor. Share of traffic from different areas were determined along the corridor. The project falls in Lakhimpur and Sonitpur districts of Assam. The existing Right of Way (RoW) varies from 7m to 40m, which has been based on the details obtained through village maps collected from Land Circle Office. The entire road stretch falls in the State of Assam and lies in the administrative boundaries of Lakhimpur and Sonitpur Districts. The location map of Lakhimpur and Sonitpur Districts are shown in ***Figure*** 3-1***.***

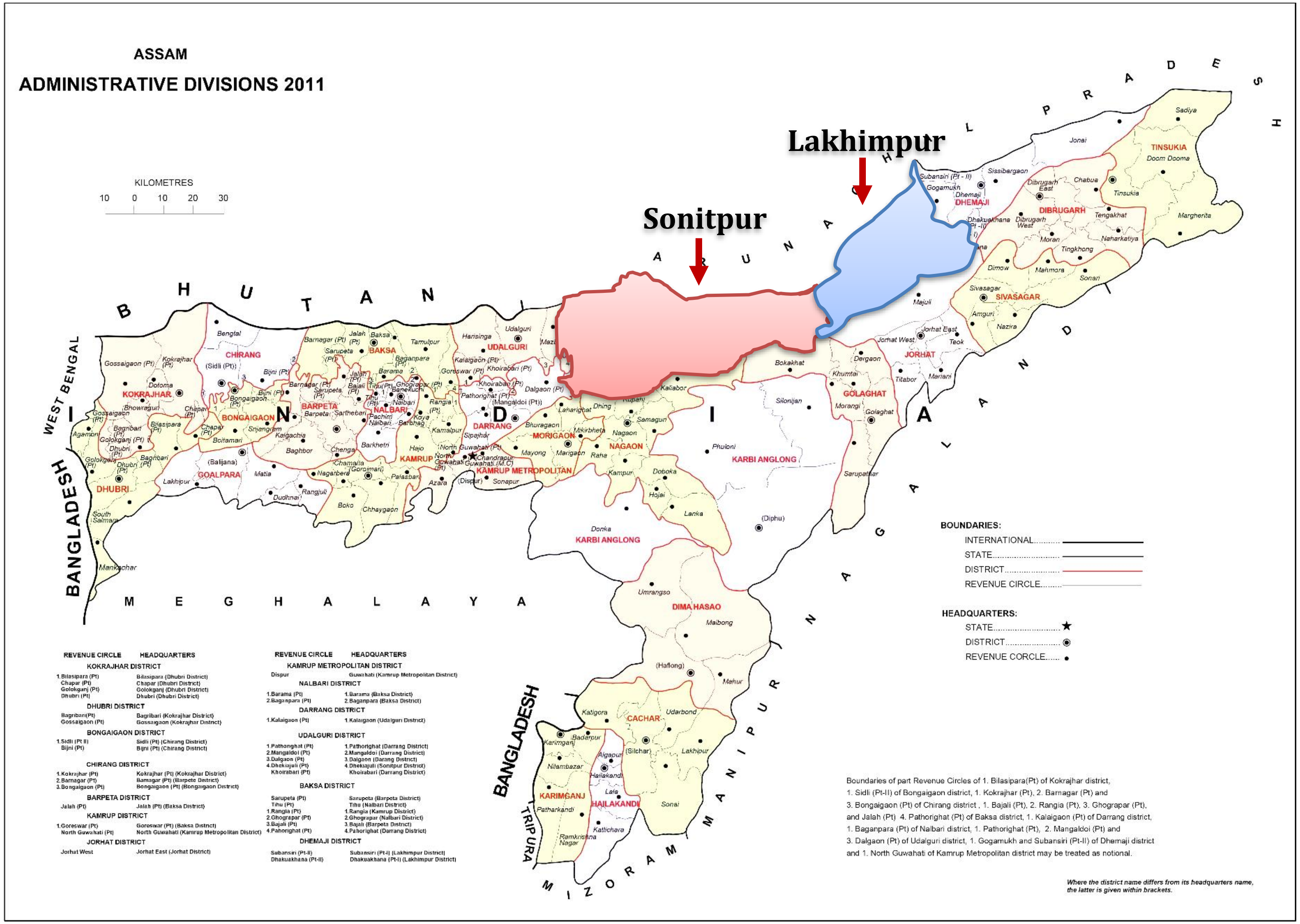


Figure 3-1: Location Map of Lakhimpur and Sonitpur District

A detailed accounting of the socio-economic profile of the Project Influence Area (PIA) has been prepared, which covers the PIA's economic performance of the past and establishes the likely growth prospects of the future. The output of this Chapter is the economic growth prospects of the PIA with respect to certain selected economic variables and serves as the basis for arriving at a realistic traffic growth rate.

3.4 Demographic Profile of PIA

According to the census of India 2011, the total population of Assam is 3,12,05,576 out of which 2,68,07,034 and 43,98,542 are rural and urban population respectively. Total population of Lakhimpur District is 10,42,137 out of which 9,50,804 and 91,333 are from Rural and Urban area respectively. In comparison to that, the total population of Sonitpur District is 19,24,110 out of which 17,50,265 and 1,73,845 are from Rural and Urban area respectively.

Also, it is observed that Lakhimpur & Sonitpur Districts population constituted 3.34 and 6.16 percent of total Assam population in 2011 respectively. Both Lakhimpur and Sonitpur recorded 17.22 and 9.04 percent increase in the population when compared with census 2001 respectively. ***Table*** 3-1***, Table* 3-2 and *Figure*** 3-2 shows the demographic profile of the district.

Table 3-1: Demographic profile of project road

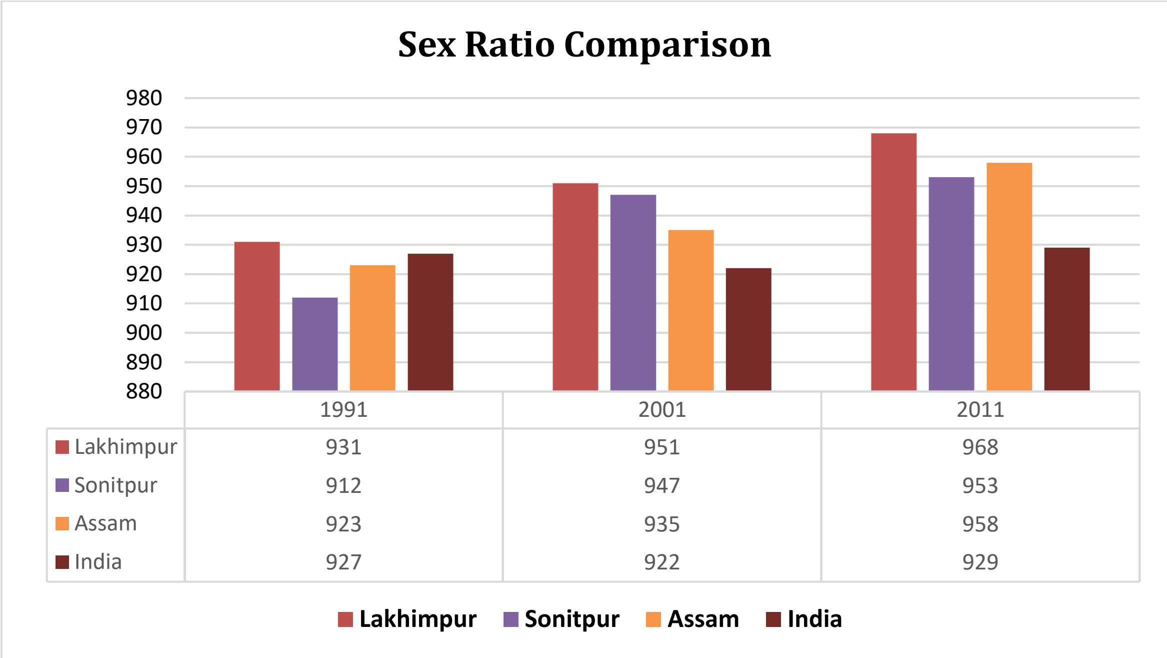
State/ District	Year	Population			% of Urban Population (Urban/ Total)	Avg. Density (people/sq.km)
		Total	Rural	Urban		
Assam	2011	3,12,05,576	2,68,07,034	43,98,542	16.41%	398
Project Area District						
Lakhimpur	2011	10,42,137	9,50,804	91,333	8.76%	458
Sonitpur	2011	19,24,110	17,50,265	1,73,845	9.05%	370

Source: Census of India, 2011

Table 3-2: Demographic features of project road

State/ District	Year	Population		Literacy Rate	
		Male	Female	Male	Female
Assam	2011	1,59,39,443	1,52,66,133	77.85%	66.27%
Project Area District					
Lakhimpur	2011	4,82,582	4,68,222	83.52%	58.04%
Sonitpur	2011	9,83,904	9,40,206	73.65 %	60.73 %

Source: Census of India, 2011



Source: Census of India, 2011

Figure 3-2: Sex ratio Comparison

3.4.1 Urbanization

It is clear from ***Table*** 3-1 that the urbanization of Assam is 16.41% whereas Lakhimpur & Sonitpur District are 8.76% and 9.05% respectively.

3.5 Occupational Structure

As per 2011 Census, the state has a total workforce of 1,19,69,690 consisting of 86,87,123 main workers, 32,82,567 marginal workers and 1,92,35,886 non-workers. The work participation rate of the state is 38.38 %.

As per 2011 Census, total workforce of Lakhimpur district is 3,96,551 consisting of 2,54,487 main workers, 1,42,064 marginal workers and 5,54,253 non-workers. Whereas the total workforce of Sonitpur district is 7,70,606 consisting of 5,58,325 main workers, 2,12,281 marginal workers and 11,53,504 non-workers. The work participation rate of Lakhimpur and Sonitpur are 38.05% and 40.05% respectively. The work force participation in state and PIA are given in ***Table*** 3-3**.**

Table 3-3: Workforce Participation in State and PIA

State/ PIA	Total Workers	Main	Marginal	WPR (%)
Assam	1,19,69,690	86,87,123	32,82,567	38.38
Project Influenced Area				
Lakhimpur	3,96,551	2,54,487	1,42,064	38.05

State/ PIA	Total Workers	Main	Marginal	WPR (%)
Sonitpur	7,70,606	5,58,325	2,12,281	40.05

Source: Census of India, 2011

Distribution of workers by economic activity is given below in ***Table*** 3-4***.***

Table 3-4: Distribution of workers by Economic Activity (%)

State/Districts	Cultivators	Agricultural laborers	Household Industry	Other workers
Assam	31,38,554	9,03,294	2,42,071	44,03,204
Project Influenced Area				
Lakhimpur	2,39,377	43,922	10,983	1,35,713
Sonitpur	2,49,123	1,14,865	25,719	380,899

Source: Census of India, 2011

3.6 State Income

The GSDP at constant price has increased to Rs.192399.92 crore during the year 2016-17 registering a growth of 6.8% over the previous year. GSDP of Assam at constant price was estimated at Rs.180165.57 crore (PE) for the year 2015-16. This is also showing an increase of 9.05% over the year the year 2014-15. NSDP of Assam at constant price increased to Rs.173050.49 crore (QE) during 2016-17 at a growth of 6.43% over the previous year. NSDP of Assam was estimated at Rs.162591.47 crore (PE) for 2015-16. This has also a growth of 11.04% over the previous year.

3.6.1 Per Capita Income composition of State

The estimates when studied in relation with the total population of the state, indicates the Standard of Living of the People in the state. The estimates of Per Capita Income at Constant (2011-12) prices are presented in ***Table*** 3-5***.***

Table 3-5: Per Capita Income (2011-12)

Year	2011-12	2015-16	2016-17	2017-18
PCI (Rs.) At current price	41,142	60,817	67,375	72,289
PCI (Rs.) At constant price	41,142	50,642	52,728	54,122

Source: Statistical Handbook of Assam, 2018

3.6.2 Sectorial Growth Rate

The overall view of sectorial composition of the state economy at constant prices for 2011-12 to 2016-17 is tabulated in ***Table*** 3-6*.*

Table 3-6: Sector wise Contribution of GSDP at Constant Prices in Lacs

Sector	2011-12	2012-13	2013-14	2014-15	2015-16(P)	2016-17 (Q)
Primary	43,13,102	46,63,092	44,60,238	45,71,658	48,24734	50,09,585
Secondary	29,20,885	28,07,887	32,40,779	35,21,090	38,82,094	40,82,354
Tertiary	62,95,033	64,98,604	68,93,110	74,67,172	82,66,199	89,70,951
Total GSDP	1,43,17,491	1,47,34,238	1,54,52,540	1,65,21,230	1,80,16,557	1,92,39,992

Source: Economic Survey of Assam, 2017-18

The contribution of the primary sector (30.12%) in 2011-12, has come down to 26.04% in 2016-17. Whereas, the contribution of the secondary sector recorded at 20.40% in 2011-12, has also gone up to 21.21% in 2016-17. Also, contribution of tertiary sector reported 43.97 % in 2011-12 has gone marginally up to 46.63% in 2015-16.

3.7 Main Economic Sectors

3.7.1 Agriculture

Agriculture and allied activities have played a very important role in the socio-economic development of Assam, as its economy is largely both rural and agrarian. It is the backbone of the State's economy and holds the key to the overall development of the State. In Assam, the soil, topography, rainfall and climate in general are very conducive for agricultural activity, mainly for the cultivation of rice. The main crops other the rice include wheat, pulses and oilseeds. The main cash crops include sugarcane, turmeric and several oil seeds including Sesamum, Mustard and Linseed. The state has huge areas under fruit cultivation of which bananas, pineapples are the main ones. Agro statistics summary is shown in ***Table*** 3-7*.*

Table 3-7: Agro statistics summary

S. No.	Component	Growth/Ratio/ Production
1	Net State Domestic Product (NSDP) at current prices (2015-16)	2,01,757 (Rs. Crore)
2	State Income from Agriculture & allied activities at current prices (2015-16)	26,208 (Rs. Crore)
3	Share of Agriculture & Allied GSDP (Avg. from FY2011 to FY2016)	20.50 %
4	Net area sown (2016-17)	2773855 ha.
5	Gross cropped area (2016-17)	4087449 ha.

S. No.	Component	Growth/Ratio/ Production
7	Percentage of gross irrigated area to gross cropped area	5.85 %
8	Area under Rice Cultivation (2017-18)	2,434 (‘000 ha.)
9	Rice Production (2017-18)	5284 (‘000 tonne)
10	Area under Pulse Cultivation (2017-18)	155 (‘000 ha.)
11	Pulse Production (2017-18)	116 (‘000 tonne)
12	All Food grain production (2017-18)	5526 (‘000 tonne)
14	Area under Fibre Production (2017-18)	74 (‘000 ha.)
15	Index number of agricultural production	148.15
16	Primary agricultural credit societies	11,277
17	Total working capital of co-op. societies (` crore)	3644.45

Source: Statistical Handbook of Assam, 2018

3.7.2 Industries

The Industry sector comprises Mining & Quarrying, Manufacturing, Electricity, Gas, Water Supply & other Utility Services and Construction. In GDP of the State it is estimated that there will be a 5.11% growth at current prices in 2016-17(QE) over previous year. At current prices, the share of growth of the sub sectors to the Industry sector is estimated in Mining and Quarrying 1.90%, Manufacturing 9.32%, Electricity, Gas, Water supply & other utility Services 6.50% and Construction 3.50%. At constant prices, the contribution of the sub sectors to the Industry sector during the same year is estimated at 1.80% in Mining and Quarrying, 7.90% in Manufacturing, 7.170% in Electricity, Gas, Water Supply & Other Utility Services and 1.70% in construction.

Creation of environment for industrialization by setting up Industrial infrastructure in the perspective of industrial development and attract investment through proper planning is the prime objective of the State Government. To achieve the goal the Department is creating a good number of infrastructural facilities as well as upgrading the existing ones located in different districts of the state. Infrastructural facilities in the State are Export Processing Industrial Park (EPIP), Industrial Infrastructure Development Centre (IIDC), Growth Centers, Food Processing Industrial Park, Industrial Estates, Industrial Areas, etc. The State is richly endowed with mineral resources and is a major contributing factor for industrial performance. At present (in 2017), there are 20 Industrial Estates, 8 Mini Industrial Estates, 20 Industrial Areas and 18 Growth Centers in the State where 800 Industrial units are functioning. One Export Promotion Industrial Park (EPIP) has also been established with world class infrastructure at Amingaon in Kamrup(Rural) district, where 44 industrial units are producing export quality product of various kinds. In addition, 11 Industrial Infrastructure Development (IID) Centre in different districts and 3 Industrial Growth Centre, one Food Park at Chaygaon in Kamrup District and one North East Mega Food Park at Nalbari District have been established. The Department has established 3 (three) Industrial Growth centre (under a centrally sponsored project) at Balipara (Chariduar), Matia and Chaygaon. NSDP for industrial sector is shown in **Table** 3-8*.*

Table 3-8: NSDP of Industrial Sector at Current Prices

							(Rs. In Lacs)
Sr. No.	**Base year 2011-12**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16 (P)**	**2016-17 (Q)**
I	Mining and quarrying	12,88,077	12,72,547	12,18,973	12,40,709	21,12,074	21,56,030
II	Manufacturing	12,74,688	13,04,587	16,59,125	17,40,262	19,59,374	21,68,037
III	Electricity, Gas, Water Supply & Utility Services	1,30,994	1,36,995	1,70,118	2,02,877	2,08,050	2,29,498
IV	Construction	11,31,858	12,03,628	14,44,115	15,11,089	16,00,628	16,60,312
NSDP Industry Group		38,25,617	39,17,757	44,92,331	46,94,937	58,80,126	62,13,877

Source: Economic Survey of Assam, 2017-18

3.8 Land Use

The total geographical area of Assam for year 2016-17 (P) has been estimated at 78,43,800 Hectare. The land use classification of Assam 2016-17 (P) is described in ***Table* 3-9**.

Table 3-9: Land Use Classification of Assam

Particulars	**Forest**	**Area under Non-Agricultural Use**	**Barren and Unculturable Land**	**Permanent pastures and other Grazing Land**	**Misc. Trees groves not included in Net Area sown**	**Cultivable Waste Land**	**Fallow Land**	**Net Area Sown**
Total Area (In Ha.)	18,52,694	24,84,463	11,91,251	1,69,745	2,22,490	1,43,509	1,97,044	27,73,855
Percentage Contribution	23.62	31.67	15.19	2.16	2.84	1.83	2.51	35.36

Source: Statistical hand Book of Assam, 2018

3.9 Transportation

The major modes of transport in India are roads, railways, airways, shipping and inland waterways. The sector is dominated by road transport, both in terms of share in passenger and freight carried and in terms of contribution to the national economy. Between the two main modes of transport, viz., road and railways, road transport carries about 90 percent of the total passenger traffic and 67 percent freight traffic.

Sustained economic growth has brought about expansion of the transport sector in India. The share of transport sector in Gross Value Added (GVA) decreased from 4.9 percent in 2011-12 to 4.85 percent in 2016-17. The contribution of road transport sector in GVA has remained more or less stable at 3.30 percent during the same period. The share of road transport in the transport sector value addition has also remained stable at about 66 percent. ***Table*** 3-10 below gives the share of various subsectors of the transport sector in GVA since 2011-12.

Table 3-10: Percentage Share of Different Modes of Transport in Gross Value Added (GVA) at base year (2011-12)

Sector/Year	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Transport Sector	4.92	5.02	5.01	4.99	4.98	4.85
Railways	0.75	0.81	0.80	0.81	0.82	0.77
Road Transport	3.28	3.24	3.3	3.3	3.26	3.12
Water Transport	0.09	0.08	0.08	0.08	0.08	0.07
Air Transport	0.05	0.05	0.05	0.05	0.06	0.16
Services Incidental to Transport	0.78	0.78	0.77	0.77	0.77	0.74

Source: Road Transport Year Book, 2016-17, MoRTH

3.9.1 Road Network

Roads are the major mode of transportation service available in the Assam. During the last decade, not only the length but quality of roads has also improved. However, there are still many areas which need to be worked upon, especially in rural region. Length of road in Assam is shown in ***Table*** 3-11***.***

Table 3-11: Road Length (km) by Category of Road in Assam

Category of Road	Length (In Km)
National Highways	3,900
State Highways	2,530
Major District Roads	4,379
Urban Roads	1,615
Rural Roads	37,030

Category of Road	Length (In Km)
Total	49,454

Source: Economic Survey of Assam, 2017-18

2.1.1.1 Vehicle Fleet

Road transport also plays a key role in promoting equitable socio-economic development across regions of the country. Road transport facilitates universal access to public services and promotes development of backward regions by opening them to trade and investment. Easy accessibility, flexibility of operations, door-to-door service and reliability have earned road transport a greater significance in both passenger and freight traffic vis-à-vis other modes of transport. There were 28,17,390 registered vehicles in 2016 as compared to 30,28,665 in 2017 in Assam and the percentage with the registration is increased by 12.57 percent. Category wise Vehicle Registrations for Assam and India is shown in ***Table*** 3-12***.***

Table 3-12: Category wise Vehicle Registrations – Assam and India

Sl. No.	Category	Vehicle Population as on 31st March, 2017	Vehicle Population as on 31st March, 2017	(%) contribution of the State to the total
		Assam	India	
1	Two Wheelers	19,74,790	18,70,91,277	1.06
2	Cars	6,20,197	2,38,07,986	2.60
3	Taxis	60,209	26,94,806	2.23
4	Jeeps	16,193	22,65,488	0.71
5	Light Motor Vehicle (Passenger)	10,632	56,58,585	0.19
6	Buses	21,749	13,40,456	1.62
7	Light Motor Vehicle (Goods)	1,31,545	68,93,395	1.91
8	Multi-axle/Articulated Vehicles	3,331	10,17,678	0.33
9	Trucks and Lorries	1,37,204	43,45,264	3.16
10	Tractors	47,332	76,55385	0.62
11	Trailers	21,686	20,24,757	1.07
12	Others	-	27,68,121	-

Source: Road Transport Year Book, 2016-17, MoRTH

3.9.2 Railway Network

Assam has total railway route length 2440.39 Km. at present. This 2440.39 km is broad gauge railway length with no meter gauge and narrow-gauge railway. As per Indian Railway Statistical

Publication 2015-16, the total Railway Route length of India as on 31st March, 2016 is 66687 Km. out of which Electrified Route length is 23555 Km. Assam shares 3.7 percent of the total Railway Route length of the country.

3.9.3 Civil Aviation

Assam is well connected with the rest of the country through Air Transport. The State has the highest numbers of operational civil airports in the North-East and these are located at Guwahati, Tezpur, Jorhat, Dibrugarh, North Lakhimpur and Silchar. In addition to these civil airports, small private airstrips in the interior areas are present in large numbers. Some small and remote airstrips are being operated under private operators like tea gardens and PSUs. ***Table*** 3-13 depicts the statistics status of Air Transport of Assam.

Table 3-13: Air Transport Statistics of Assam

Year	Air Traffic Movement (No.)	Passenger Handled (No.)	Freight loaded/Unloaded (Ton)	Average number of flights per day	Average number of passengers handled per day	Average Cargo Handled per day (Ton)
2004-05	20334	828640	5199	57	2270	18
2011-12*	35022	2685871	8601	96	7359	24
2012-13*	33535	2526434	6668	92	6922	18
2013-14*	29426	2442613	8124	81	6692	22
2014-15*	30363	2552861	10796	83	6994	30
2015-16*	24392	3103961	11976	67	8504	33
2016-17	37383	3759494	17283	-	-	-

** Figures excluding Lakhimpur, Tezpur and Jorhat Airport.*

Source: Directorate General of Civil Aviation Statistical Division, New Delhi

3.10 Economic Perspective-State Level

3.10.1 Past Growth

The past performance of the state economy of Assam has been studied by analyzing time series data on NSDP and income originating from the main economic sectors. The per-capita NSDP is given in ***Table*** 3-14***.***

Table 3-14: Yearly Growth in NSDP and Per Capita NSDP at constant prices for the year 2011-12 to 2016-17

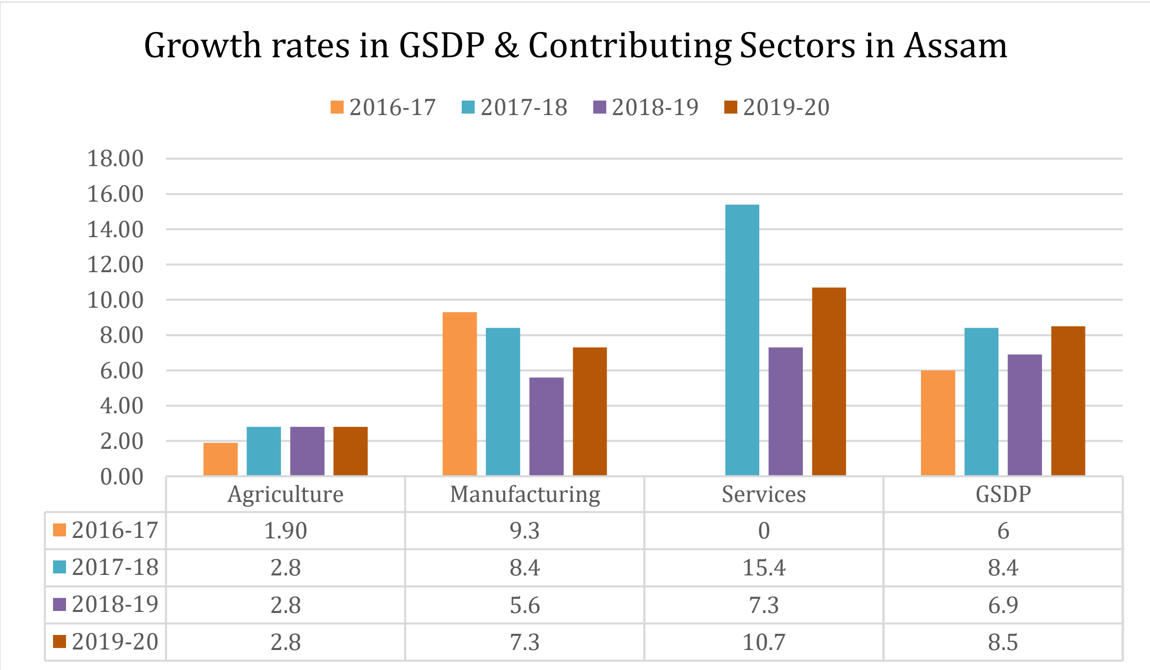
Year	Percentage Growth Over Previous Year at Constant Prices Per Capita NSDP
2012-13	1.14
2013-14	3.35
2014-15	4.20

Year	Percentage Growth Over Previous Year at Constant Prices Per Capita NSDP
2015-16	8.16
2016-17	3.68

Source: Economic Survey of Assam, 2017-18

3.10.2 Future Growth of the Economy

Assam's GSDP is estimated to grow at a rate of 8.5% in 2019-20 over the previous year. This is higher than the 5% GDP growth rate estimated for the country. Agriculture, Industry, and Services are estimated to contribute 17%, 39%, and 44%, respectively to the economy in 2019-20. The industry and services sector have seen a decline in growth in recent years, while the agriculture sector continues to grow at a low rate.



Source: PRS India – Assam Budget Analysis 2020 – 2021

Figure 3-3: Growth Rates of GSDP & Various Contributing Sectors

The future growth of Assam seems to be on the brighter side as the government of Assam has approved 11 integrated infrastructure development centres across the state. The Government has also set a target to generate 6,500 MW power in the state by 2030. Furthermore, with the adoption of various policies like North East Industrial Investment Promotion Policy and Industrial Policy of Assam, the state is facilitating businesses through fiscal incentives and multi-year concessions to investors.

3.11 Conclusion

Based on the primary and secondary data analysis, some conclusions have been drawn and are being presented below:

- The work force participation among the village population was found to be low.
- Availability of work in the region is mostly agriculture and its related activities.
- Women work participation was found to be very less resulting in financially dependency. The role of women is basically towards their household duties.
- Literacy rate in the region is progressive. Also, during site visits many schools were found in the villages. Women opt for higher education as informed during the interactions with school principals.

3.12 Recommendation

Awareness program regarding importance of education among males and females should be increased. At village level meetings can be organized which will enhance the importance of education especially of women. In schools, anagwadi etc such programs can be organized for the locals. In the awareness program can be designed by introducing price money for the achievers in education especially women, students should be taken to the field trips etc. IEC activities to be organized for the locals.

Skill development activities should be organized by creating self-help groups, field visit to be organized, events to be organized for displaying of artifacts made by the locals, field visits for information regarding work participation of women awareness regarding funding agencies such as NABARD, Govt. Schemes for self-help Groups etc. Monitoring of such activities can be based on the participation of men and women in such programs, increase of women participation in skill development training, evaluation of gender ratio every year etc.

CHAPTER 4

TRAFFIC STUDIES AND DEMAND FORECASTS

4 Traffic Studies and Demand Forecasts

4.1 Introduction

The Government of Assam, Public Works Roads Department (PWRD), Guwahati, Assam (the "Authority") is engaged in the improvement and development of SH & MDRs roads project under Asom Mala Programme and as part of this endeavor, the Authority has decided to undertake preparation of Detailed Project Report (DPR) for widening to Two Lane with Paved Shoulders to various Roads in the State of Assam (for an approximate length 1,270 Kms) under EPC mode.

As a part of this Authority has decided to appoint Consultancy services for Feasibility Study cum DPR, for improvement/widening to Two Lane with Paved Shoulders of Road Gohpur Dholpur Road via Arunachal Highway, Daimalu, Alupara, and Simaluguri including 2 Major RCC Bridges over River Kokila (**Ghagrabasti to Hawajan Road**) (Length: 28.136 Km) District-Sonitpur & Lakhimpur (Group-3: A28) under EPC Mode basis, and has decided to carry out the bidding process for selection of a private entity as the bidder to whom the Project may be awarded. After evaluation of Technical and Financial proposal, Public Works Roads Department of Assam has appointed M/s. Fortress Infracon Limited, Mumbai, as consultant to prepare the Detailed Project Report for the above road stretches under vide Letter of Work Order No. CE/AXOM MALA/8/2019/11, dated 31st October, 2019.

As per the traffic conditions the future requirement to two / four lane with paved shoulder has been proposed. As per the work order and scope of the work, the required traffic surveys (As per IRC: 09-1972 and IRC: 102-1988) carried out and also their analysis are discussed in this Chapter.

4.2 Scope of Services

The detailed scope of services for traffic surveys is as follows:

- To carry out 7 days' x 24 hrs. Classified Traffic Volume Count (TVC) Survey at locations informed to Client.
- To analyze the data collected through possible leakage points and study of travel pattern to determine through traffic for important segments of the route.
- Determination of possible leakage points and alternative diversion routes by detailed network study.
- To carry out Origin-Destination (OD) and Axle Load surveys.
- To carry out Intersection Volume Count (TMC) Survey (1-day x 24 hour) at Major intersections along the project road.
- To carry out Pedestrian & Cattle/Animal Crossing Traffic Count Survey.
- To carry out Speed and Delay Survey
- Calculation of MSA values based on Traffic volume for use in the pavement design.
- Parking Surveys in Urban Areas
- Surveys for Bus Shelters and Truck Lay Bye

The details of the data collection, primary as well as secondary, results from its analysis are presented in the following sections.

4.3 Traffic Surveys and Analysis

Traffic surveys such as mid-block Classified Traffic Volume Counts (TVC) by manual systems, Origin-Destination (OD) surveys are conducted on selected locations and Turning Movement Counts (TMC) are carried out at identified major junctions to understand the existing traffic pattern and to check the adequacy of the number of homogenous sections of the project road. The locations for the surveys were finalized based on the reconnaissance survey. All surveys have been carried out as per IRC: SP: 19-2001, guidelines.

4.3.1 Traffic Survey Locations and Schedule

Traffic survey schedule is presented in ***Table 4-1*** and the map of survey locations are shown in ***Figure 4-1*** and in ***Annexure 4-9.***

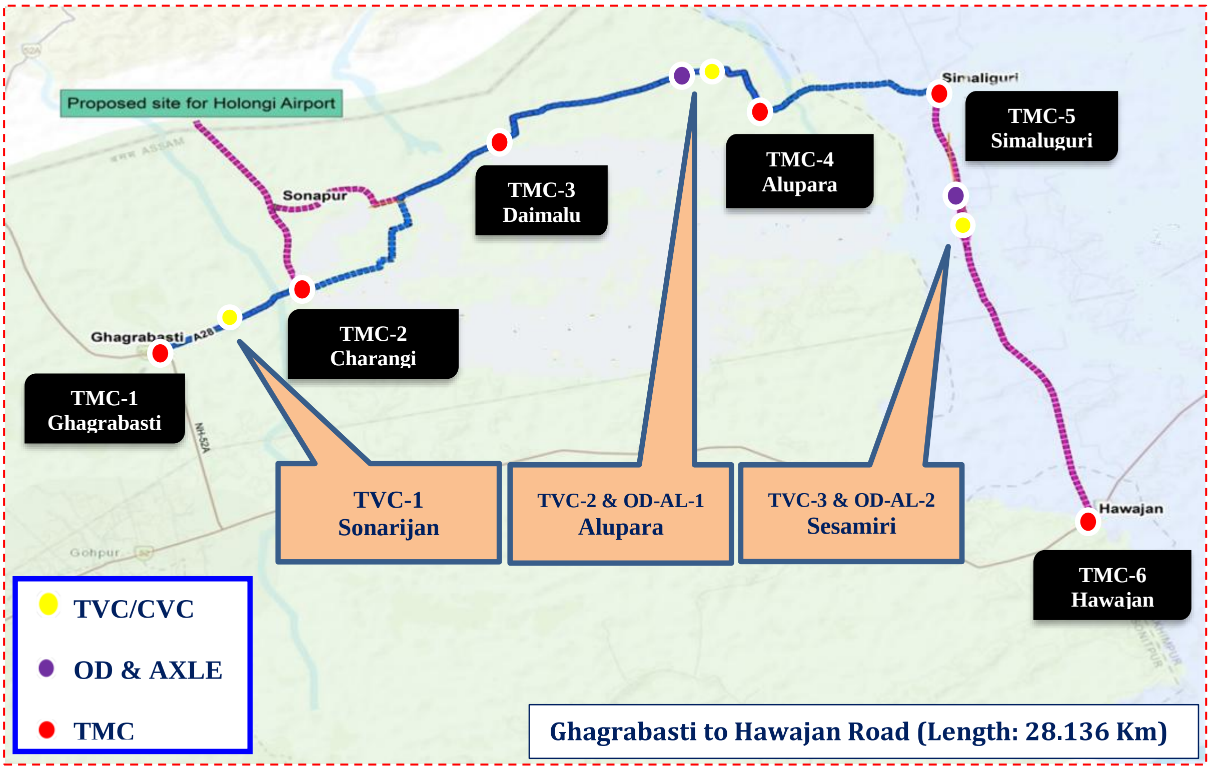
Table 4-1: Traffic Survey Schedule for Project Road

<table>
<tr><th>Type of Survey</th><th>Location</th><th>Lat-Long</th><th>Duration</th><th>Date of Survey</th></tr>
<tr><td rowspan="3">Classified Traffic Volume Count (TVC) Surveys</td><td>1) Sonarijan (Ch.07+200 Km)</td><td>26,917837, 93.650007</td><td>3 Days x 24 Hrs.</td><td>07/12/ 2019 & 20/01/2020 to 21/01/2020*</td></tr>
<tr><td>2) Alupara (Ch.13+600 Km)</td><td>26.970612, 93.715637</td><td>4 Days x 24 Hrs.</td><td>03/12/ 2019 to 06/12/2019</td></tr>
<tr><td>3) Sesamiri (Ch.18+960 Km)</td><td>26.956418, 93.751547</td><td>7 Days x 24 Hrs.</td><td>03/12/ 2019 to 07/12/2019 & 20/01/2020 to 21/01/2020*</td></tr>
<tr><td rowspan="2">O-D Surveys</td><td>1) Alupara (Ch.13+600 Km)</td><td>26.970612, 93.715637</td><td rowspan="2">1 Day x 24 Hrs.</td><td>04/12/2019</td></tr>
<tr><td>2) Sesamiri (Ch.18+960 Km)</td><td>26.956418, 93.751547</td><td>04/12/2019</td></tr>
<tr><td rowspan="2">Axle Load Surveys</td><td>1) Alupara (Ch.13+600 Km)</td><td>26.970612, 93.715637</td><td rowspan="2">1 Day x 24 Hrs.</td><td>04/12/2019</td></tr>
<tr><td>2) Sesamiri (Ch.18+960 Km)</td><td>26.956418, 93.751547</td><td>04/12/2019</td></tr>
<tr><td rowspan="6">Turning Movement Count (TMC) Surveys at 06 Locations</td><td>1) Ghagrabasti Tiniali (Ch.00+0Km)</td><td>26.921310, 93.622772</td><td rowspan="6">1 Day 24 x Hrs.</td><td>23/01/2020</td></tr>
<tr><td>2) Charangi Tiniali (Ch.04+800 Km)</td><td>26.950486, 93.639148</td><td>21/01/2020</td></tr>
<tr><td>3) Daimalu Market (Ch.09+860 Km)</td><td>26.967622, 93.697602</td><td>11/12/2019</td></tr>
<tr><td>4) Alupara Tiniali (Ch.13+630 Km)</td><td>26.970453, 93.715578</td><td>05/12/2019</td></tr>
<tr><td>5) Simaluguri (Ch.16+760 Km)</td><td>26.968336, 93.749247</td><td>05/12/2019</td></tr>
<tr><td>6) Hawajan (Ch.28+800 Km)</td><td>26.889380, 93.775051</td><td>05/12/2019</td></tr>
<tr><td>Speed-Delay Surveys</td><td colspan="2">Full Stretch (Ch. 24.800 Km)</td><td>1 Day</td><td>25/01/2020</td></tr>
<tr><td>Pedestrian / Animal Crossing Traffic Surveys</td><td colspan="2">1) Ghagrabasti, 2) Charangi, 3) Daimalu, 4) Alupara, 5) Simaluguri, 6) Hawajan</td><td>1 Day</td><td>05/12/ 2019 to to 21/01/2020</td></tr>
</table>

Source: As per Consultant proposed schedule & PWRD Consultations

**-Difference in the dates due to surveys activities suspended during the NRC issues in the Assam state.*

Map of Traffic Survey Locations



Source: Project Road Map based on Google Image

Figure 4-1: Map of Traffic Survey Locations at Project Road

4.3.2 Survey Methodology

4.3.2.1 Classified Traffic Volume Count (TVC) Survey

The main objectives of Classified Traffic Volume Counts were to assess the traffic characteristics in terms of average daily traffic, hourly traffic variation, peak hour traffic, traffic composition and directional distribution.

To carryout traffic counts, the vehicles were grouped under the various categories (as per IRC: SP 19-2001 and IRC: 09-1972). Vehicle classification system adopted is given in ***Table 4-2.***

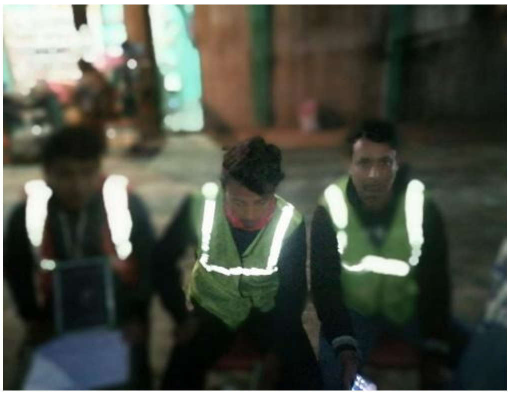
Table 4-2: Vehicle Classification System

Vehicle Classification System		
Class	**Code**	**Vehicle**
01	2W	Two-Wheeler
02	3W	Auto Rickshaw
03	LMV	Car/Jeep/Taxi
04	LCV	Mini Buses
05	SB	Standard Buses
06	LCV	Tempo/Traveler
07	LCV	LCV's (Goods)
08	2A	2-Axle Trucks
09	3A	3-Axle Trucks
10	MAV	Multi-Axle Trucks
11	TRCT+TRL	Tractors with Trailer

Vehicle Classification System		
Class	**Code**	**Vehicle**
12	TRCT	Tractors without Trailer
13	CYCLE	Cycle
14	CYCRSHW	Cycle Rickshaw
15	AD	Animal Drawn
16	OV	Other Vehicles

Source: As per IRC: SP 19-2001 and IRC: 09-1972

Traffic volume count was carried out by Classified Traffic Volume Counting (TVC) manual system under the supervision of a Transport Planner. The traffic count data was recorded at 15-minute intervals for each vehicle group. The Performa used for carrying out the traffic count survey is presented in ***Annexure 4-1.***


TVC Survey Locations @ Sonarijan (7+200), Alupara (13+600) and Sesamiri (18+960)

4.3.2.2 Origin-Destination Survey

The main objectives of Origin-Destination Surveys were to:

- Assess the travel pattern of passenger and goods traffic on project road
- Estimate through traffic for project road
- Estimate the frequency of travel for all modes of vehicle i.e. trips/day, trips/month etc.

- Estimate potential divertible traffic to and from alternate routes

OD & Axle Load Surveys Locations @ Alupara (Ch. 13+600 Km) & Sesamiri (Ch. 18+960 Km)

Roadside Interview (RSI) Method was adopted for conducting the OD survey (IRC: 102-1988). The vehicles were stopped on random sample basis with the help of police, and the drivers were interviewed by trained enumerators to collect the desired information/data. This survey was carried out along with Classified Traffic Volume Count, so as to get the expanded OD matrices which will give the complete picture of travel pattern followed by all the modes. Comprehensive information on origin & destination of trip, Frequency of trips were collected for both Passenger and Freight vehicles. The Performa used for recording the OD & Axle load data information is presented in ***Annexure-4-2.***

4.3.2.3 Turning Movements Count at Junctions

Junction counts were carried out at 06 locations. The objective to carry out junction count was to identify the traffic leaving and entering the project road from various directions, etc. (IRC 62-1976, IRC: SP: 41-1994, IRC: SP: 19-2001). The Performa used for recording the information is presented in ***Annexure 4-3.***

TMC Survey Locations on Project Road

4.3.3 Passenger Car Units (PCUs) / Passenger Car Equivalent (PCE) Factors

The various vehicle types having different sizes and characteristics were converted into equivalent passenger car units. The passenger car equivalents (PCE) factors for each category of vehicles, recommended by Indian Road Congress in "Guidelines for Capacity of Roads in Rural Areas" (IRC-64-1990) and IRC-108:2015 were used for this purpose and are presented in ***Table 4-3****.*

Table 4-3: Recommended PCU Factors for Various Types of Vehicles on Rural Roads

S. No.	Vehicle Type	Equivalency Factor
1.	Motor Cycle or Scooter	0.50
2.	Passenger Car, Pick-up Van or Auto-rickshaw	1.00
3.	Agricultural Tractor, Light Commercial Vehicles	1.50
4.	Truck or Bus	3.00
5.	Truck-trailer, Agriculture Tractor-trailer	4.50
6.	Cycle	0.50
7.	Cycle-rickshaw	2.00

S. No.	Vehicle Type	Equivalency Factor
8.	Hand Cart	3.00
9.	Horse-drawn Vehicle	4.00
10.	Bullock Cart	8.00

Source: Guidelines for Capacity of Roads in Rural Areas (IRC: 64-1990 & IRC-108:2015)

4.3.4 Classified Traffic Volume Count (TVC) Survey

Traffic volume data collected from the location was computerized and analyzed to study average daily traffic, hourly and daily variation of traffic, peak hour share/percentage, traffic composition and directional flows.

4.3.5 Average Daily Traffic (ADT)

Based on reconnaissance survey, 7-day classified volume count survey was carried out along the project road. The traffic volumes counted in 15-minute intervals have been aggregated to one-hour volumes. The hourly volumes have been aggregated into daily volumes for the entire survey period (7-days). The daily volumes are then averaged for ADT. To express the classified vehicular count in terms of PCUs, the PCU factors as given in IRC-108: 2015 have been considered. Based on the survey, Average Daily Traffic is arrived at Sonarijan, Alupara and Sesamiri locations are presented in ***Table 4-4***.

Table 4-4: Average Daily Traffic (ADT) (Both Direction)

Vehicle Type	Average Daily Traffic (ADT) (Year 2019-2020)					
	@ Sonarijan (Ch. 07+200) (3 Days)		@ Alupara (Ch. 13+600) (4 Days)		@ Sesamiri (Ch.18+960) (7 Days)	
	ADT in Vehicles	ADT in PCUs	ADT in Vehicles	ADT in PCUs	ADT in Vehicles	ADT in PCUs
Two Wheelers	**366**	183	**321**	160	**806**	403
3 Wheelers	**060**	060	**024**	024	**030**	030
Car/ Vans/ Jeeps	**112**	112	**107**	107	**100**	100
Minibuses	**000**	000	**000**	000	**000**	000
Standard Buses	**002**	006	**000**	000	**000**	000
Tempo	**021**	032	**025**	037	**062**	092
LCV's (Goods)	**000**	000	**001**	001	**004**	006
2-Axle Trucks	**010**	030	**001**	002	**000**	001
3-Axle Trucks	**000**	000	**000**	000	**000**	000
Multi-Axle Trucks	**000**	000	**000**	000	**000**	000
Tractors + Trailer	**007**	032	**006**	025	**009**	039
Tractors	**005**	007	**001**	002	**001**	002
Cycle	**262**	131	**489**	245	**661**	330
Cycle Rickshaw	**000**	000	**000**	001	**000**	000
Animal Drawn	**000**	000	**001**	002	**000**	000
Others	**000**	000	**000**	000	**000**	000
Total Traffic	**845**	**593**	**974**	**604**	**1673**	**1005**
Motorized	583	462	484	357	1012	674
Non-Motorized	262	131	490	247	661	331

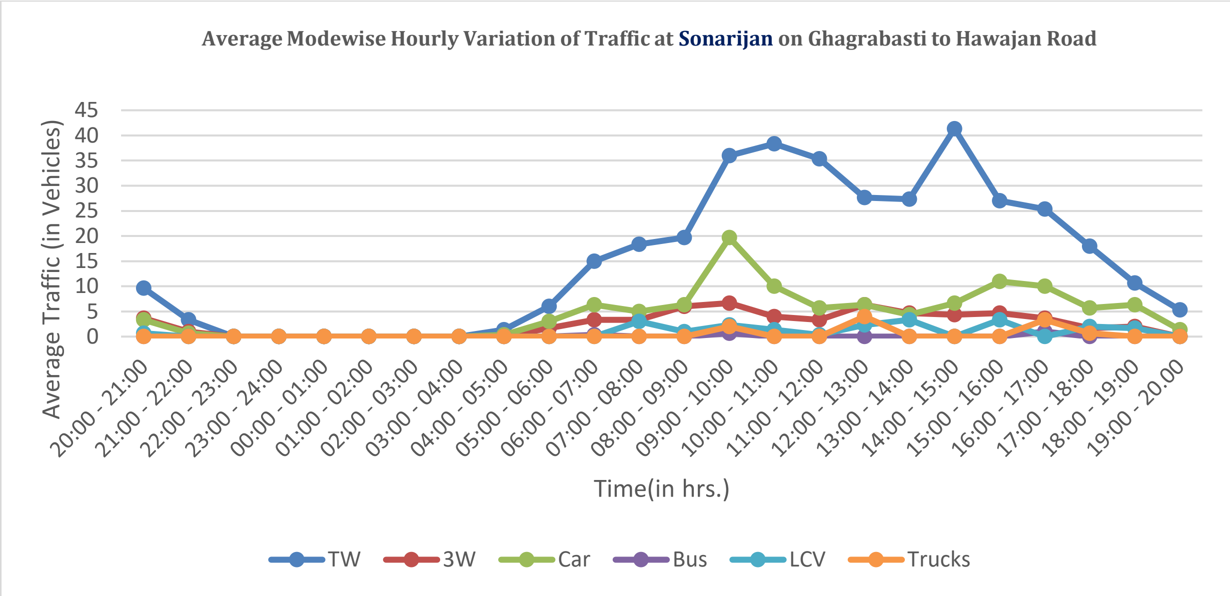
Source: As per Traffic Surveys Data 2019-2020

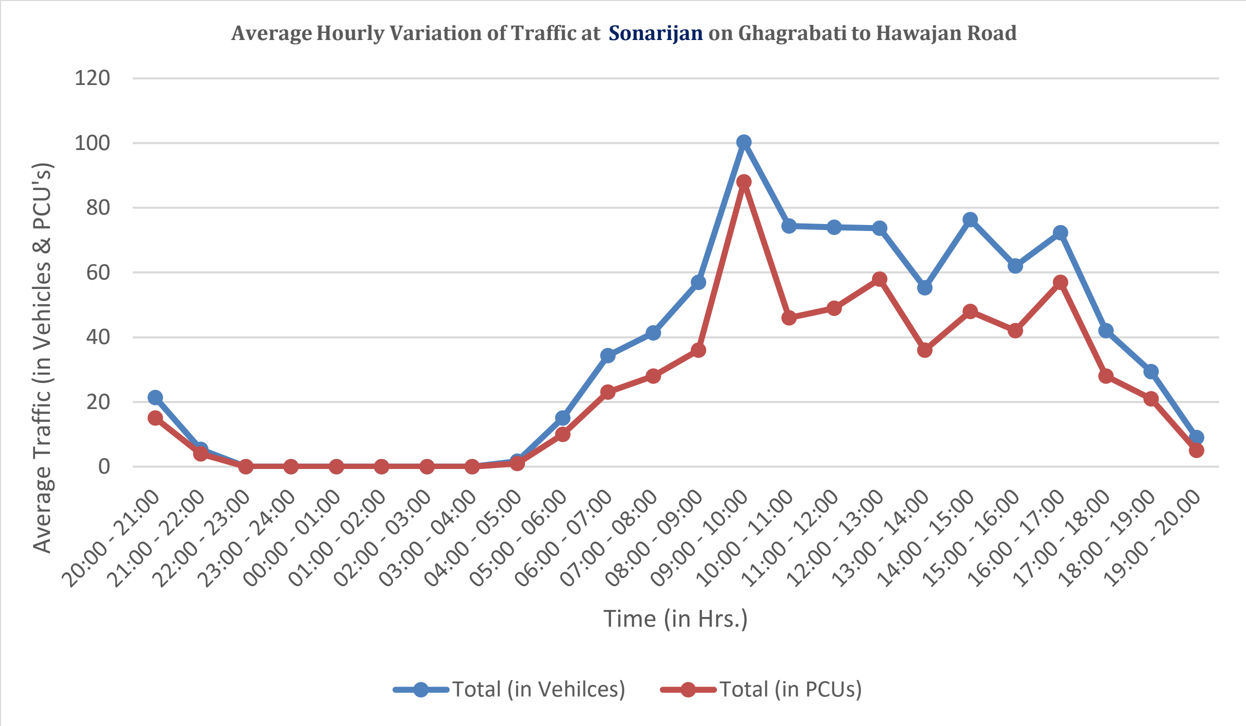
Observations:

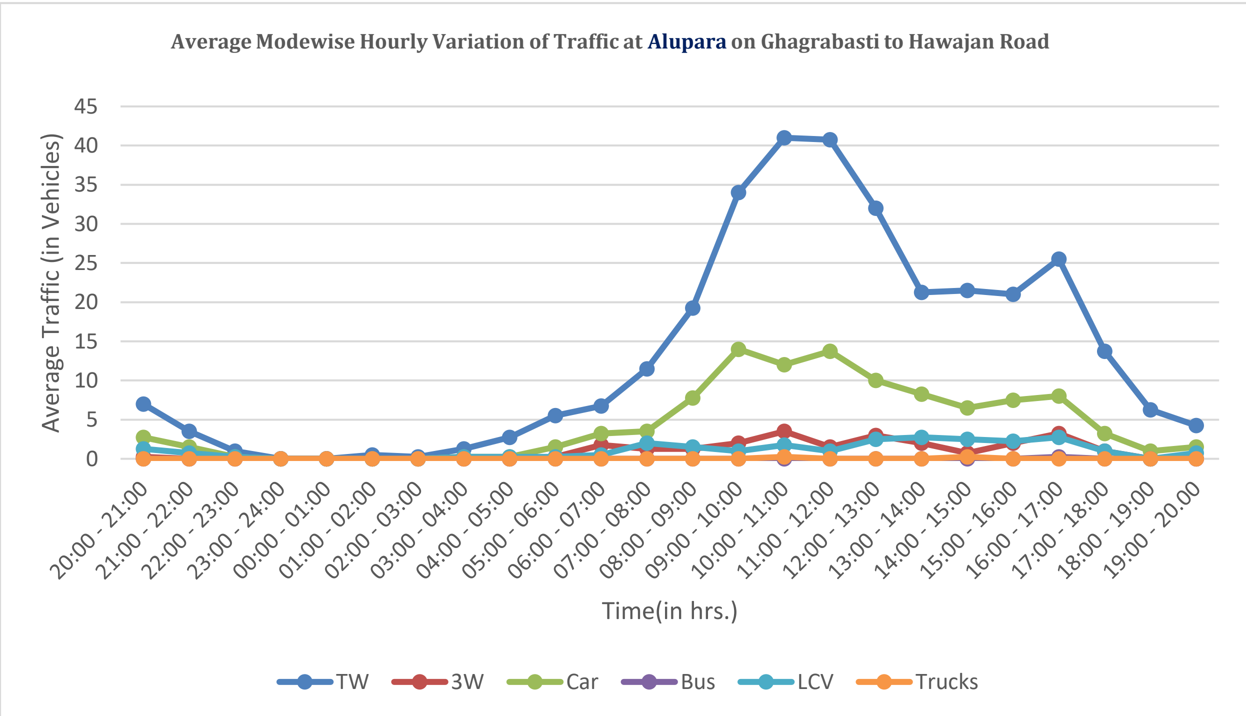
- The share of Two-Wheeler traffic at Sonarijan (43%), Alupara (33%) & Sesamiri (48%) is observed higher than other vehicles.
- The share of Passenger traffic i.e., Car, TW, Buses and passenger Auto traffic observed at Sonarijan (64%), Alupara (46%) & Sesamiri (56%) respective locations.
- The share of Goods vehicles traffic is observed at Sonarijan (05%), Alupara (04%) & Sesamiri (05%) respective locations.
- Non-motorized vehicles traffic share is observed at Sonarijan (31%), Alupara (50%) & Sesamiri (39%) respective locations.

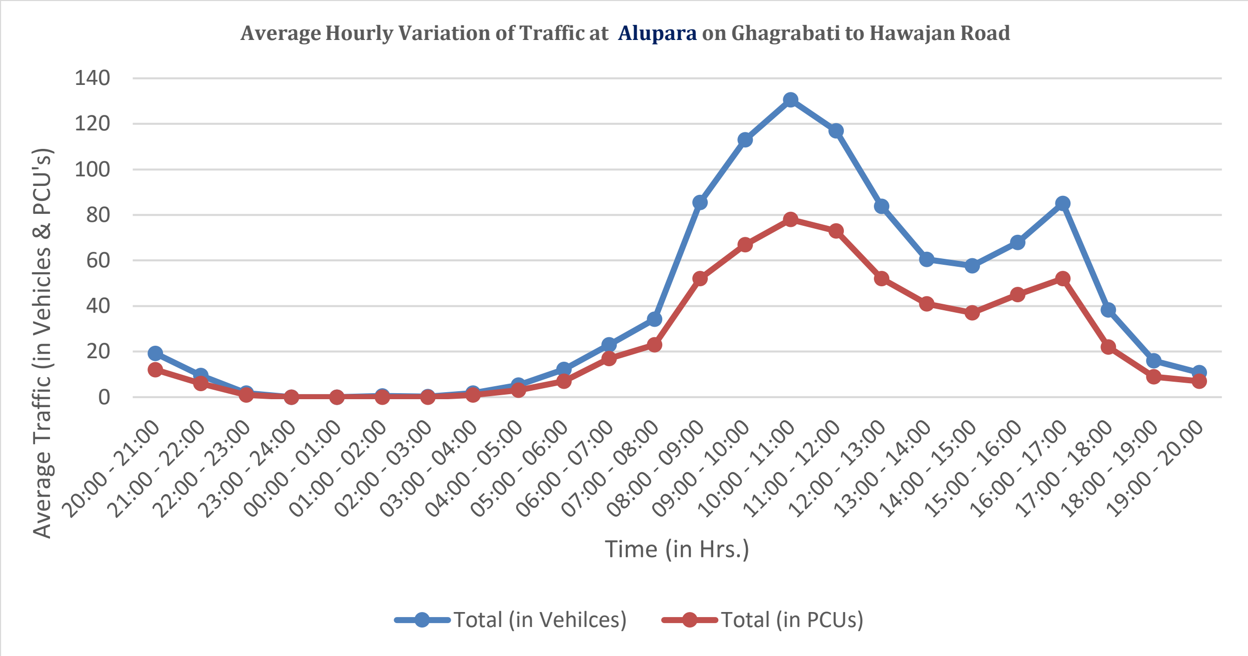
4.3.5.1 Hourly Variation of Traffic

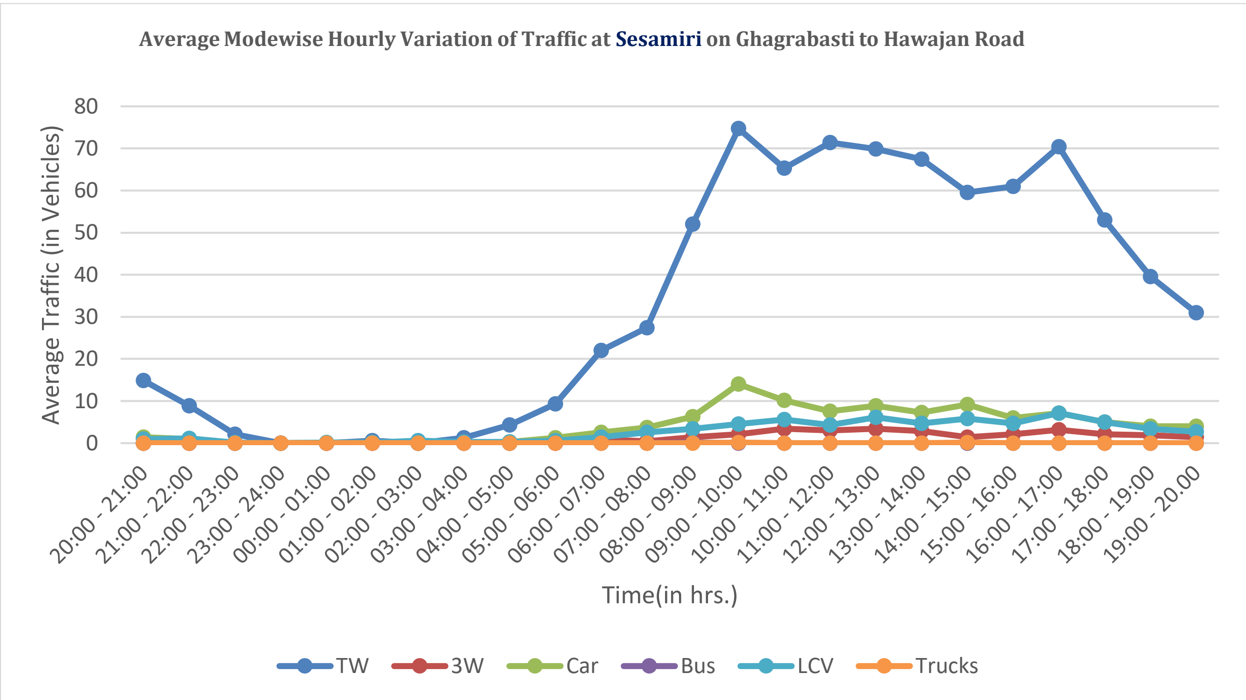
Hourly variation (average of 3/4/7 days) of mode-wise traffic and total traffic at the survey location (Sonarijan, Alupara & Sesamiri) is presented in ***Figure 4-2.***




Average Hourly Variation of Traffic at Sonarijan on Ghagrabati to Hawajan Road
Average Traffic (in Vehicles & PCU's)
120
100
80
60
40
20
0
20:00 - 21:00
21:00 - 22:00
22:00 - 23:00
23:00 - 24:00
00:00 - 01:00
01:00 - 02:00
02:00 - 03:00
03:00 - 04:00
04:00 - 05:00
05:00 - 06:00
06:00 - 07:00
07:00 - 08:00
08:00 - 09:00
09:00 - 10:00
10:00 - 11:00
11:00 - 12:00
12:00 - 13:00
13:00 - 14:00
14:00 - 15:00
15:00 - 16:00
16:00 - 17:00
17:00 - 18:00
18:00 - 19:00
19:00 - 20.00
Time (in Hrs.)
Total (in Vehilces)
Total (in PCUs)


Average Modewise Hourly Variation of Traffic at Alupara on Ghagrabasti to Hawajan Road
Average Traffic (in Vehicles)
45
40
35
30
25
20
15
10
5
0
20:00 - 21:00
21:00 - 22:00
22:00 - 23:00
23:00 - 24:00
00:00 - 01:00
01:00 - 02:00
02:00 - 03:00
03:00 - 04:00
04:00 - 05:00
05:00 - 06:00
06:00 - 07:00
07:00 - 08:00
08:00 - 09:00
09:00 - 10:00
10:00 - 11:00
11:00 - 12:00
12:00 - 13:00
13:00 - 14:00
14:00 - 15:00
15:00 - 16:00
16:00 - 17:00
17:00 - 18:00
18:00 - 19:00
19:00 - 20.00
Time(in hrs.)
TW
3W
Car
Bus
LCV
Trucks


Average Hourly Variation of Traffic at Alupara on Ghagrabati to Hawajan Road
Average Traffic (in Vehicles & PCU's)
Time (in Hrs.)
Total (in Vehilces)
Total (in PCUs)


Average Modewise Hourly Variation of Traffic at Sesamiri on Ghagrabasti to Hawajan Road
Average Traffic (in Vehicles)
Time(in hrs.)
TW
3W
Car
Bus
LCV
Trucks

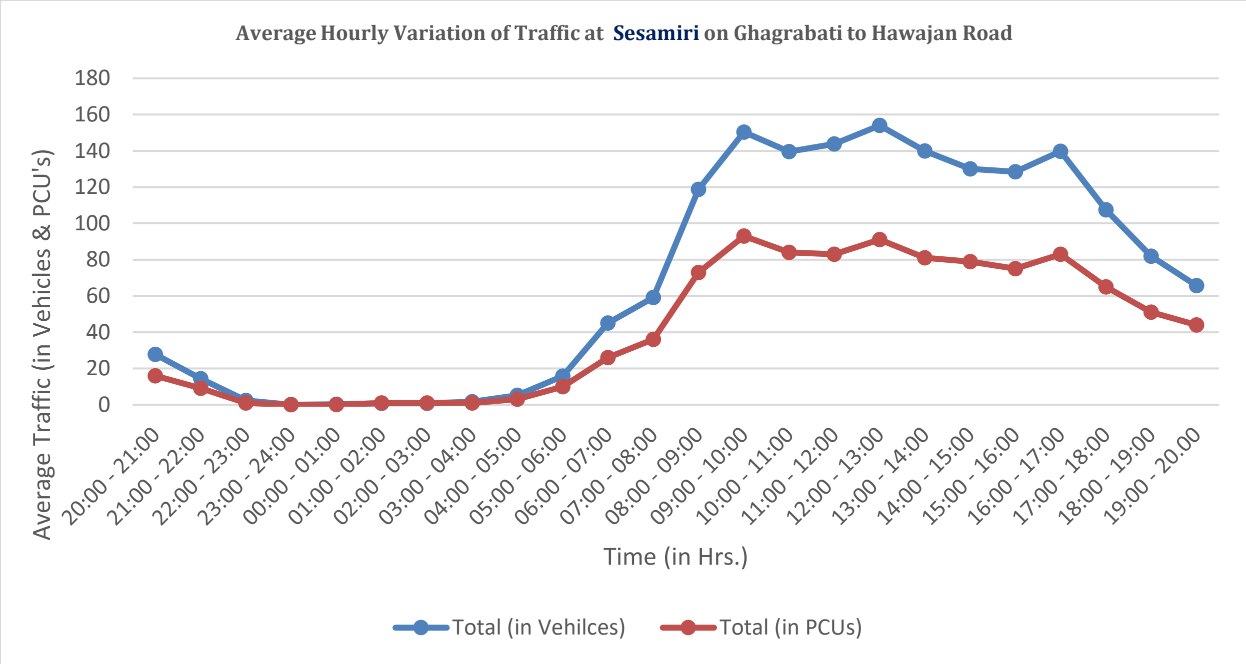
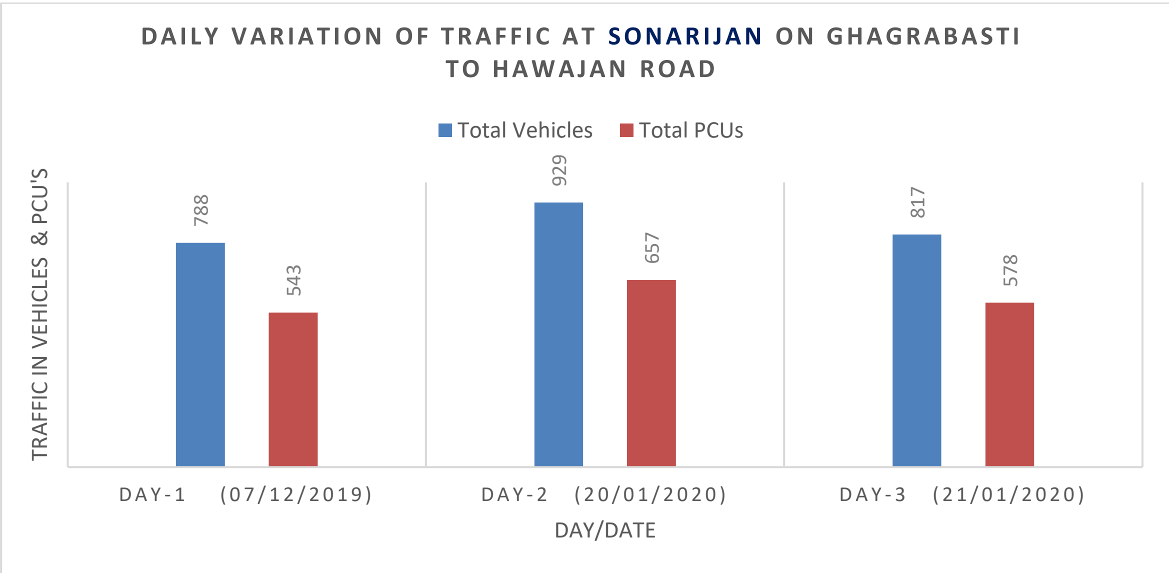
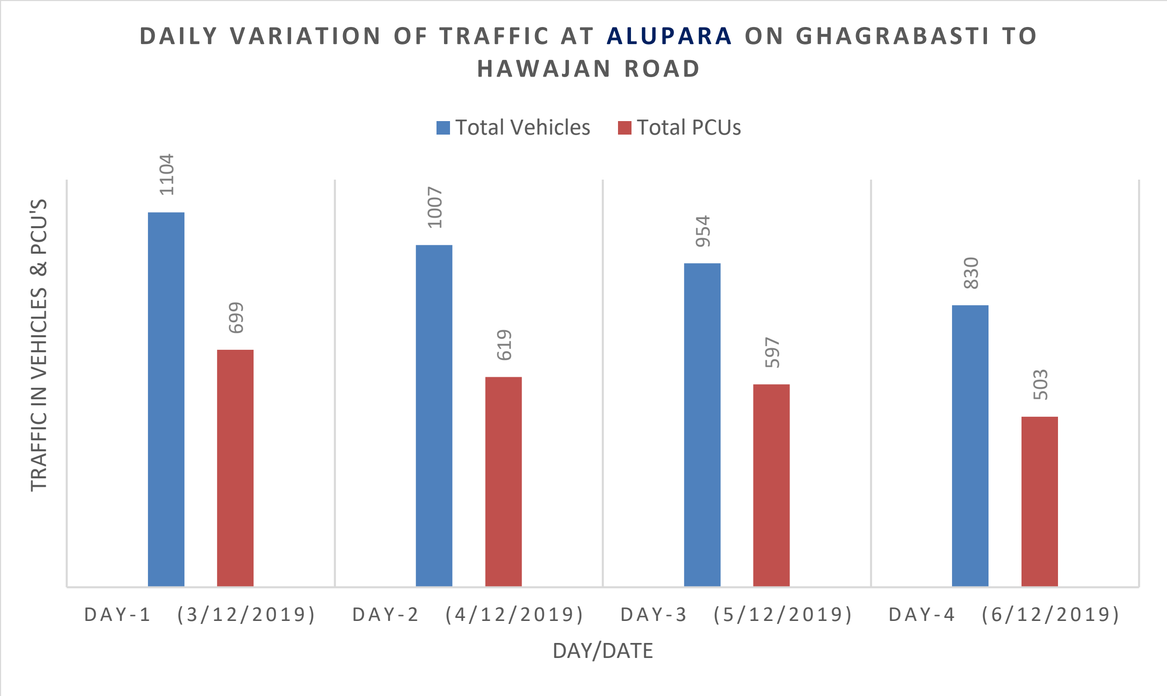


Figure 4-2: Hourly Variation of Traffic at Sonarijan, Alupara & Sesamiri on Ghagrabasti to Hawajan Road

4.3.5.2 Daily Variation of Traffic

Location-wise daily variation of traffic at the survey locations (Sonarijan, Alupara & Sesamiri) along the Ghagrabasti to Hawajan road project corridor is presented in ***Figure 4-3***.





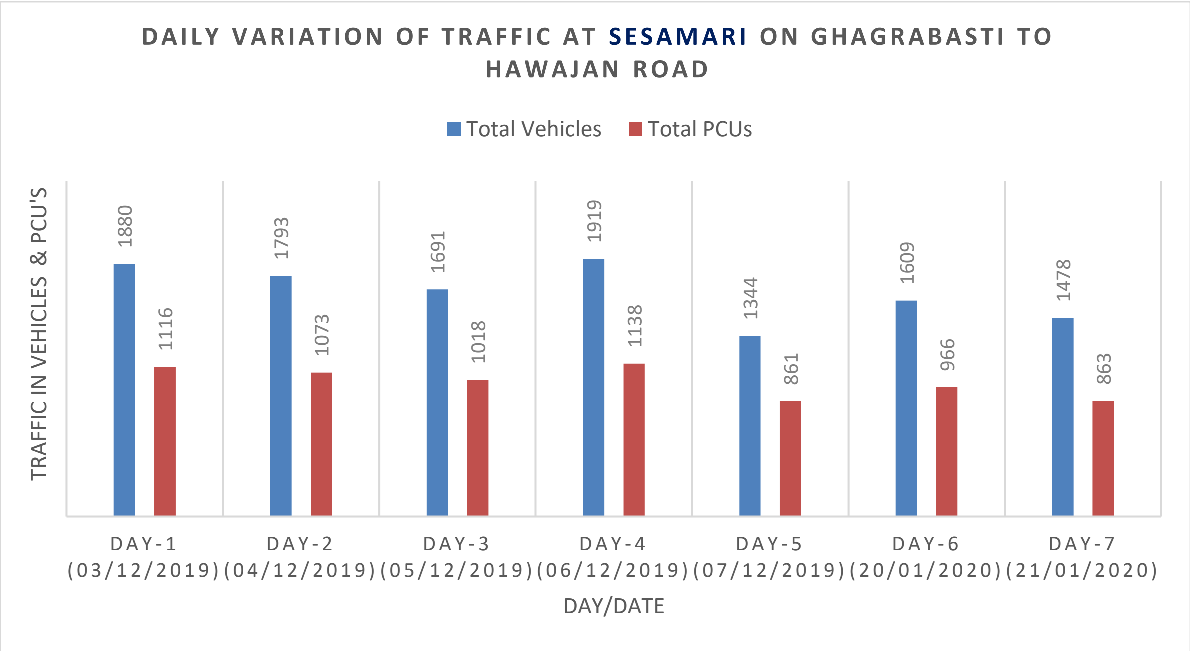
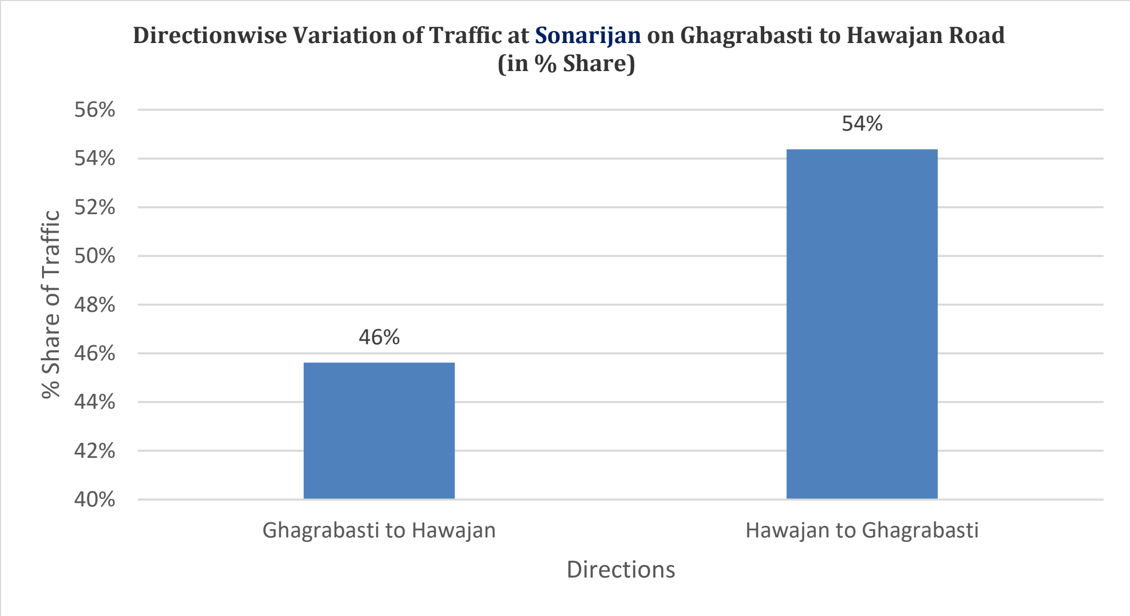
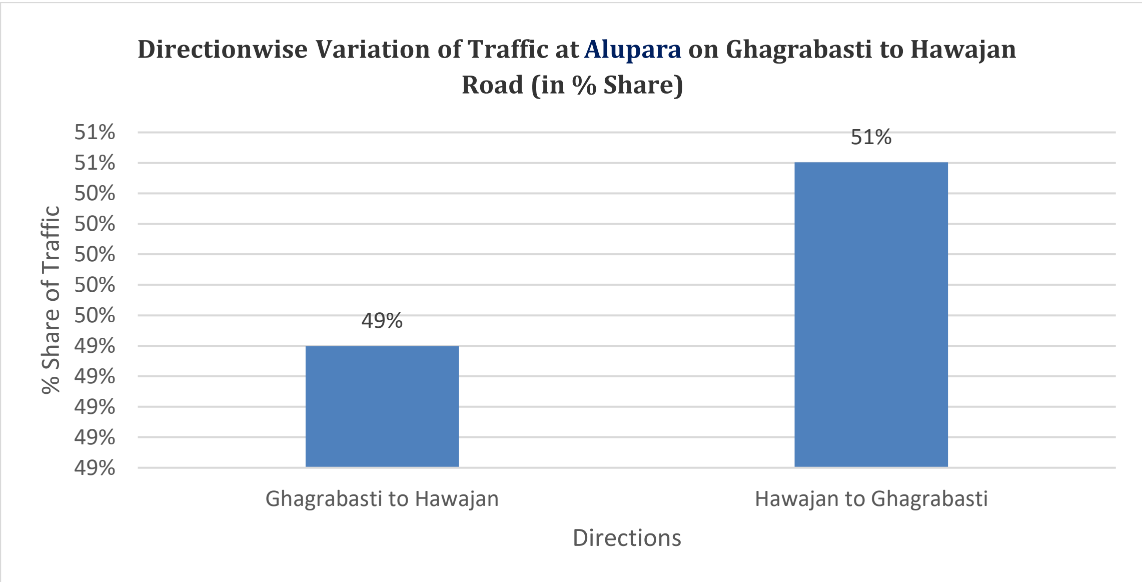


Figure 4-3: Daily Variation of Traffic at Sonarijan, Alupara & Sesamiri on Ghagrabasti to Hawajan Road

4.3.5.3 Direction-wise Split of Traffic

Direction-wise variation of traffic along the project road (@ Sonarijan, Alupara & Sesamiri) is presented in ***Figure 4-4***. Traffic from Ghagrabasti to Hawajan direction is little higher at Sesamiri (49.20%) location and Hawajan to Ghagrabasti direction is observed little higher at Sonarijan (54%) location as compared to other directions.


Directionwise Variation of Traffic at Sonarijan on Ghagrabasti to Hawajan Road
(in % Share)
56%
54%
52%
50%
48%
46%
44%
42%
40%
% Share of Traffic
46%
54%
Ghagrabasti to Hawajan
Hawajan to Ghagrabasti
Directions


Directionwise Variation of Traffic at Alupara on Ghagrabasti to Hawajan
Road (in % Share)
51%
51%
50%
50%
50%
50%
50%
49%
49%
49%
49%
49%
% Share of Traffic
49%
51%
Ghagrabasti to Hawajan
Hawajan to Ghagrabasti
Directions

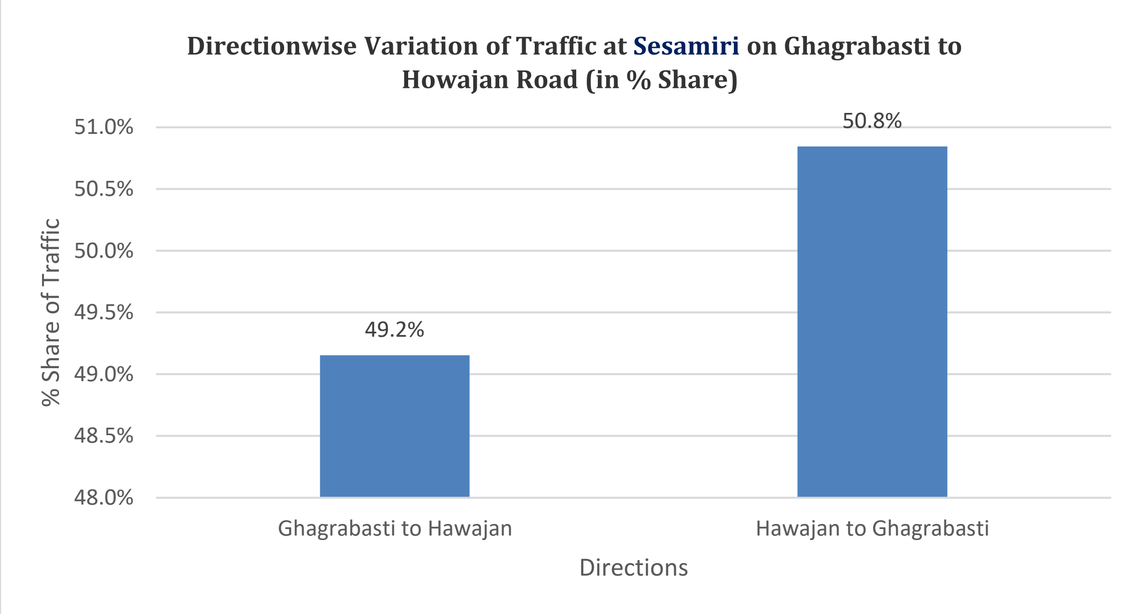


Figure 4-4: Direction-wise Split of Traffic along the Project Road

4.3.5.4 Traffic Composition on the Project Road

The traffic composition of vehicles at the survey locations (Sonarijan, Alupara & Sesamiri) is worked out and presented in ***Table 4-5*.**

Table 4-5: Traffic Composition along the Project Road

Vehicle Type	% Traffic Composition at Ghagrabasti to Hawajan Road (3/4/7-Day ADT)		
	@ Sonarijan	@ Alupara	@ Sesamiri
Two Wheelers	43.29%	32.91%	48.16%
3 Wheelers	07.14%	02.44%	01.78%
Car/ Vans/ Jeeps	13.26%	10.96%	05.99%
Mini Buses	00.00%	00.03%	00.01%
Standard Buses	00.24%	00.00%	00.00%
Tempo	02.53%	02.52%	03.68%
LCV’s (Goods)	00.00%	00.08%	00.26%
2-Axle Trucks	01.18%	00.05%	00.02%
3-Axle Trucks	00.00%	00.00%	00.00%
Multi-Axle Trucks	00.00%	00.00%	00.00%
Tractors + Trailer	00.83%	00.56%	00.52%
Tractors	00.55%	00.13%	00.09%
Cycle	30.98%	50.24%	39.49%
Cycle Rickshaw	00.00%	00.03%	00.00%
Animal Drawn	00.00%	00.05%	00.00%
Others	00.00%	00.00%	00.01%
Total	**100%**	**100%**	**100%**

Source: As per Actual Traffic Surveys Data & Consultant Estimates

Observations:

- Traffic during weekend is observed to be low due to the absence of work trips
- Two-wheeler traffic is observed to be significant

- Share of commercial traffic is observed 03% to 05% on project Road
- Passengers contribution is observed in range of 45% to 65%.
- Cycle/NMT users share on the project road is found very high 30% to 50%.

4.3.6 Seasonal Correction Factor (SCF)

The traffic plying on any road generally varies over different periods of year depending on the cycle of different socio-economic activities in the regions through which it passes. Therefore, in order to have more realistic picture of the traffic on the project road, it is required to assess seasonal variation in traffic to estimate Annual Average Daily Traffic (AADT) and Peak Season AADT. Therefore, the ADT observed during the survey duration is multiplied by a Seasonal Correction Factor (SCF) to derive AADT and Peak season AADT. The seasonal correction factor is generally derived from secondary data sources such as past month-wise traffic data on the project road, sales of fuel at different filling stations along the project highway etc. Due to non-availability of past traffic data on the project road monthly figures of fuel sales collected from petrol pumps along the project road is considered for calculation of seasonal correction factors.

To understand the seasonal variation of traffic along the project road, Consultant has collected last five years fuel sales data from various fuel stations located along the project road (as per IRC 108:1996). Based on fuel sales data collected Seasonal Correction Factor (SCF) is worked out and presented in ***Table 4-6***. The SCF is arrived by considering data from all the fuel stations together for petrol and diesel. The SCF of December month is adopted as per the TVC survey schedule. The secondary data collected is provided in ***Annexure 4-5.***

Table 4-6: Seasonal Correction Factor

Section	Passenger Vehicles and Other Commercial Vehicles		
	Petrol	Diesel	Others
Ghagrabasti to Hawajan Road	0.993	1.071	1.00

Source: Consultant Estimates based on Petrol & Diesel Sales Data along Project Road

4.3.7 Annual Average Daily Traffic (AADT)

AADT is derived by applying seasonal correction factors to ADT for Sonarijan, Alupara & Sesamiri locations are presented in ***Table 4-7 and 4-8***. The factor arrived based on petrol data is applied for petrol-based vehicles such as two wheelers, three wheelers etc. and factor arrived based on diesel data is applied for diesel-based vehicles such as bus, truck etc. For non-motorized vehicles, SCF of 1.0 is assumed.

Table 4-7: Annual Average Daily Traffic (AADT) (3/4/7-Day TVC)

Vehicle Type	Ghagrabasti to Hawajan Road AADT (Year 2019-2020)					
	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs
	@ Sonarijan		@ Alupara		@ Sesamiri	
Two Wheelers	363	182	318	159	800	400

Vehicle Type	Ghagrabasti to Hawajan Road AADT (Year 2019-2020)					
	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs
	@ Sonarijan		@ Alupara		@ Sesamiri	
3 Wheelers	**060**	060	**024**	024	**029**	029
Car/ Vans/ Jeeps	**111**	111	**106**	106	**100**	100
Mini Buses	**000**	000	**000**	000	**000**	000
Standard Buses	**002**	006	**000**	000	**000**	000
Tempo	**023**	035	**026**	039	**066**	099
LCV's (Goods)	**000**	000	**001**	002	**005**	008
2-Axle Trucks	**011**	033	**001**	003	**000**	000
3-Axle Trucks	**000**	000	**000**	000	**000**	000
Multi-Axle Trucks	**000**	000	**000**	000	**000**	000
Tractors + Trailer	**007**	032	**006**	027	**009**	041
Tractors	**005**	008	**001**	002	**002**	003
Cycle	**262**	131	**489**	245	**661**	331
Cycle Rickshaw	**000**	000	**000**	000	**000**	000
Animal Drawn	**000**	000	**001**	004	**000**	000
Others	**000**	000	**000**	000	**000**	000
Total Traffic	**844**	**596**	**973**	**610**	**1672**	**1010**
Motorized	582	465	483	361	1011	679
Non-Motorized	262	131	490	249	661	331

Source: Consultant Estimates based on Actual Traffic Survey Data

Table 4-8: Annual Average Daily Traffic (AADT) (3/4/7-Day TVC)

Vehicle Type	Ghagrabasti to Hawajan Road AADT (Year 2024-2025)					
	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs
	@ Sonarijan		@ Alupara		@ Sesamiri	
Two Wheelers	**511**	255	**448**	224	**1126**	563
3 Wheelers	**084**	084	**034**	034	**041**	041
Car/ Vans/ Jeeps	**154**	154	**147**	147	**139**	139
Minibuses	**000**	000	**000**	000	**000**	000
Standard Buses	**003**	008	**000**	000	**000**	000
Tempo	**032**	048	**036**	054	**091**	137
LCV's (Goods)	**000**	000	**001**	002	**007**	010
2-Axle Trucks	**014**	043	**001**	004	**000**	000
3-Axle Trucks	**000**	000	**000**	000	**000**	000
Multi-Axle Trucks	**000**	000	**000**	000	**000**	000
Tractors + Trailer	**010**	044	**008**	037	**012**	056
Tractors	**007**	010	**001**	002	**003**	004
Cycle	**262**	131	**490**	245	**662**	331

Vehicle Type	Ghagrabasti to Hawajan Road AADT (Year 2024-2025)					
	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs	Annual Average Daily Traffic (AADT) in Vehicles	AADT in PCUs
	@ Sonarijan		@ Alupara		@ Sesamiri	
Cycle Rickshaw	**000**	000	**000**	000	**000**	000
Animal Drawn	**000**	000	**001**	004	**000**	000
Others	**000**	000	**000**	000	**000**	000
Total Traffic	**1077**	**777**	**1167**	**753**	**2080**	**1281**
Motorized	814	646	677	504	1419	950
Non-Motorized	262	131	491	249	662	331

The details of AADT along with seasonality factor are presented in ***Annexure- 4-4.***

4.3.8 Turning Movement Survey

To assess the impact of major cross roads, turning movement survey was carried out at identified important junctions. Percentage of turning traffic and major findings are given in ***Table 4-9***. Detailed Direction-wise traffic data is presented in ***Annexure 4-6***.

Table 4-9: Summary of Junction Counts along the Project Road

S. No.	Location	Total Junction Traffic Vehicles (PCU)	Total Turning Traffic Vehicles (PCU)	% Turning Traffic	Peak Hour Traffic Vehicles (PCU)
1	Ghagrabasti Tiniali (Ch.00+0Km)	4026 (4086)	1694 (1286)	42%	333 (319) 07:00- 08:00
2	Charangi Tiniali (Ch.04+800 Km)	2765 (1886)	1670 (1178)	60%	266 (214) 13:00- 14:00
3	Daimalu Market (Ch.09+860 Km)	984 (564)	550 (310)	56%	111 (67) 07:00- 08:00
4	Alupara Tiniali (Ch.13+630 Km)	1934 (1107)	983 (599)	51%	384 (206) 09:00- 10:00
5	Simaluguri (Ch.16+760 Km)	7429 (4762)	4712 (3036)	63%	794 (524) 09:00- 10:00
6	Hawajan (Ch.28+800 Km)	9417 (10004)	3577 (2473)	38%	853 (852) 15:00- 16:00

Source: Consultant Estimates based on TMC Survey Data

Inference:

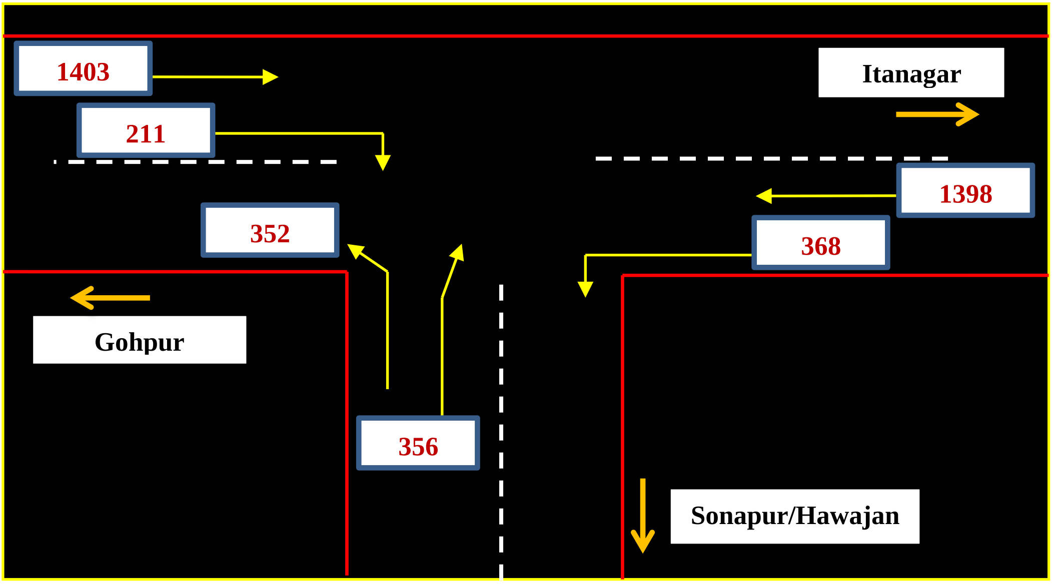
- The turning traffic at Charangi, Simaluguri, Daimalu Market and Alupara Junctions is observed to be comparatively high
- The turning traffic at Hawajan and Ghagrabasti Tiniali Junctions is observed to be comparatively low
- Total Traffic at Hawajan Tiniali (NH-15) is observed to be very high as compare to other junctions
- Total Traffic at Daimalu Tiniali is observed to be low as compare to other junctions

- Peak hours traffic is observed on between time 07:00 to 10:00 in the morning and 13:00 to 16:00 Hrs. in the evening.

As per IRC 62-1976, Grade Separator should be provided at intersection of rural highway if ADT (fast vehicles) at the crossroads within the next 5 years exceeding 5000 nos. The **Annexure-4.10**-Forecasts of Intersection Turning Movements shows the Summary of Peak Hour Intersection Flows.

The flow diagrams representing the turning movement volumes are shown below.

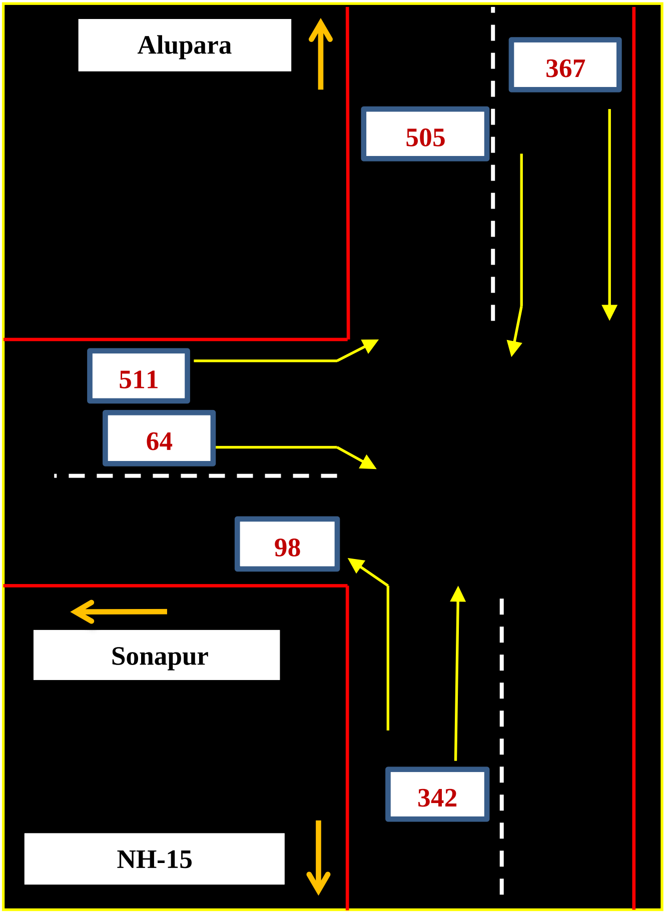
1) Total Traffic (in PCUs) at Start Point Ghagrabasti Tiniali Junction (NH-52A)



Inference:

- The turning traffic from Itanagar to Sonapur/Hawajan is observed to be comparatively very high. This is mainly local town passenger traffic.
- The turning traffic from Gohpur to Sonapur/Hawajan is observed to be comparatively low
- Through traffic at this junction is about 2800 PCUs
- Traffic turning from other directions to Sonapur/Hawajan direction is about 578 PCUs
- Traffic diverting from Sonapur/Hawajan direction to other directions is about 708 PCUs.

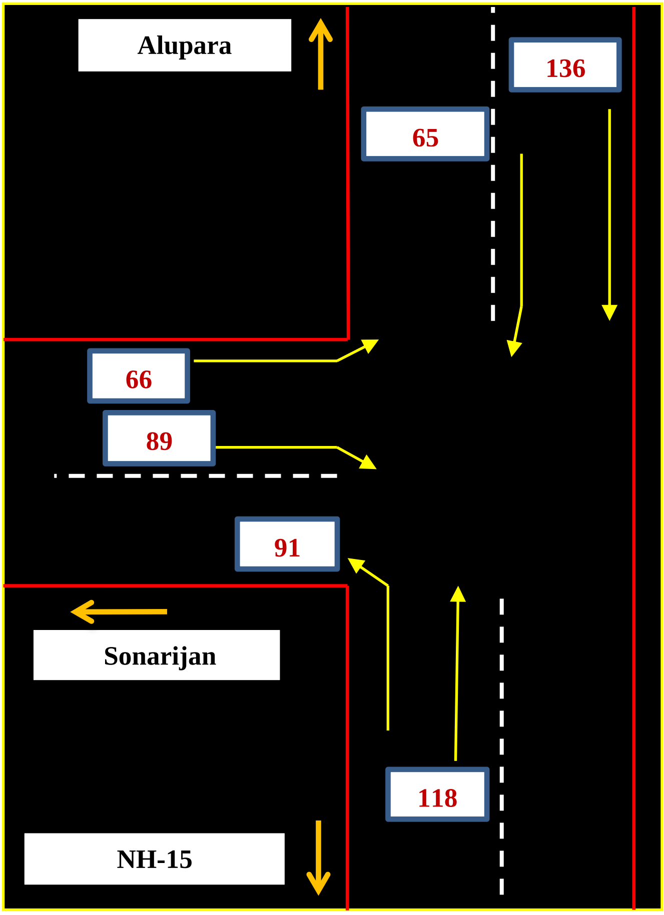
2) Total Traffic (in PCUs) at Charangi Gaon Tiniali



Inference:

- The turning traffic from Sonapur to Alupara is observed to be comparatively very high
- The turning traffic from Sonapur to NH-15 is observed to be comparatively low
- Through traffic at this junction is about 709 PCUs
- Traffic turning from other directions to Alupara direction is about 853 PCUs
- Traffic diverting from Alupara direction to other directions is about 872 PCUs.

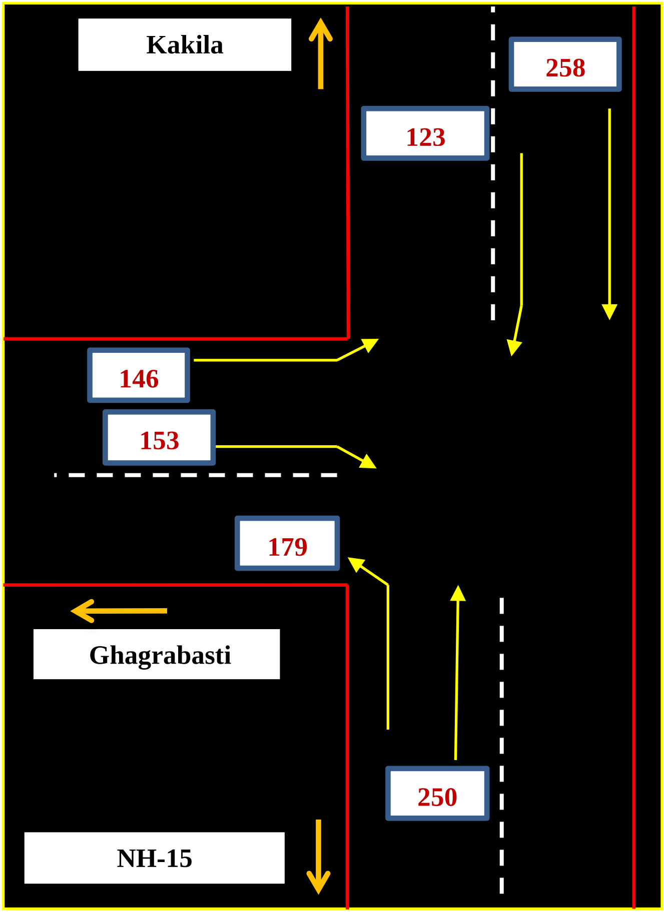
3) Total Traffic (in PCUs) at Daimalu Kakila Market



Inference:

- The turning traffic from NH-15 to Sonarijan is observed to be comparatively very high
- The turning traffic from Sonarijan to Alupara is observed to be comparatively low
- Through traffic at this junction is about 254 PCUs
- Traffic turning from other directions to Alupara direction is about 183 PCUs
- Traffic diverting from Alupara direction to other directions is about 201 PCUs.

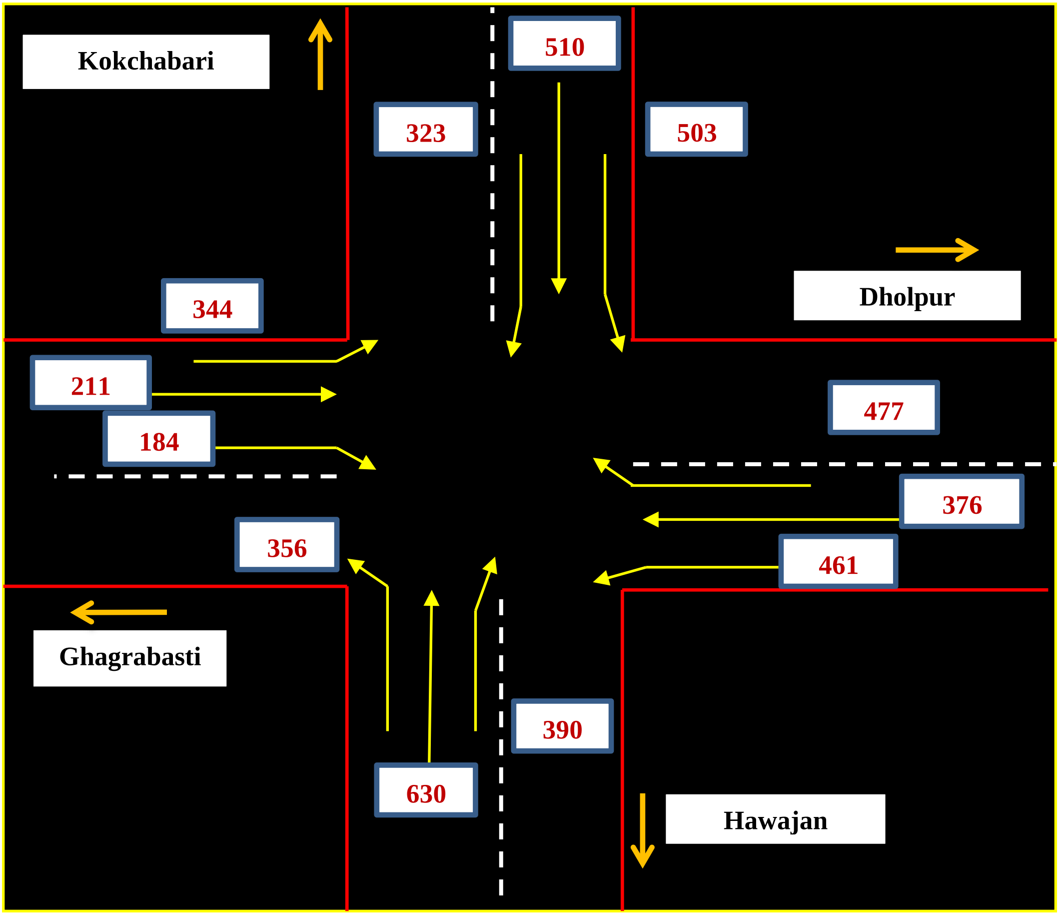
4) Total Traffic (in PCUs) at Alupara Tiniali



Inference:

- The turning traffic from NH-15 to Ghagrabasti is observed to be comparatively very high
- The turning traffic from Kakila to Ghagrabasti is observed to be comparatively low
- Through traffic at this junction is about 508 PCUs
- Traffic turning from other directions to Ghagrabasti direction is about 301 PCUs
- Traffic diverting from Ghagrabasti direction to other directions is about 298 PCUs.

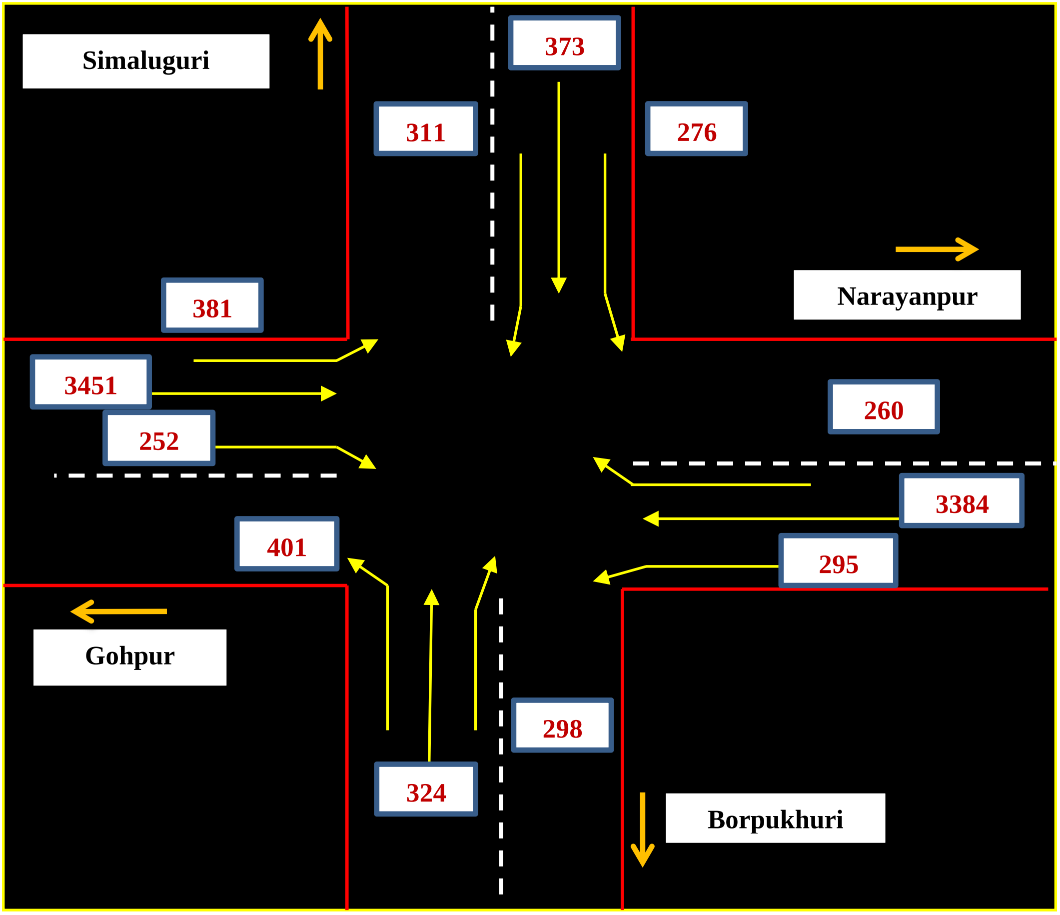
5) Total Traffic (in PCUs) at Simaluguri Chariali Junction



Inference:

- The turning traffic from Kokchabari to Dholpur is observed to be comparatively very high
- The turning traffic from Ghagrabasti to Hawajan is observed to be comparatively low
- Through traffic at this junction is about 1727 PCUs
- Traffic turning from other directions to Ghagrabasti & Hawajan directions is about 1055 & 1155 PCU's respectively.
- Traffic diverting from Ghagrabasti to Hawajan directions to other directions is about 738 & 1176 PCU's respectively.

6) Total Traffic (in PCUs) at Hawajan Chariali Junction NH-15



Inference:

- The turning traffic from Gohpur to Simaluguri is observed to be comparatively very high
- The turning traffic from Gohpur to Borpukhuri is observed to be comparatively low
- Through traffic at this junction is about 7531 PCUs
- Traffic turning from other directions to Simaluguri direction is about 965 PCU's.
- Traffic diverting from Simaluguri direction to other directions is about 960 PCU's.

4.3.9 Origin-Destination Survey

To understand the existing travel pattern, Origin-Destination (O-D) surveys are carried out for 1day x 24 hours at two different locations (Alupara & Sesamiri). Information like origin, destination and commodity carried, frequency of trips etc., are collected during the survey.

4.3.9.1 Justification for Selection of OD Location

The Origin Destination survey location was selected considering the factors such as; length of the road, network of the road, existing roads homogeneous sections, major intersections, diversions of the road, movements of the vehicles, availability of alternative routes, leakages, connectivity to the NH, SH, & MDR roads, etc. The main objective behind these locations is to gather maximum samples for OD analysis and its estimates. The other reason is TVC survey location which was set at the same place. There are two homogeneous OD sections has been considered in this project road i.e. Ghagrabasti to Simaluguri (at Alupara) and Simaluguri to Hawajan (at Sesamiri) to covered maximum observations.

4.3.9.2 Sample Size of O-D Survey

As discussed earlier, the vehicles for the OD survey were interviewed on a random sample basis. The collected data is coded, processed and expanded to total traffic using the expansion factors for each vehicle type. The percentage samples collected for various categories of vehicles for the O-D survey are given in ***Table 4-10***.

Table 4-10: Sample Size of O-D Survey (in %)

Vehicle Type	@ Alupara (Ch. 13+600)	@ Sesamiri (Ch. 18+960)
Car/Jeep/Taxi	55%	69%
Mini Bus	00 %	100%
Std. Bus	00 %	00%
Mini LCV	62%	63%
LCV	00 %	57%
2 Axle	00 %	00%
3 Axle	00 %	00%
MAV (> 3 Axle)	00 %	00%

Source: Consultant Estimates based on O-D Survey Data

4.3.9.3 Zoning

In order to assess the traffic pattern on the project influence area, zoning system is developed keeping in view the major generation and attraction points. The entire project influence area is divided into 13 zones and the same is presented in ***Table 4-11****.*

Table 4-11: OD Zoning System

Zone No.	Description Project Influence Zones of Assam
1	Alupara
2	Daimalu
3	Dholpur
4	Gohpur
5	Hawajan
6	Simaluguri
7	Narayanpur
8	Lakhimpur
9	Sonitpur
10	Kamrup
11	Assam
12	Arunachal
13	Nagaland

Source: Consultant Estimates based on O-D Survey Data

4.3.9.4 Zone-wise Influence Factors

The O-D survey results provide a clear indication of the region, which contribute to the traffic on the existing roads in the project influence area. Number of trips originating from and destined to any zone represents the influence of that zone on the traffic.

The O-D matrices developed from O-D survey data is used to estimate the influence factors. Thus, estimated zone-wise influence factors are presented in ***Table 4-12***. Expanded matrices are given in ***Annexure 4-7***.

Table 4-12: Zone-wise Influence Factors at Project Road

Sl. No.	Zone Name	%age Share @ Alupara		%age Share @ Sesamiri	
		Passenger Vehicles	Goods Vehicles	Passenger Vehicles	Goods Vehicles
1	Alupara	12.28%	12.50%	00.00%	00.00%
2	Daimalu	35.96%	18.75%	00.00%	00.00%
3	Dholpur	01.75%	00.00%	02.77%	02.96%
4	Gohpur	02.63%	06.25%	01.39%	01.34%
5	Hawajan	00.00%	00.00%	18.79%	24.33%
6	Simaluguri	02.63%	00.00%	46.53%	42.74%
7	Narayanpur	01.75%	00.00%	02.77%	01.34%
8	Lakhimpur	00.88%	06.25%	07.63%	09.64%
9	Sonitpur	34.21%	28.13%	09.71%	05.34%
10	Kamrup	00.00%	00.00%	00.69%	01.34%
11	Assam	07.89%	15.63%	09.71%	10.98%
12	Arunachal	00.00%	09.38%	00.00%	00.00%
13	Nagaland	00.00%	03.13%	00.00%	00.00%
Total		**100.00%**	**100.00%**	**100.00%**	**100.00%**

Source: Consultant Estimates based on O-D Survey Data

Observations

- The Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur, Kamrup, Assam, Arunachal, Nagaland, etc. regions/districts/states/ zones have significant influence on the project road at both the OD survey locations.

4.3.9.5 State-wise Influence Factors (PIA-Project Influence Area)

District/State-wise influence factors based on OD survey is estimated and presented in ***Table 4-13.***

Table 4-13: State-wise Influence Factors

State Shares/PIA	Passenger Vehicles	Goods Vehicles
	%age @ Alupara & Sesamiri	
Lakhimpur	11%	14%
Sonitpur	80%	66%
Kamrup	0.3%	01%
Assam	09%	13%
Arunachal	00%	05%

State Shares/PIA	Passenger Vehicles	Goods Vehicles
	%age @ Alupara & Sesamiri	
Nagaland	00%	02%
Total	**100%**	**100%**

Source: Consultant Estimates based on O-D Survey Data

Observations:

- For Passenger Traffic at Lakhimpur, Sonitpur (Tezpur), Kamrup, Assam, etc. districts/states/zones, are found very significant influence at Ghagrabasti to Hawajan Road, and very important significant influence of Assam state is observed among the others.
- For Freight Traffic at Sonitpur (Tezpur), Lakhimpur, Kamrup, Assam, Arunachal Pradesh, Nagaland, etc. districts/states/zones, are found very significant influence at Ghagrabasti to Hawajan Road, and very important significant influence of Assam state is observed among the others.
- This indicates that the growth of traffic on this project road corridor is basically dependent on the development pattern within the districts and growth of economy within the state. Moreover, the traffic along the corridor is basically local in nature and long-haul traffic is generally marginal share along the corridor.

For working out the growth rates of proposed project road, Consultant has considered the Districts & State-wise influence factors of **Alupara** & **Sesamiri** survey location.

4.3.9.6 Frequency Distribution

Frequency distribution based on OD survey at Alupara & Sesamiri locations is estimated and presented in ***Table 4-14***.

Table 4-14: Frequency Distributions on Project Road at Alupara & Sesamiri

Trip Frequency	Car / Jeep / Taxi	Mini Bus	Std. Bus	Mini LCV	LCV	2 Axle	3 Axle	MAV (> 3 Axle)
	@ Alupara							
Daily (Up/Down)	81%	00%	00%	38%	00%	00%	00%	00%
2-3 Time a Week	07%	00%	00%	25%	00%	00%	00%	00%
Once a Week	07%	00%	00%	31%	00%	00%	00%	00%
Fortnightly	02%	00%	00%	00%	00%	00%	00%	00%
Monthly	02%	00%	00%	00%	00%	00%	00%	00%
Occasionally	02%	00%	00%	06%	00%	00%	00%	00%
Grand Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**000%**	**000%**
	@ Sesamiri							
Daily (Up/Down)	74%	100%	00%	46%	25%	00%	00%	00%

Trip Frequency	Car / Jeep / Taxi	Mini Bus	Std. Bus	Mini LCV	LCV	2 Axle	3 Axle	MAV (> 3 Axle)
2-3 Time a Week	24%	00%	00%	54%	75%	00%	00%	00%
Once a Week	03%	00%	00%	00%	00%	00%	00%	00%
Fortnightly	00%	00%	00%	00%	00%	00%	00%	00%
Monthly	00%	00%	00%	00%	00%	00%	00%	00%
Occasionally	00%	00%	00%	00%	00%	00%	00%	00%
Grand Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**000%**	**000%**

Source: Consultant Estimates based on O-D Survey Data

Observations:

- For both passengers and goods vehicles at Ghagrabasti to Hawajan road, single trip (Daily) up & down are observed to be high, followed by return journey trips.
- For Commercial traffic on project road, single & return trips are observed proportionally. Few Occasionally trips are also observed.
- Maximum samples observed are Car, Mini LCV, LCV, Few Buses, etc.
- There are no freight vehicles found on this stretch.

4.3.9.7 Commodity Distribution

Location-wise, mode-wise and direction-wise Commodity distribution at Alupara & Sesamiri locations was derived from O-D data and presented in ***Table 4-15 & Table 4-16***.

Table 4-15: Mode Wise Commodity Distribution on Project Road (Alupara)

Sr. No.	Commodity Type	Mini LCV	LCV	2 Axle	3 Axle	MAV
1	Food Grains	00%	00%	00%	00%	00%
2	Food Products	08%	00%	00%	00%	00%
3	Fruit and Vegetables	00%	00%	00%	00%	00%
4	Milk & Milk Products	00%	00%	00%	00%	00%
5	Textiles and Clothing	00%	00%	00%	00%	00%
6	Petroleum Product	00%	00%	00%	00%	00%
7	Iron and Steel	08%	00%	00%	00%	00%
8	Fertilizer	00%	00%	00%	00%	00%
9	Chemical	00%	00%	00%	00%	00%
10	Lime/Lime Stone	00%	00%	00%	00%	00%
11	Minerals and Ore	00%	00%	00%	00%	00%
12	Bamboo	00%	00%	00%	00%	00%
13	Jute	00%	00%	00%	00%	00%
14	Sand/Aggregate	00%	00%	00%	00%	00%
15	Cement	00%	00%	00%	00%	00%
16	Coal/Coke	00%	00%	00%	00%	00%
17	Machine Parts/Vehicle	00%	00%	00%	00%	00%
18	Wood/Wooden Products	00%	00%	00%	00%	00%

Sr. No.	Commodity Type	Mini LCV	LCV	2 Axle	3 Axle	MAV
19	Empty	84%	00%	00%	00%	00%
20	Others	00%	00%	00%	00%	00%
Total		**100%**	**000%**	**000%**	**000%**	**000%**

Source: Consultant Estimates based on O-D Survey Data

Table 4-16: Mode Wise Commodity Distribution on Project Road (Sesamiri)

Sr. No.	Commodity Type	Mini LCV	LCV	2 Axle	3 Axle	MAV
1	Food Grains	06%	00%	00%	00%	00%
2	Food Products	06%	00%	00%	00%	00%
3	Fruit and Vegetables	03%	00%	00%	00%	00%
4	Milk & Milk Products	00%	00%	00%	00%	00%
5	Textiles and Clothing	00%	00%	00%	00%	00%
6	Petroleum Product	08%	00%	00%	00%	00%
7	Iron and Steel	00%	00%	00%	00%	00%
8	Fertilizer	00%	00%	00%	00%	00%
9	Chemical	00%	00%	00%	00%	00%
10	Lime/Lime Stone	00%	00%	00%	00%	00%
11	Minerals and Ore	00%	00%	00%	00%	00%
12	Bamboo	08%	00%	00%	00%	00%
13	Jute	00%	00%	00%	00%	00%
14	Sand/Aggregate	00%	50%	00%	00%	00%
15	Cement	00%	00%	00%	00%	00%
16	Coal/Coke	00%	00%	00%	00%	00%
17	Machine Parts/Vehicle	06%	00%	00%	00%	00%
18	Wood/Wooden Products	00%	00%	00%	00%	00%
19	Empty	62%	50%	00%	00%	00%
20	Others	00%	00%	00%	00%	00%
Total		**100%**	**100%**	**000%**	**000%**	**000%**

Source: Consultant Estimates based on O-D Survey Data

Observations:

- Major movement of Mini-LCV & LCV found on this project road. Major commodity carried along the project corridor is observed to be Food Grains, Food Products, Agriculture Vegetables/Fruits/Milk/Milk Products, etc.
- The other commodity is observed that is Bamboo, Petroleum Product, Iron and Steel, etc.
- The other considerable commodity carried along the project road is Construction Machine Parts & Material, Sand, Aggregate, Bamboo, Wood/Wooden products etc.
- Empty Vehicles are observed to high due to the return trips of loaded vehicles.

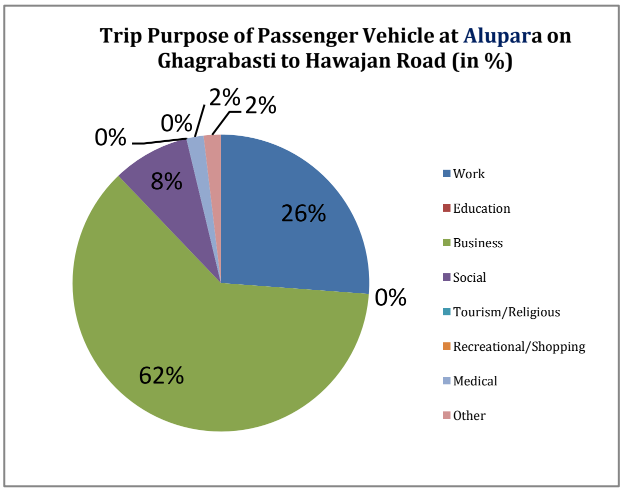
4.3.9.8 Passenger Vehicles - Trip Purpose

The purpose of trip frequency for passengers' vehicles are shown the following ***Table 4-17*** and in ***Figure 4-5***.

Table 4-17: Trip Purpose of Passenger Vehicles

Sr. No.	Trip Purpose	% Share @ Alupara	% Share @ Sesamiri
1	Work	26%	81%
2	Education	00%	08%
3	Business	62%	07%
4	Social	08%	00%
5	Tourism/Religious	00%	00%
6	Recreational/Shopping	00%	00%
7	Medical	02%	00%
8	Other	02%	04%
Total		**100%**	**100%**

Source: Consultant Estimates based on O-D Survey Data



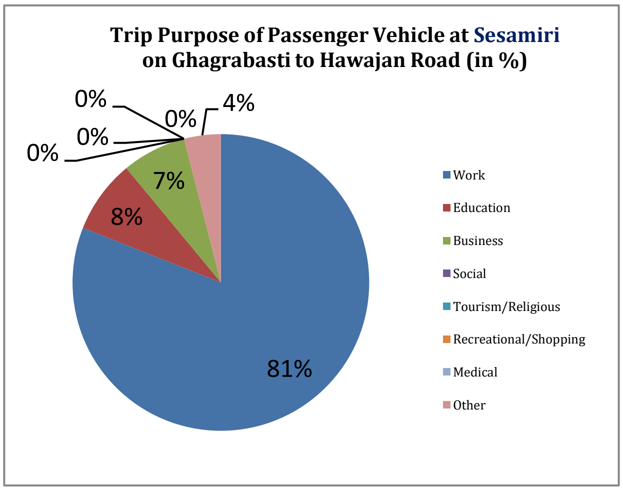


Figure 4-5: % Share of Trip Purpose of Passenger Vehicles

Observations:

- Major passenger trip purpose along the project corridor is observed to be Work and Business purpose. Social and Educational trips are also observed.
- Few Medical & Other trips samples also found.

4.3.10 Speed and Delay Survey

The survey was conducted by adopting moving car observer method. The study corridor was demarcated into single homogeneous section. The test vehicle was run at the perceptible average speed of traffic stream along the project road. The observers traveling in test car noted the journey, running & delay timings and cause of delays, if any. The test vehicle was run in one direction of the traffic stream and number of run were made in the peak/ off-peak hours. The cause and duration of stoppages and other delays were recorded. The purpose of this survey was to identify the critical locations or bottlenecks and to assess the existing level of service of traffic operations. Information collected from this survey included journey time, journey speed, vehicular delay, Causes of Delay etc.

The speed and delay survey were conducted along the entire project road. Survey was conducted in day time periods. The survey data was analyzed to assess the journey and running speeds on the entire project road. The details of survey data are presented in the bellow ***Table 4-18***.

Speed and Delay Survey on Project Road

Table 4-18: Speed and Delay Survey on Ghagrabasti to Hawajan Road

Speed & Delay Survey and Analysis of Data (on 25th January, 2020)				
DPR Road Group-3-A28: Ghagrabasti to Hawajan Road				
Sr. No.	**Start Time**	**End Time**	**Delay Time**	**Delay Reason**
1	**10:27:00**	10:27:15		Start Point - Ghagrabasti
2	10:27:15	10:27:50	0:00:35	Traffic
3	10:27:50	10:30:55		
4	10:30:55	10:33:45	0:02:50	Bridge under Construction on Solangi River / Left Turn
5	10:33:45	10:36:15		
6	10:36:15	10:38:00	0:01:45	Speed Breaker / Right Turn / Road Breakdown
7	10:38:00	10:38:50		
8	10:38:50	10:42:00	0:03:10	Left + Right Turn / Road Breakdown

Speed & Delay Survey and Analysis of Data (on 25th January, 2020)				
DPR Road Group-3-A28: Ghagrabasti to Hawajan Road				
Sr. No.	**Start Time**	**End Time**	**Delay Time**	**Delay Reason**
9	10:42:00	10:42:50		
10	10:42:50	10:44:00	0:01:10	Right + Left Turn / Road breakdown
11	0:00:00	0:00:00	0:42:20	Reverse Trip Via NH-15 to Sonarijan Wooden Bridge - Missing Link need to Extra Travel 26+800 Km and Delay Time 42:20
12	10:44:00	10:44:30	0:00:30	Road Breakdown
13	10:44:30	10:46:35		
14	10:46:35	10:46:40	0:00:05	Left Turn
15	10:46:40	10:47:15		
16	10:47:15	10:47:22	0:00:07	Right Turn
17	10:47:22	10:49:00		
18	10:49:00	10:49:30	0:00:30	Pedestrian Crossing
19	10:49:30	10:53:15	0:03:45	Market / Right Turn / Road Breakdown
20	10:53:15	10:57:00		
21	0:00:00	0:00:00	0:56:26	Bridge under Construction on Sesa River, Reverse Trip Via NH-15 to Sesa River Alupara Side to Sesa River Simaluguri End- Missing Link need to Extra Travel 26+600 Km and Delay Time 56:26
22	10:57:00	10:57:30	0:00:30	Unpaved Road
23	10:57:30	10:59:15		
24	10:59:15	10:59:25	0:00:10	Right Turn
25	10:59:25	11:00:30	0:01:05	4 Arm Junction / Right Turn /Pedestrian Crossing
26	11:00:30	11:05:10		
27	11:05:10	11:05:20	0:00:10	Traffic
28	11:05:20	11:08:50		
29	11:08:50	11:11:13	0:02:23	Road Breakdown / Railway Crossing
30	11:11:13	11:11:30		
31	11:11:30	11:13:00	0:01:30	Road Breakdown
32	11:13:00	11:13:25		
33	11:13:25	11:14:45	0:01:20	Road Breakdown
34	11:14:45	11:15:30		
35	11:15:30	11:18:00	0:02:30	Road Breakdown
36	11:18:00	11:20:10		
37	11:20:10	11:20:42	0:00:32	Road Breakdown
38	11:20:42	**11:20:42**		End Point - Hawajan
Total Travel / Journey Time				: **00 Hours 53 Minutes 42 Seconds**
Total Delay Time				: **00 Hours 24 Minutes 37 Seconds**
Actual Travel Time				: **00 Hours 29 Minutes 05 Seconds**
Length/Distance of the Road				: **24.800 Km**
Time Taken (in Hrs.)				: **00:53.42 Hrs.**
Speed (Km/Hrs.) (on Journey Time)				: **27.85 Km/Hrs.**
Speed (Km/Hrs.) (on Actual Travel Time)				: **50.44 Km/Hrs.**

Source: Consultant Estimates based on Speed & Delay Survey Data

The average journey speed along the project corridor is varying from 25 kmph to 30 kmph considering the delay and without considering the is varying from 45 kmph to 50 kmph.

4.3.11 Pedestrian and Animal Count Survey Along and Across the Road

Intensity of pedestrians crossing the project road will be used for deciding on locations requiring pedestrian facilities in the form of underpass, pedestrian crossing, skywalks, foot over bridge, ramps, etc.




Pedestrian & Animal Count Survey on Project Road

Pedestrian-vehicular conflict can be effectively studied through the indicator suggested in IRC 103-2012, ‘Guidelines for Pedestrian Facilities’. The code suggests some form of control measure at mid-blocks and intersections where the indicator PV^2 is greater than or equal to 2×10^8. Where ‘P’ is the peak hour pedestrian volume and ‘V’ is the number of vehicles in that peak hour. The analysis was undertaken separately for each of the intersection where traffic surveys were conducted. A summary of the peak values for PV^2 and the hour in which the same is observed is presented in ***Table 4-19***. The **Annexure-4.11** presented the Forecasts of Pedestrian Movements.

Table 4-19: Pedestrian-Vehicular Conflict at Ghagrabasti to Hawajan Road

Sr. No.	Location	Peak Hour	Pedestrians	Corresponding Peak Hour Vehicles	PV^2	$PV^2/10^8$	Remarks
1	00+000	14.00-15.00	138	289	11525898	0.1153	Ghagrabasti Jn
2	04+800	12.00-13.00	72	193	2681928	0.0268	Charangi Tiniali
3	09+860	08.00-09.00	287	70	1406300	0.0141	Daimalu Kakila
4	13+630	08.00-09.00	99	237	5560731	0.0556	Alupara Tiniali
5	16+760	12.00-13.00	211	610	78513100	0.7851	Simaluguri Junction
6	28+800	12.00-13.00	288	636	116494848	1.1649	Hawajan

Source: Consultant Estimates based on Pedestrian Count Survey Data

It can be seen that at all the survey locations, indicator PV^2 value is less than 2 x 10^8 of limiting value as mentioned in IRC:103. Therefore, there is no need of providing special pedestrian safety measures. However, proper traffic safety measures will be recommended at all these junction locations. Even though adequate control measures are required at all these locations for pedestrian safety. Control measures are also required, in following conditions as specified in the IRC 103:2012.

1) Approach speed of vehicles exceed 65 kmph
2) Waiting time becomes too long for pedestrian/vehicles
3) Accidents records indicate 5 or more injuries to pedestrians in a year due to collision with vehicles.

The pedestrian and animal survey count were conducted along and across the project road at major locations/junctions/inhabitants as mentioned above. Surveys were conducted in 15 minutes time interval for 12-hour time period. The details of survey counts are presented in the below ***Figure 4-6 to Figure 4-13***.

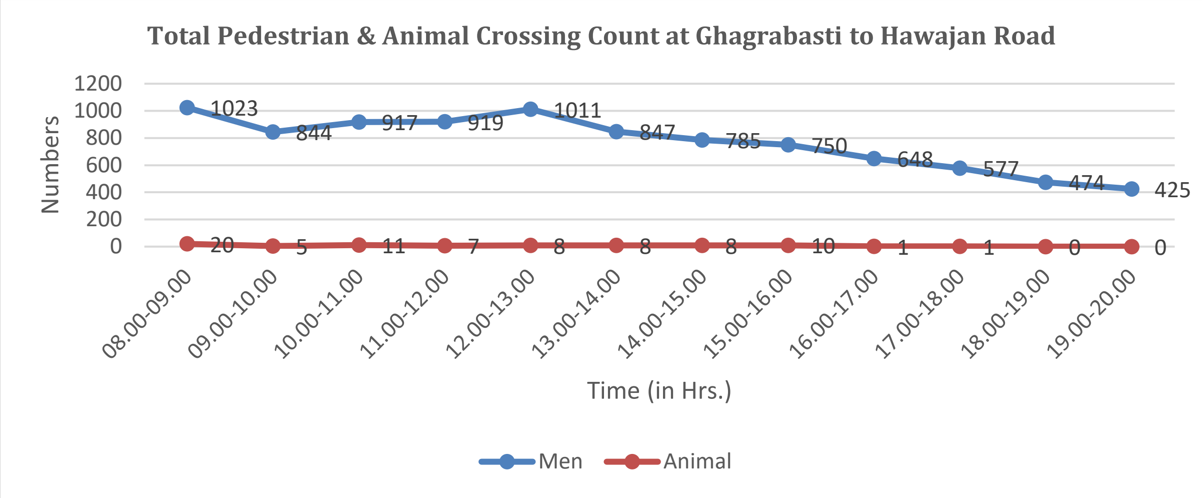


Figure 4-6: Total Pedestrian and Animal Count on Project Road

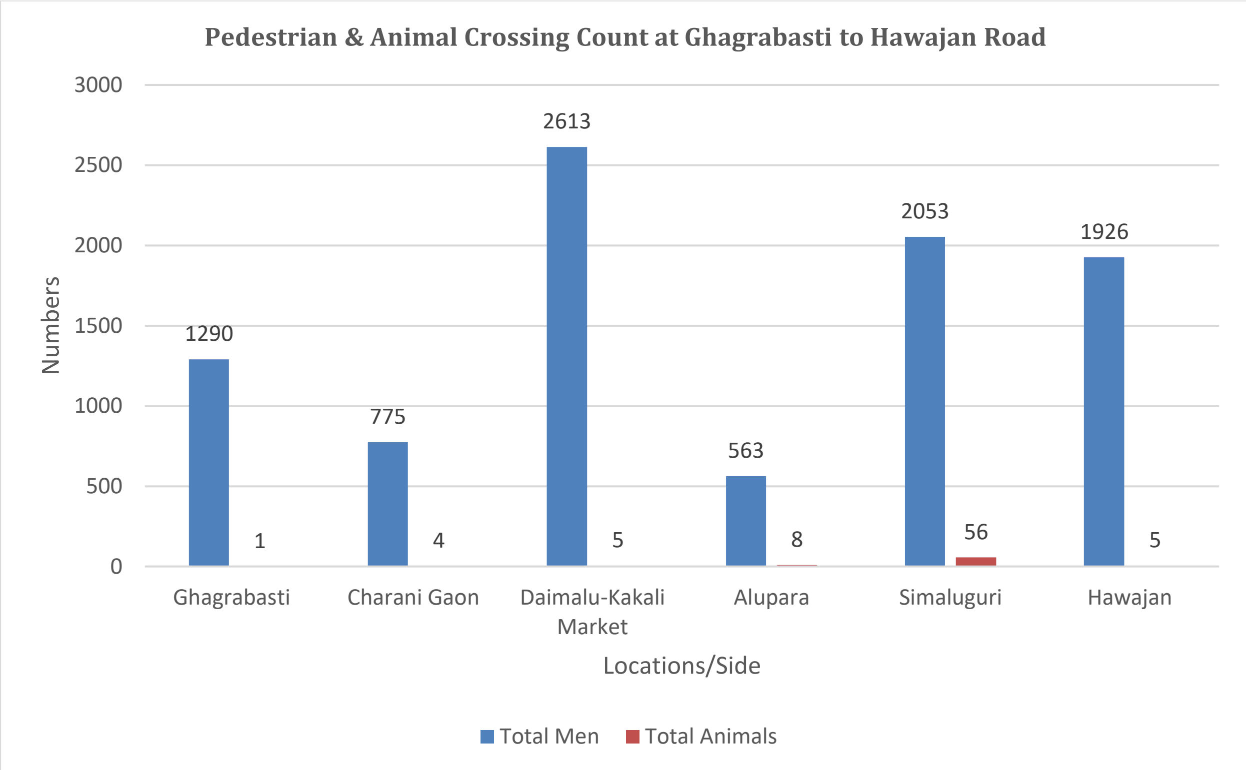


Figure 4-7: Total Pedestrian and Animal Count at Major Locations

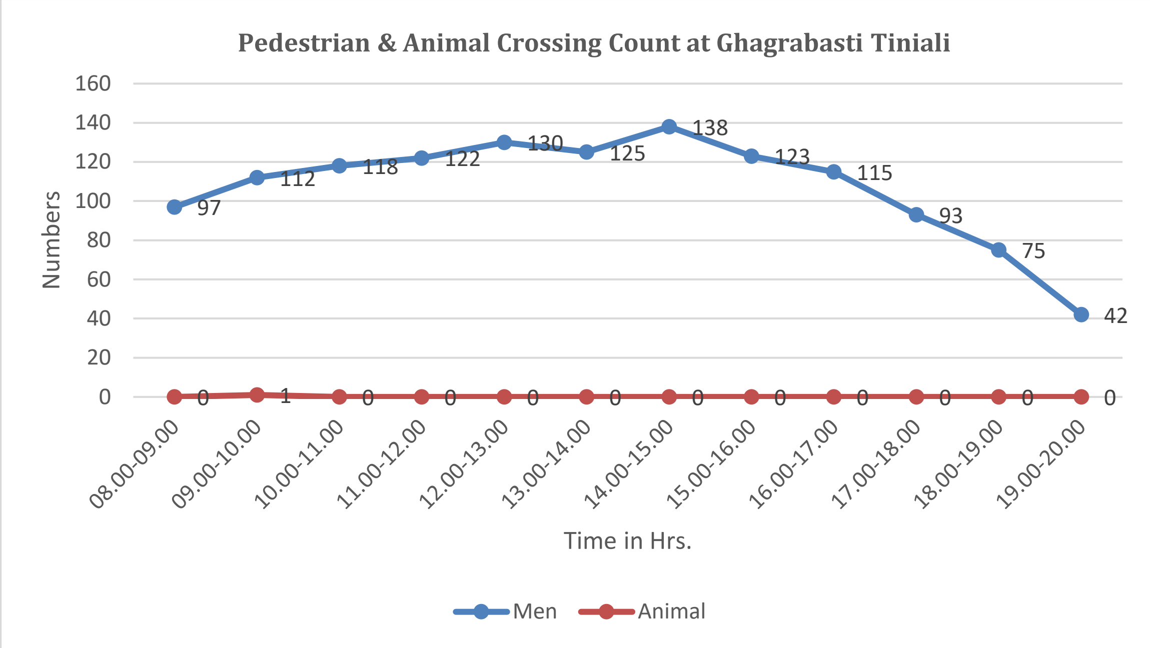


Figure 4-8: Total Pedestrian and Animal Count at Ghagrabasti Tiniali

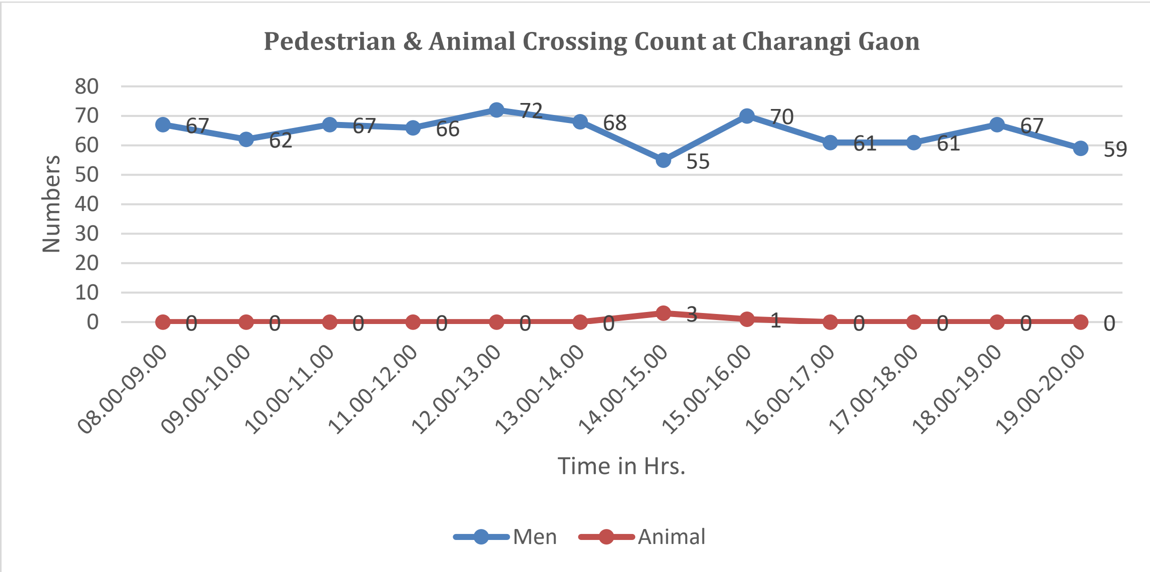


Figure 4-9: Total Pedestrian and Animal Count at Charangi Gaon

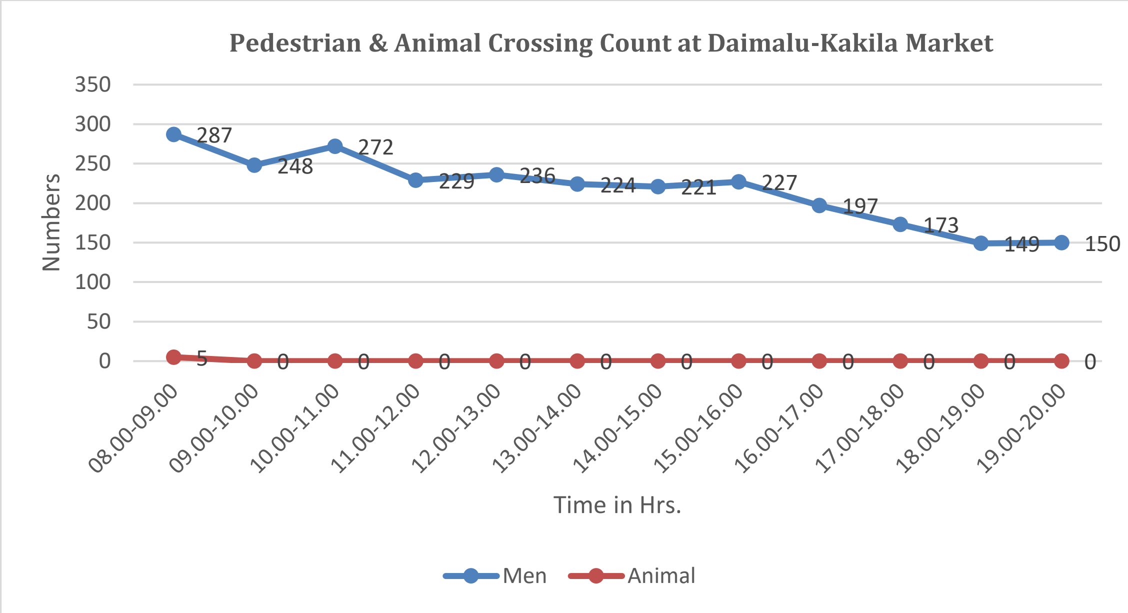


Figure 4-10: Total Pedestrian and Animal Count at Daimalu Kakila Market Junction

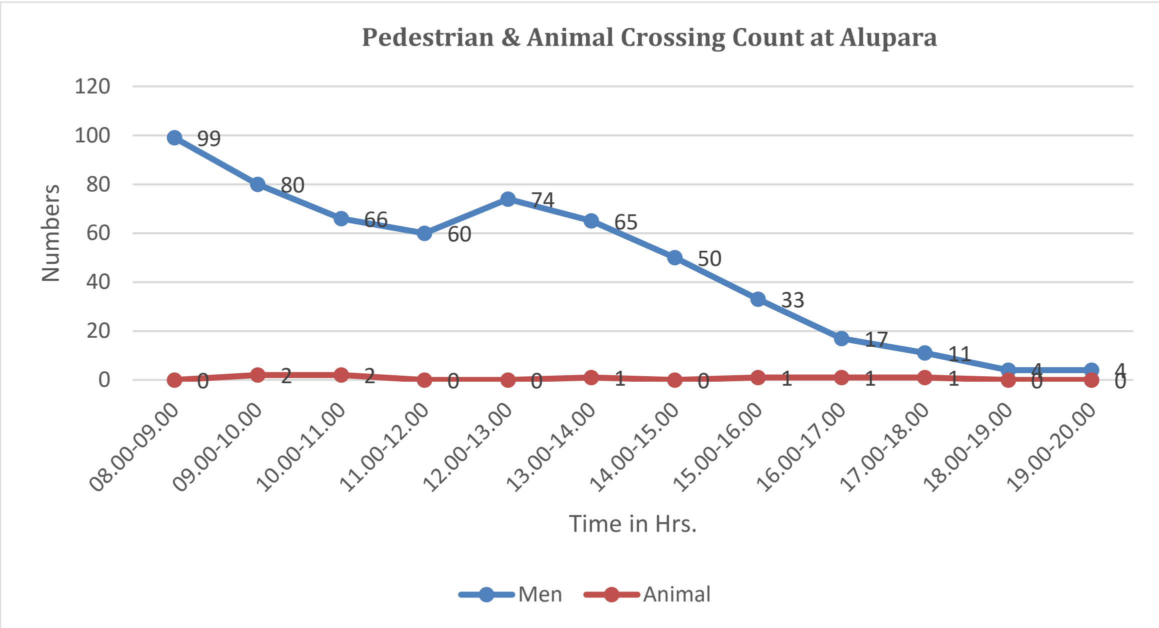


Figure 4-11: Total Pedestrian and Animal Count at Alupara Junction

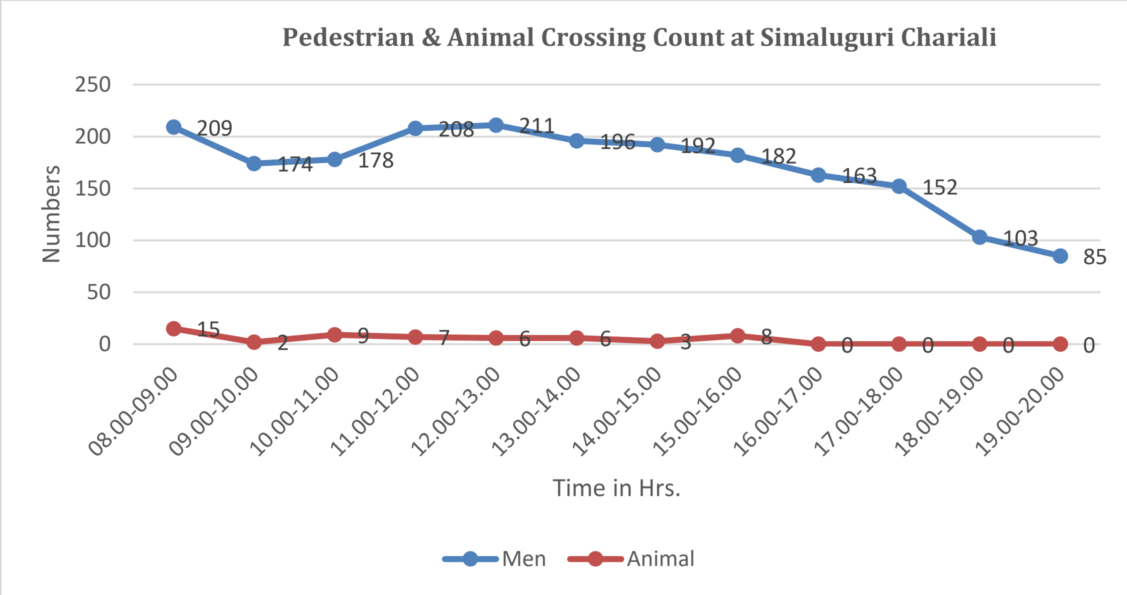


Figure 4-12: Total Pedestrian and Animal Count at Simaluguri Chariali

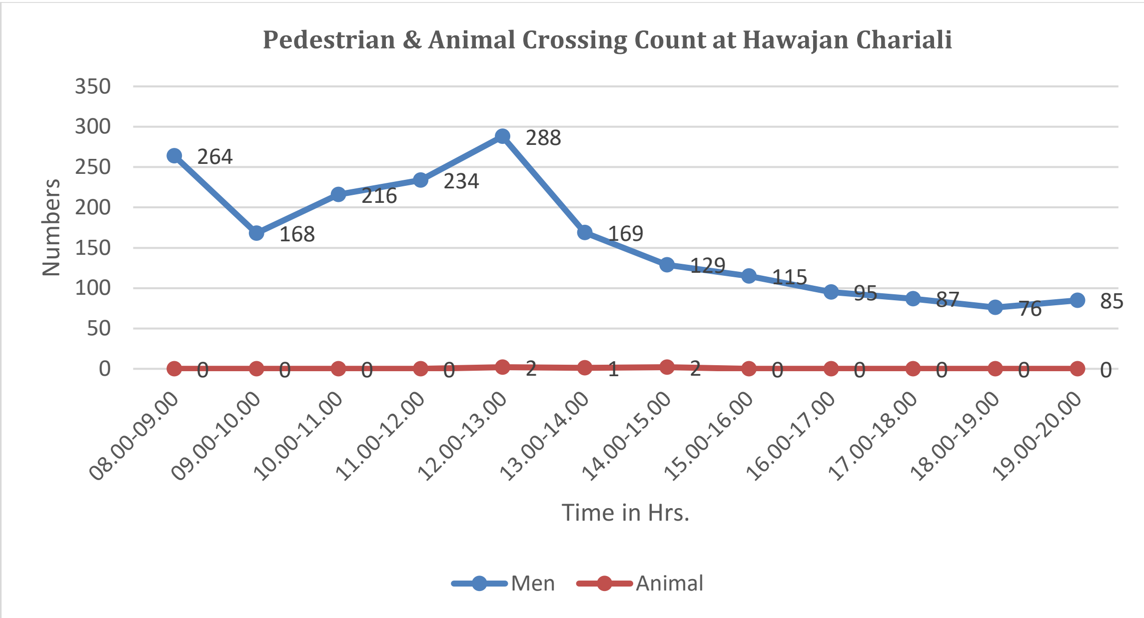


Figure 4-13: Total Pedestrian and Animal Count at Hawajan Junction

4.3.12 Parking Survey in Urban Areas

The availability of less space in urban areas has increased demand for parking space especially in central business area. The solution for this is systemic survey and management of traffic and pedestrian, is the one of the options to decongest roads and solve parking and pedestrian problems. Before taking any measures for betterment of conditioned, data regarding availability of parking space, extent of its usage and parking surveys are required to all this information. This project road has no major parking issues as it comes under the rural road. Adequate measures will be provided at the major junctions and intersections in the design and improvement proposal of the road.

4.3.13 Bus Shelters and Truck Lay Bye Surveys

A proper **Bus Bye and Bus Shelters** facilities are required for passengers' travelers to use the bus transport services for their day to day commutes along the project roads/highways. It has to be provided on both sides of the project roads/highways for each direction of travel independently. The buses have to be allowed to stop for dropping and picking up passengers only at the bus bays and bus shelters locations. The bus bay and passenger shelter have to be designed to provide for safe and convenient use by physically challenged persons as well. The bus bays and passenger shelter have to be conformed to the specifications and standards given in IRC. The number and broad location of bus shelters to be provided. The bus bays and shelters to be located only near the pedestrian movements and actual requirements locations. In hilly areas, the bus bays and shelters to be located, preferably, where the road is straight on both sides, gradients are flat and the visibility is reasonably good. The bus bay has to be provided with a shelter for passengers. The shelter has to be structurally safe and aesthetic in appearance, while also being functional so as to protect the waiting passengers adequately from sun, wind and rain. If the shelter is constructed on the till side, slopes shall be properly dressed and suitably protected to avoid slips.

Based on the survey along the project road few bus/passengers' shelters have been proposed. The existing bus shelters will be modify based on the current requirements and availability of the space.

Truck Lay Bye surveys required to provide the adequate number and size of truck lay-bye for parking of trucks by the side of the project road. There are guidelines in regard to location, size and facilities to be provided at the truck lay-byes. In general, it is to be located near check barriers, interstate borders, places of conventional stops of the truck operators, etc. The places to be identified on the basis of field survey and shall have adequate space for facilities and future growth. The truck lay-byes shall have the facilities like; Paved parking, Rest areas with toilets, Drinking water, Telephone, adequate Lighting facilities, etc.

In this proposed project road, there is no as such requirement of truck lay bye facility. Based on the traffic data it is observed that there is no requirement of truck lay bye facilities on the proposed Ghagrabasti to Hawajan road.

4.4 Estimation of Traffic Growth Rate

Traffic growth rates and projections have been carried out as per IRC-108. Traffic movement on the project road as observed from OD surveys show that, major influence of Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur (Tezpur), Kamrup, Assam, Arunachal, Nagaland, etc. districts/zones/states and Assam state is predominant. Accordingly, traffic projections have taken into consideration the transport demand arising out of future economic development in the contributing districts of Assam state.

Traffic forecast has been based on demand elasticity approach, wherein a relationship was established between traffic and socio-economic indicators. Traffic growth rates by vehicle type, for the project road corridor have been determined. The projection for future traffic involves critical analysis of some of the key Socio-economic indicators and the rate of change expected during the study period in the project influence area. These broadly include:

- Macro-Economic Scenario-Growth Rate(s) and Composition of Net State Domestic Product (NSDP) & Net District Domestic Product (NDDP), at the State and Project Influence Area (PIA level)
- PIA Economy, Sectoral Production and Potential
- PIA, Population and Urbanization
- Perspective Growth of PIA

Long term forecasting of traffic on project road during the time horizon of the study is required for highway designing and assessing the economic and financial viability of the proposed investment. For this purpose, a study of past trends in traffic growth is undertaken. However, the traffic growth rates established for this study are based on elasticity approach, wherein a relationship is established between traffic data and socio-economic indicators. The methodology thus adopted incorporates the perspective growth envisaged in the state economy and the changes in transport demand elasticities over a period of time as basic data input. It must be noted that the growth in agriculture and manufacturing sectors affect the growth of traffic in freight vehicles, while growth in income affects growth in passenger vehicles like two-wheelers, cars and buses. Traffic growth rates by vehicle type, for the project road corridor, have been determined for horizon years.

4.4.1 Past Trends in Traffic Growth & Economic Parameters

The trend growth rates for the vehicle registration data of Assam state, is worked out for various categories of vehicles. The trend analysis of vehicle registration data of Assam state gives the growth rates as presented below in ***Table 4-20*** and in ***Annexure 4-8***.

Table 4-20: Average Annual Growth Rates of Registered Vehicles

Vehicles Type	***Year 2011-12 to 2018-19***
	Assam State Growth Rates (%)
Car	09.87
Auto	09.99
Bus	12.25
Truck	09.55

Sources: Motor Transport Statistics of Assam from Year 2011-2019, Transport Statistic India-2014-MoRTH.

The trend growth rates of the economic parameters/variables namely NSDP, PCI & Population is worked out for Assam state, and the same have been presented below in ***Table 4-21.***

Table 4-21: Average Annual Growth Rates of Economic Parameters (%)

Vehicles Type	***Year 2011-12 to 2018-19***
	Assam State Growth Rates (%)
NSDP/NDDP	07.08
PCI	05.77
Population	01.23
Manufacture + Agriculture	07.54

Sources: Economic Survey of Assam (2011-2019), Directorate of Economics & Statistics, Assam, Reports (2011-2019), Central Statistics Office (MOSPI), Govt. of India, Population Census, GoI, 2011 & 2001.

4.4.2 Economic Perspective

The perspective growth rates for NSDP/NDDP are considered accordingly for Assam state and reproduced in ***Table 4-22***.

Table 4-22: Perspective Annual Growth Rates of PIA District in (%)

Period	Assam
2020-2025	6.00
2025-2030	6.25
2030-2035	5.75
2035-2040	5.50
Beyond 2040	5.50

Source: Adopted based on Economic Parameters data

4.4.3 Transport Demand Elasticity

As stated earlier, the Consultants have used elasticity approach for determining the growth rates of future traffic. This involved establishing a quantitative relationship between traffic growth as the dependent variable and growth in NSDP/NDDP or sectoral income, PCI and Population as the independent variable.

The analysis of the O-D survey data along the project corridor indicates a strong influence of Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur (Tezpur), Kamrup, Assam, Arunachal, Nagaland, etc. districts/zones/states in the traffic generation / attraction. As the traffic contribution is mainly from the Assam state, the consultants have developed the transport demand elasticity's with respect to economic indicators of respective Assam state. The methodology involved fitting log-log regression equations to the time series data.

$$\boxed{\mathbf{Log_e\, P = A_0 + A_1\, Log_e\, GNP}}$$

Where;

P = Traffic Volume

GNP = Gross National Product/NDDP/NSDP

A_0 = Regression Constant

A_1 = Regression Coefficient

The value of A_1 is known as the Elasticity Coefficient. The Elasticity Coefficient is the factor by which the GNP/NSDP/NDDP growth rate has to be multiplied to arrive at the growth rate of traffic. While PCI/NSDP/NDDP at constant prices is taken as independent variable for passenger vehicles, the combined income from agriculture and manufacturing is considered as independent variable for freight vehicles.

As regards the traffic data, the Consultants have used vehicle registration data of Assam state Project Influence Area (PIA) state to determine the transport demand elasticity with respect to economic variables namely Per Capita Income (PCI), Net State Domestic Product (NSDP) and Population for different categories of vehicles. Motor Cycles is based with PCI & Population, Cars/Auto/Bus is based with NSDP/NDDP & Population, and Trucks / Multi Axles is based on NSDP/NDDP. The following table gives the Independent Variable considered for estimating elasticity for different types of vehicles & combined Weighted Average. Elasticity values obtained are presented in ***Table 4-23*** for location as per scope of work at survey locations - @ Alupara & Sesamiri Village; the same is presented in ***Table 4-23***.

Table 4-23: Transport Demand Elasticities for Registered Vehicles (2011-2019)

Vehicle Type	Independent Variable	Combined with Weighted Average	
		Elasticity	**R2**
Motor Cycles	PCI	02.00	0.98
	NDDP	01.68	0.98
	POPULATION	10.06	0.99
Cars	PCI	01.33	0.85
	NDDP	01.13	0.88
	POPULATION	07.02	0.96
Auto	PCI	01.48	0.92
	NDDP	01.25	0.94
	POPULATION	00.00	0.00
Buses	PCI	01.88	0.86
	NDDP	01.58	0.88
	POPULATION	09.59	0.90
Trucks/ M. Axles	NDDP	01.12	0.90
	Manufacture + Agriculture	01.00	0.87

Source: As per Consultant Estimates

Future elasticity values can be related to the past values in the initial period. As regions become more and more self-sufficient, the need for long-distance transport diminishes. In line with the suggestions of the World Bank/ADB, it has been assumed that transport demand elasticity for both freight and passenger traffic tends to decline over time and approach unity and even less. The suggested elasticity values by ADB guidelines Road Development Plan-Vision 2021 India are presented in ***Table 4-24***.

Table 4-24: Suggested Elasticity Values

Year	Suggested Elasticity Values as per					
	Road Development Plan - Vision 2021			ADB Guide Lines		
	Car	Bus	Truck	Car	Bus	Truck
2001-2006	1.7	1.4	1.5	2.0	1.6	2.0
2006-2011	1.6	1.3	1.4	2.0	1.6	2.0
2011-2016	1.5	1.2	1.2	1.8	1.5	1.9
2016-2021	1.4	1.1	1.1	1.8	1.5	1.9

Source: Road Development Plan-Vision 2021 India & ADB Guidelines

Car, two/three-wheeler registration data may not reflect the ground reality since the growth of these modes is more on urban stretches than on inter-city routes. In light of the above the elasticity of these modes has been appropriately moderated for the future period. Car elasticities that have gradually declined over time will continue to decline and approach unity. Two and three-wheeler being urban and short haul passenger modes, the growth of these can be expected to be less than bus or cars on intercity routes.

Over the years there is a change in passenger movement with more and more persons shifting towards personalized modes. Moreover, the buses are usually plying on fixed pre-decided routes.

Regarding freight traffic, as mentioned earlier, a large chunk is contributed by Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur (Tezpur), Kamrup, Assam, Arunachal, Nagaland, etc. districts/zones/states. The projected elasticity values adopted in the study are presented below in ***Table 4-25*** for Survey Locations at Alupara & Sesamiri village.

Table 4-25: Projected Transport Demand Elasticities

Period	T/W	Auto	Car	Bus	LCV	2AT	3AT	MAV
2020-2025	1.18	1.16	1.13	0.98	1.12	0.92	1.11	1.12
2025-2030	1.16	1.14	1.11	0.96	1.10	0.67	1.11	1.10
2030-2035	1.11	1.09	1.06	0.91	1.05	0.42	1.06	1.05
2035-2040	1.06	1.04	1.01	0.86	1.00	0.17	1.01	1.00
Beyond 2040	1.01	0.99	0.96	0.81	0.95	-0.08	0.96	0.95

Source: As per Consultant Estimates

4.4.4 Projected Traffic Growth Rates

The projected rates of growth of traffic are based on projected vehicular elasticities and economic perspective of the PIA. The growth of passenger modes and goods mode are based on the respective vehicular elasticities and the perspective growth of the Assam state. Prediction of the future growth accurately is difficult because of the various parameters affecting growth. Based on the experience in similar projects, two more growth scenarios have been considered for studying the impact on the traffic growth rates:

- *Low Growth Rates-Pessimistic Scenario (15% less growth than Normal scenario)*
- *High Growth Rates-Optimistic Scenario (7.5% more growth than Normal scenario)*

The projected annual average rates of growth for different modes of vehicles are presented below in ***Table 4-26*** for Ghagrabasti to Hawajan Road.

Table 4-26: Projected Growth of Traffic

Period	T/W	Auto	Car	Bus	LCV	2AT	3AT	MAV
Normal Growth Scenario								
2020-2025	7.08	6.96	6.76	5.89	6.70	5.50	6.64	6.73
2025-2030	7.25	7.13	6.91	6.01	6.86	4.17	6.92	6.89
2030-2035	6.38	6.27	6.07	5.24	6.02	2.40	6.08	6.05
2035-2040	5.83	5.72	5.53	4.74	5.48	0.92	5.54	5.51
Beyond 2040	5.55	5.45	5.26	4.47	5.21	-0.46	5.26	5.24
Low Growth Scenario								
2020-2025	6.0	5.9	5.7	5.0	5.7	4.7	5.6	5.7
2025-2030	6.2	6.1	5.9	5.1	5.8	3.5	5.9	5.9
2030-2035	5.4	5.3	5.2	4.5	5.1	2.0	5.2	5.1
2035-2040	5.0	4.9	4.7	4.0	4.7	0.8	4.7	4.7
Beyond 2040	4.7	4.6	4.5	3.8	4.4	-0.4	4.5	4.5
High Growth Scenario								
2020-2025	7.6	7.5	7.3	6.3	7.2	5.9	7.1	7.2
2025-2030	7.8	7.7	7.4	6.5	7.4	4.5	7.4	7.4
2030-2035	6.9	6.7	6.5	5.6	6.5	2.6	6.5	6.5
2035-2040	6.3	6.2	5.9	5.1	5.9	1.0	6.0	5.9
Beyond 2040	6.0	5.9	5.7	4.8	5.6	-0.5	5.7	5.6

Source: As per Consultant Estimates

Traffic Growth Rates for Slow Moving Traffic / Non-Motorized Traffic (NMT)

The slow-moving vehicles essentially cater to short haul traffic, meeting localized demand for transportation of passengers and goods from rural areas in up country to the nearest market towns and urban centers. These are gradually being replaced by motorized vehicles. The slow-moving traffic is not expected to have high growth rates on MDRs/SHs/NHs. As such, slow moving traffic of animal drawn vehicles and cycle rickshaws is likely to be growing on the project road by a low growth rate of 2 percent per annum. However, the cycles are likely to increase by 2 percent per annum. This would be on account of educational, recreational (including social) and work trips.

The following ***Table 4-27*** shows the registered other vehicles data from 2010-11 to 2018-19 in Assam state for other categories of vehicles adopted as an indicative to work out the NMT growth rates.

Table 4-27: Registered Other Vehicles (2010 to 2019)

Year	Other Vehicles
2010-2011	22384
2011-2012	23347
2012-2013	23320
2013-2014	13817
2014-2015	10824
2015-2016	12187
2016-2017	12469
2017-2018	17759
2018-2019	15117
Average Growth Rates	**4.16%**

Source: Assam Motor Transport Department, Various year books 2010 to 2019

Due to non-availability of Project Influence Area (PIA) registered NMT vehicles data, other vehicles Assam state data used as an indicative to adopt the growth rates for NMT vehicles. The following ***Table 4-28*** shows the adopted NMT traffic growth rates for Ghagrabasti to Hawajan road.

Table 4-28: Adopted NMT Traffic Growth Rates (in %)

Vehicle Type	Period 1 (Up to 2025)	Period 2 (2025 to 2030)	Period 3 (2030 to 2035)	Period 4 (2035 to 2040)	Period 5 (2040 to 2045)
Animal Cart	2.16%	2.21%	1.96%	1.94%	1.55%
Bicycle	2.16%	2.21%	1.96%	1.94%	1.55%
Pedestrian	1.00%	1.00%	1.00%	1.00%	1.00%
Rickshaw	2.16%	2.21%	1.96%	1.94%	1.55%

Source: Adopted value based on Various Secondary Data & Reports of Assam Transport Dept.

The adopted NMT vehicle growth rates are at lower side as compared to the average NMT newly registered vehicle growth rates of Assam state.

4.4.5 Estimation of Corridor Traffic and Projections

Based on the traffic and travel characteristics, gathered through primary as well as secondary surveys, and the road network characteristics, the traffic that is likely to use the 2 lanes with paved shoulder road in the post project scenario was estimated. The project road traffic comprises of the following components:

- **Normal Traffic**

  Normal Traffic is the traffic which is already plying on the project road sections and continues to use the project road after improvement.

- **Induced Traffic**

  Induced Traffic represents the new traffic because of new travelers making use of the improved or new facility. The induced traffic is considered at 10% of the normal traffic in the project road.

- **Diverted Traffic**

  Diverted traffic is the traffic which would be diverted to the project road sections from the alternative routes and also the traffic which might divert away from the project road due to toll. Traffic to be diverted on the project road is considered at the rate of 10% of the normal traffic. It will be added after commencing the facilities in the year 2027-2028.

- **Developmental Traffic**

  Developmental traffic is the one which would be generated from the proposed developments in the immediate influence area of the project road and which are considered as the normal growth.

  There are many such major developments planned along the corridor. And the same consideration has made while deciding perspective growth for the region.

  This project road is potential to attract the diverted and induced traffic once it gets operational. This corridor is shorter in terms of distance to connect from Narayanpur NH15 to NH415 and further to Itanagar. This will save users time and vehicle operating cost. This corridor is also connecting to future proposed airport at Hollongi, Arunachal Pradesh state. This road will serve as a feeder route to the airport connectivity in near future.

4.4.6 Projected Traffic (for Most Likely Scenario)

Traffic projections were carried out for study period 20+3 years (2024-25 to 2046-47) by applying the estimated vehicle-wise traffic growth rates to the base year (2019) traffic.

The projected traffic volume obtained in terms of Average AADT, and its composition is shown in ***Table 4-29, Table 4-30 & Table 4-31*** for Sonarijan, Alupara & Sesamiri sections for Normal Growth Scenario.

Table 4-29: Projected Traffic at Ghagrabasti to Hawajan Road-Sonarijan (For Most Likely Scenario/Normal Growth Scenario)

Year	Two Wheelers	3 Wheelers	Car/ Vans/ Jeeps	Mini Buses	Std Buses	Tempo	LCV	2A Trucks	3A Trucks	MAT/MAV	Tractors + Trailer	Tractors	Cycle	Cyc Rick	Animal Drw	Others	Total Vehicles	Total PCUs
2024	511	84	154	0	3	32	0	14	0	0	10	7	262	0	0	0	1077	777
2025	548	90	165	0	3	34	0	15	0	0	10	7	262	0	0	0	1134	822
2026	588	96	176	0	3	36	0	16	0	0	11	8	262	0	0	0	1196	869
2027	708	116	212	0	4	44	0	19	0	0	13	10	315	0	0	0	1440	1046
2028	759	124	226	0	4	47	0	19	0	0	14	10	315	0	0	0	1519	1107

Year	Two Wheelers	3 Wheelers	Car/ Vans/ Jeeps	Mini Buses	Std Buses	Tempo	LCV	2A Trucks	3A Trucks	MAT/MAV	Tractors + Trailer	Tractors	Cycle	Cyc Rick	Animal Drw	Others	Total Vehicles	Total PCUs
2029	814	133	242	0	4	50	0	20	0	0	15	11	315	0	0	0	1605	1172
2030	866	142	257	0	4	53	0	21	0	0	16	12	315	0	0	0	1685	1233
2031	922	150	272	0	4	56	0	21	0	0	17	12	315	0	0	0	1771	1297
2032	980	160	289	0	5	60	0	22	0	0	18	13	315	0	0	0	1861	1366
2033	1043	170	306	0	5	63	0	22	0	0	19	14	315	0	0	0	1958	1438
2034	1109	181	325	0	5	67	0	23	0	0	20	15	315	0	0	0	2060	1515
2035	1174	191	343	0	5	71	0	23	0	0	21	15	315	0	0	0	2159	1589
2036	1243	202	362	0	6	74	0	23	0	0	23	16	315	0	0	0	2264	1667
2037	1315	213	382	0	6	79	0	23	0	0	24	17	315	0	0	0	2375	1749
2038	1392	226	403	0	6	83	0	24	0	0	25	18	316	0	0	0	2492	1836
2039	1473	239	426	0	7	87	0	24	0	0	27	19	316	0	0	0	2616	1928
2040	1554	252	448	0	7	92	0	24	0	0	28	20	316	0	0	0	2740	2020
2041	1641	265	471	0	7	97	0	24	0	0	29	21	316	0	0	0	2871	2116
2042	1732	280	496	0	7	102	0	23	0	0	31	22	316	0	0	0	3009	2217
2043	1828	295	522	0	8	107	0	23	0	0	33	23	316	0	0	0	3155	2324
2044	1929	311	550	0	8	113	0	23	0	0	34	24	316	0	0	0	3309	2437
2045	2036	328	579	0	9	118	0	23	0	0	36	26	316	0	0	0	3471	2556
2046	2149	346	609	0	9	125	0	23	0	0	38	27	316	0	0	0	3642	2682
2047	2269	365	641	0	9	131	0	23	0	0	40	29	316	0	0	0	3822	2814
2048	2395	384	675	0	10	138	0	23	0	0	42	30	316	0	0	0	4012	2953
2049	2528	405	710	0	10	145	0	23	0	0	44	32	316	0	0	0	4213	3100
2050	2668	427	748	0	11	153	0	23	0	0	46	33	316	0	0	0	4425	3255
2051	2816	451	787	0	11	161	0	22	0	0	49	35	316	0	0	0	4648	3418
2052	2972	475	828	0	12	169	0	22	0	0	51	37	316	0	0	0	4883	3590
2053	3137	501	872	0	12	178	0	22	0	0	54	39	316	0	0	0	5132	3771
2054	3312	528	918	0	13	187	0	22	0	0	57	41	316	0	0	0	5394	3963
2055	3495	557	966	0	13	197	0	22	0	0	60	43	320	0	0	0	5673	4166
2056	3689	588	1017	0	14	207	0	22	0	0	63	45	326	0	0	0	5971	4381

Source: As per Consultant Estimates

Table 4-30: Projected Traffic at Ghagrabasti to Hawajan Road-Alupara (For Most Likely Scenario/Normal Growth Scenario)

Year	Two Wheelers	3 Wheelers	Car/ Vans/ Jeeps	Mini Buses	Std Buses	Tempo	LCV	2A Trucks	3A Trucks	MAT/MAV	Tractors + Trailer	Tractors	Cycle	Cyc Rick	Animal Drw	Others	Total Vehicles	Total PCUs
2024	448	34	147	0	0	36	1	1	0	0	8	1	490	0	1	0	1167	753
2025	480	36	157	0	0	38	1	1	0	0	9	1	490	0	1	0	1215	788
2026	515	39	168	0	0	41	2	1	0	0	9	2	490	0	1	0	1267	826
2027	620	46	202	0	0	49	2	2	0	0	11	2	588	0	1	0	1524	994
2028	665	50	216	0	0	53	2	2	0	0	12	2	588	0	1	0	1591	1043
2029	713	53	231	0	0	56	2	2	0	0	13	2	588	0	1	0	1663	1095
2030	759	57	245	0	0	60	2	2	0	0	14	2	588	0	1	0	1730	1145
2031	807	60	260	0	0	63	2	2	0	0	15	2	588	0	1	0	1802	1197
2032	859	64	276	0	0	67	3	2	0	0	16	3	588	0	1	0	1878	1253
2033	914	68	293	0	0	71	3	2	0	0	16	3	588	0	1	0	1959	1312
2034	972	72	310	0	0	76	3	2	0	0	17	3	589	0	1	0	2045	1375
2035	1029	76	328	0	0	80	3	2	0	0	18	3	589	0	1	0	2129	1435
2036	1088	81	346	0	0	84	3	2	0	0	19	3	589	0	1	0	2217	1500
2037	1152	85	365	0	0	89	3	2	0	0	20	3	589	0	1	0	2310	1567
2038	1219	90	385	0	0	94	4	2	0	0	22	4	589	0	1	0	2409	1639
2039	1290	95	406	0	0	99	4	2	0	0	23	4	589	0	1	0	2513	1715
2040	1362	101	428	0	0	104	4	2	0	0	24	4	589	0	1	0	2618	1791
2041	1437	106	450	0	0	109	4	2	0	0	25	4	589	0	1	0	2729	1871
2042	1517	112	474	0	0	115	4	2	0	0	27	4	589	0	1	0	2846	1955
2043	1601	118	499	0	0	121	5	2	0	0	28	5	589	0	1	0	2969	2044

Year	Two Wheelers	3 Wheelers	Car/ Vans/ Jeeps	Mini Buses	Std Buses	Tempo	LCV	2A Trucks	3A Trucks	MAT/MAV	Tractors + Trailer	Tractors	Cycle	Cyc Rick	Animal Drw	Others	Total Vehicles	Total PCUs
2044	1690	124	525	0	0	127	5	2	0	0	29	5	590	0	1	0	3099	2138
2045	1784	131	553	0	0	134	5	2	0	0	31	5	590	0	1	0	3236	2237
2046	1883	138	582	0	0	141	5	2	0	0	33	5	590	0	1	0	3380	2341
2047	1988	146	612	0	0	148	6	2	0	0	34	6	590	0	1	0	3533	2451
2048	2098	154	644	0	0	156	6	2	0	0	36	6	590	0	1	0	3693	2567
2049	2214	162	678	0	0	164	6	2	0	0	38	6	590	0	1	0	3863	2689
2050	2337	171	714	0	0	173	7	2	0	0	40	7	590	0	1	0	4041	2818
2051	2467	180	751	0	0	182	7	2	0	0	42	7	590	0	1	0	4230	2953
2052	2604	190	791	0	0	191	7	2	0	0	44	7	596	0	1	0	4434	3099
2053	2748	200	833	0	0	201	8	2	0	0	46	8	608	0	1	0	4656	3256
2054	2901	211	876	0	0	212	8	2	0	0	49	8	627	0	1	0	4895	3424
2055	3062	223	922	0	0	223	9	2	0	0	51	9	652	0	1	0	5153	3604
2056	3232	235	971	0	0	234	9	2	0	0	54	9	684	0	1	0	5432	3797

Source: As per Consultant Estimates

Table 4-31: Projected Traffic at Ghagrabasti to Hawajan Road-Sesamiri (For Most Likely Scenario/Normal Growth Scenario)

Year	Two Wheelers	3 Wheelers	Car/ Vans/ Jeeps	Mini Buses	Std Buses	Tempo	LCV	2A Trucks	3A Trucks	MAT/MAV	Tractors + Trailer	Tractors	Cycle	Cyc Rick	Animal Drw	Others	Total Vehicles	Total PCUs
2024	1126	41	139	0	0	91	7	0	0	0	12	3	662	0	0	0	2080	1281
2025	1208	43	148	0	0	98	7	0	0	0	13	3	662	0	0	0	2182	1348
2026	1295	47	158	0	0	104	8	0	0	0	14	3	662	0	0	0	2292	1421
2027	1561	56	191	0	0	125	10	0	0	0	17	4	794	0	0	0	2758	1710
2028	1674	60	204	0	0	134	10	0	0	0	18	4	795	0	0	0	2899	1803
2029	1795	64	218	0	0	143	11	0	0	0	20	4	795	0	0	0	3050	1903
2030	1909	68	231	0	0	152	12	0	0	0	21	5	795	0	0	0	3193	1997
2031	2031	73	245	0	0	161	12	0	0	0	22	5	795	0	0	0	3344	2097
2032	2161	77	260	0	0	171	13	0	0	0	23	5	795	0	0	0	3506	2204
2033	2299	82	276	0	0	181	14	0	0	0	25	5	795	0	0	0	3677	2317
2034	2445	87	293	0	0	192	15	0	0	0	26	6	796	0	0	0	3859	2437
2035	2588	92	309	0	0	202	15	0	0	0	28	6	796	0	0	0	4036	2553
2036	2738	98	326	0	0	214	16	0	0	0	29	6	796	0	0	0	4223	2676
2037	2898	103	344	0	0	225	17	0	0	0	31	7	796	0	0	0	4421	2806
2038	3067	109	363	0	0	238	18	0	0	0	32	7	796	0	0	0	4630	2944
2039	3245	115	383	0	0	251	19	0	0	0	34	8	796	0	0	0	4852	3089
2040	3426	122	404	0	0	264	20	0	0	0	36	8	796	0	0	0	5075	3236
2041	3616	128	425	0	0	278	21	0	0	0	38	8	797	0	0	0	5310	3390
2042	3816	135	447	0	0	292	22	0	0	0	40	9	797	0	0	0	5558	3552
2043	4028	143	471	0	0	307	23	0	0	0	42	9	797	0	0	0	5820	3724
2044	4252	150	495	0	0	323	24	0	0	0	44	10	797	0	0	0	6096	3904
2045	4488	158	521	0	0	340	26	0	0	0	46	10	797	0	0	0	6387	4095
2046	4737	167	549	0	0	358	27	0	0	0	49	11	797	0	0	0	6695	4296
2047	5000	176	578	0	0	376	29	0	0	0	51	11	797	0	0	0	7019	4508
2048	5278	186	608	0	0	396	30	0	0	0	54	12	797	0	0	0	7361	4731
2049	5571	196	640	0	0	417	32	0	0	0	57	13	798	0	0	0	7722	4967
2050	5880	207	674	0	0	438	33	0	0	0	60	13	798	0	0	0	8102	5215
2051	6206	218	709	0	0	461	35	0	0	0	63	14	798	0	0	0	8504	5477
2052	6551	230	746	0	0	485	37	0	0	0	66	15	806	0	0	0	8935	5757
2053	6914	242	785	0	0	510	39	0	0	0	70	15	822	0	0	0	9398	6056
2054	7298	255	827	0	0	537	41	0	0	0	73	16	847	0	0	0	9894	6375
2055	7703	269	870	0	0	565	43	0	0	0	77	17	881	0	0	0	10426	6716
2056	8131	284	916	0	0	594	45	0	0	0	81	18	925	0	0	0	10995	7079

Source: As per Consultant Estimates

4.5 Capacity and Level of Service (LOS) Analysis

Capacity analysis for the project road has been carried out in order to define the Lane Configuration for the project road sections under the prevailing roadway and traffic conditions.

Capacity and Design Service Volume Guidelines: The design service volumes of two-lane highway for different types of terrain as specified by IRC: 64-1990: Capacity of Roads in Rural Areas has been presented in the ***Table 4-32***. The design service volumes adopted for determining the Level of Service are presented in ***Table 4-33***.

Table 4-32: Design Service Volume of Two-lane Highway In PCUs per Day (IRC -SP-64-1990)

Name of Terrain	Design Service Volume in PCUs per Day (LOS-B)		
	Intermediate Lane	Two Lane Without Paved Shoulder	Two Lane with Minimum 1.5 m Paved Shoulder
Plain	6000	15000	18000
Rolling	5700	11000	13000
Mountainous and Steep	5200	7000	9000

Source: As per IRC -SP-64-1990

Table 4-33: Design Service Volumes at Different Level of Services (LOS)

Level of Service	Intermediate Lane	2 Lane (2L)	2 Lane with Paved Shoulder (2L+PS)
A	3600	9000	10800
B	**6000**	**15000**	**18000**
C	8400	21000	25200
D	10200	25500	30600
E	12000	30000	36000

Source: As per IRC -SP-64-1990

Capacity Analysis: The capacity analysis of the project road was done on the basis of level of service for Ghagrabasti to Hawajan Road for Sonarijan, Alupara & Sesamiri section. The projected traffic with the corresponding Level of Service for total traffic is presented in ***Table 4-34, Table 4-35 & Table 4-36***.

Table 4-34: Projected Total Traffic in PCUs with LOS-Sonarijan

Year	Ghagrabasti to Howajan Road -Sonarijan			
	PCU	Level of Service (LOS)		
		Intermediate	2L	2L+PS
2024	777	A	A	A
2025	822	A	A	A
2026	869	A	A	A
2027	1046	A	A	A
2028	1107	A	A	A
2029	1172	A	A	A
2030	1233	A	A	A
2031	1297	A	A	A
2032	1366	A	A	A
2033	1438	A	A	A

Year	Ghagrabasti to Howajan Road -Sonarijan			
	PCU	Level of Service (LOS)		
		Intermediate	2L	2L+PS
2034	1515	A	A	A
2035	1589	A	A	A
2036	1667	A	A	A
2037	1749	A	A	A
2038	1836	A	A	A
2039	1928	A	A	A
2040	2020	A	A	A
2041	2116	A	A	A
2042	2217	A	A	A
2043	2324	A	A	A
2044	2437	A	A	A
2045	2556	A	A	A
2046	2682	A	A	A
2047	2814	A	A	A
2048	2953	A	A	A
2049	3100	A	A	A
2050	3255	A	A	A
2051	3418	A	A	A
2052	3590	A	A	A
2053	3771	B	A	A
2054	3963	B	A	A
2055	4166	B	A	A
2056	4381	B	A	A

Source: As per Consultant Estimate

As per the projected traffic volume, Ghagrabasti to Hawajan road at Sonarijan section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-A by 2052.

Table 4-35: Projected Total Traffic in PCUs with LOS-Alupara

Year	Ghagrabasti to Howajan Road -Alupara			
	PCU	Level of Service (LOS)		
		Intermediate	2L	2L+PS
2024	753	A	A	A
2025	788	A	A	A
2026	826	A	A	A
2027	994	A	A	A
2028	1043	A	A	A
2029	1095	A	A	A
2030	1145	A	A	A
2031	1197	A	A	A
2032	1253	A	A	A
2033	1312	A	A	A
2034	1375	A	A	A
2035	1435	A	A	A
2036	1500	A	A	A

Year	Ghagrabasti to Howajan Road -Alupara			
	PCU	Level of Service (LOS)		
		Intermediate	2L	2L+PS
2037	1567	A	A	A
2038	1639	A	A	A
2039	1715	A	A	A
2040	1791	A	A	A
2041	1871	A	A	A
2042	1955	A	A	A
2043	2044	A	A	A
2044	2138	A	A	A
2045	2237	A	A	A
2046	2341	A	A	A
2047	2451	A	A	A
2048	2567	A	A	A
2049	2689	A	A	A
2050	2818	A	A	A
2051	2953	A	A	A
2052	3099	A	A	A
2053	3256	A	A	A
2054	3424	A	A	A
2055	3604	B	A	A
2056	3797	B	A	A

Source: As per Consultant Estimate

As per the projected traffic volume, Ghagrabasti to Hawajan road at Alupara section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-A by 2054.

Table 4-36: Projected Total Traffic in PCUs with LOS-Sesamiri

Year	Ghagrabasti to Howajan Road -Sesamiri			
	PCU	Level of Service (LOS)		
		Intermediate	2L	2L+PS
2024	1281	A	A	A
2025	1348	A	A	A
2026	1421	A	A	A
2027	1710	A	A	A
2028	1803	A	A	A
2029	1903	A	A	A
2030	1997	A	A	A
2031	2097	A	A	A
2032	2204	A	A	A
2033	2317	A	A	A
2034	2437	A	A	A
2035	2553	A	A	A
2036	2676	A	A	A
2037	2806	A	A	A
2038	2944	A	A	A
2039	3089	A	A	A
2040	3236	A	A	A

Year	Ghagrabasti to Howajan Road -Sesamiri			
	PCU	Level of Service (LOS)		
		Intermediate	2L	2L+PS
2041	3390	A	A	A
2042	3552	A	A	A
2043	3724	B	A	A
2044	3904	B	A	A
2045	4095	B	A	A
2046	4296	B	A	A
2047	4508	B	A	A
2048	4731	B	A	A
2049	4967	B	A	A
2050	5215	B	A	A
2051	5477	B	A	A
2052	5757	B	A	A
2053	6056	C	A	A
2054	6375	C	A	A
2055	6716	C	A	A
2056	7079	C	A	A

Source: As per Consultant Estimate

As per the projected traffic volume, Ghagrabasti to Hawajan road at Sesamiri section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-B by 2052.

4.6 Justifications for 2 Lane Road with Paved Shoulders

Based on the traffic volume project will be qualify in future for the two-lane with paved shoulders road. Origin-destination data show that this project road connects/influenced to Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur, Kamrup, Assam, Arunachal, Nagaland, etc. major regions/districts/few states and also to various village roads, major district roads, state highways and national highways. Majorly it connects to NH-15, NH-52A, NH-415, NH-13, SH-43, SH-45, and MDR's. This project road also connects to the Nagaland and Arunachal Pradesh states borders. It has inter-state connectivity. This road is very much useful for intrastate and interstate passengers and freight traffic movements. The project road is also connecting to the new proposed Holongi Airport. The capacity of project road for Intermediate laning is reaching with LOS-B by 2043 with its current traffic estimates. Hence, considering all these factors it is indicated that in near future project road shall be required a 2 laning widening capacity to cater the future traffic. Therefore, it is required to taken up this project road for 2 laning widening and upgrading to ensure safe and smooth movement of traffic at higher speed.

4.7 Axle Load Survey (Vehicle Damage Factor-VDF)

Axle load survey has been carried out to analyze the loading pattern and to estimate Vehicle Damage Factor (VDF) for using in design of new pavement. The Axle load survey was carried out as per IRC: 37-2012, 2018 and IRC: 81-1997 at Ghagrabasti to Hawajan near Alupara (Ch.13+600) & Sesamiri (Ch.18+960) locations, using portable weigh pads.


Axle Load Survey Locations at Alupara (Ch. 13+600 Km) & Sesamiri (Ch. 18+960 Km)

Axle loads of LCVs, Bus, Two & Three Axle Trucks and Multi Axle Vehicles are recorded on random sampling basis. The vehicles were stopped with the help of police and the drivers were directed to stop their vehicles in such a way that wheel of each axle can be weighed using the weighing pad. The readings were recorded by trained enumerators for each axle separately. The axle load survey was carried out as per the formats provided by the client. The summary of VDF results from the Axle Load Survey is given below in ***Table 4-37 & Table 4-38***.

Table 4-37: Summary of Axle Load Survey Results (VDF)-@ Alupara

VDF @ Alupara (Ch. 13+600) location at Ghagrabasti to Hawajan Road			
Vehicle Types	**Ghagrabasti to Hawajan**	**Hawajan to Ghagrabasti**	**Max Both Direction**
Bus	0.00	0.00	0.0000
LCV	0.1851	0.0000	**0.1851**
2 Axle Truck	0.00	0.00	0.0000
3 Axle Truck	0.00	0.00	0.0000
MAV	0.00	0.00	0.0000

Source: Consultant Estimates as per Axle Load Survey

Table 4-38: Summary of Axle Load Survey Results (VDF)-@ Sesamiri

VDF @ Sesamiri (Ch. 18+960) location at Ghagrabasti to Hawajan Road			
Vehicle Types	**Ghagrabasti to Hawajan**	**Hawajan to Ghagrabasti**	**Max Both Direction**
Bus	0.00	0.00	0.000
LCV	2.21	0.03	**2.212**
2 Axle Truck	0.00	0.00	0.000
3 Axle Truck	0.00	0.00	0.000
MAV	0.00	0.00	0.000

Source: Consultant Estimates as per Axle Load Survey

4.8 Million Standard Axles (MSA)

MSA is worked out on the basis of initial traffic in terms of CVPD, traffic growth rates during the design life, design life in number of years, vehicle damage factor (VDF) and distribution of commercial traffic over the carriage way for proposed project road. The summary of MSA results is given below in ***Table 4-39***.

Table 4-39: Summary of MSA Results

MSA at Ghagrabasti to Hawajan Road (Both Directions)		
Years	**MSA @ Alupara (Ch. 13+600)**	**MSA @ Sesamiri (Ch. 18+960)**
08 years	0.001	0.04
10 years	0.001	0.05
15 years	0.001	0.09
20 years	**0.002**	**0.14**
30 Years	0.005	0.29

Source: Consultant Estimates

Based on the above analysis the recommended Vehicle Damage Factors (VDF) and Million Standard Axles (MSA) values are presented in the following ***Table 4-40***.

Table 4-40: Recommended VDF & MSA Values

Section	VDF Values	MSA Values
Ghagrabasti to Hawajan	**2.21**	**10**

Source: Consultant Estimates

4.9 Commercial Vehicles per Day (CVPD)

Based on the classified volume count traffic survey the commercial vehicles per day for the location (Alupara & Sesamiri) Ghagrabasti to Hawajan Road are calculated and CVPD for both directions at Ghagrabasti to Hawajan project road are presented in the following ***Table 4-41***.

Table 4-41: CVPD (Both Directions) on Ghagrabasti to Hawajan Road

Commercial Vehicle Per Day (CVPD) Both Directions AADT								
Location	**Year**	**Buses**	**LCV**	**2 Axle Truck**	**3 Axle Truck**	**MAV**	**Total Vehicles**	**Total PCUs**
Alupara-Ghagrabasti to Hawajan & Hawajan to Ghagrabasti (BOTH DIRECTION)	2024	00	02	01	00	00	**03**	**06**
	2027	00	02	02	00	00	**04**	**08**
Sesamiri- Ghagrabasti to Hawajan & Hawajan to Ghagrabasti (BOTH DIRECTION)	2024	00	07	00	00	00	**07**	**10**
	2027	00	10	00	00	00	**10**	**14**

Source: Consultant Estimates based on Traffic Survey

4.10 Conclusions and Recommendations

The traffic movement on the project road corridor is observed at lower level. This project road connects to the Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur, Kamrup, Assam, Arunachal, Nagaland, etc. major regions / districts / states and also to various village roads, major district roads, state highways and national highways. Majorly it connects to NH-15, NH-52A, NH-415, NH-13, SH-43, SH-45, and MDR's. This project road also has inter-state connectivity with Nagaland and Arunachal states. It has importance for interstate passengers and freight movements. The project road is also connecting to the new proposed Holongi Airport. The capacity of project road for Intermediate laning is reaching with LOS-B by 2043 with its current traffic estimates. Hence, considering all these above factors, it is recommended that project shall be taken up for 2 laning widening and upgrading to ensure safe and smooth movement of traffic at higher speed. It will also help to reduce the congestion and accidents level on the project road. It will be also beneficial to the uses for reducing journey travel time and operating cost of the vehicles. It will also help to protect the interest of pedestrian movement and animal crossing by providing the appropriate safeguard measures along the project corridor. With due considerations to all the above-mentioned points it is recommended that the project road corridor be upgraded to a 2-lane facility with shoulder.

CHAPTER 5

ENGINEERING SURVEYS & INVESTIGATION

5 Engineering Surveys & Investigation

5.1 Introduction

Engineering surveys and investigations have been carried out on the Project Road section for pavement evaluation, following the relevant Specifications/Codes to generate adequate database for preparing the most appropriate proposal for the rehabilitation / upgrading of the existing highway.

The various engineering surveys and investigations for the project road which have been carried out for the project are listed below:

- Road Inventory: Explained in Chapter 1 of Volume II of this report
- Pavement Condition Survey
- Traffic Surveys: Explained in detail in Chapter 3 of Volume I of this report
- Topographic Survey
- Roughness Survey
- Soil Investigations

5.2 Objectives

Preparation of highway projects involves a chain of activities, like field surveys & investigations, selection of alignment, carrying out various designs, preparation of drawings and estimates, etc. The objective of engineering surveys and investigations carried out on a particular project road is to provide a comprehensive set of data which is further analysed to obtain a conclusion on various aspects such as selection of the most cost-effective design, estimation of quantities, determination of pavement condition, topography of the road, etc.

To be compatible with technical requirements it is essential to carry out various engineering surveys, investigations and their Analysis. This could be achieved by carrying out the project preparation work either departmentally or with the help of consultants. In all the case, it must be ensured that experts having the required knowledge are deployed on the work. Use of modern instruments and survey techniques ensure high degree of accuracy and speeds up the work process.

5.3 Road & Structure Inventory

The road and bridge inventory have been carried out on the Project Road section for obtaining information regarding the location of the roads and bridges and its basic inventory such as Road Name, Surface Type, Road Width, Bridge Type and bridge width. Information obtained from inventory surveys signifies the data that are mostly static in nature and describes the physical element of the road system and road assets.

5.3.1 Road inventory survey

A detailed inventory of roads was carried out from 17th August 2020 to 20th August 2020 and inventory of structures were carried out from 13th November to 15th November, 2019 to prepare repair and rehabilitation proposals. The data/details of road inventory were collected, by actual verification & measurements. The following data were collected in the inventory survey.

Table 5-1: Road Inventory Data

Sr. No.	Particulars	Key Inputs
A)	**General Road Data**	
1	Terrain code	Plain, Rolling, Mountainous, Steep
2	Land Use	AG, C, BR, BU, IN, SBU, FR
3	Earthworks type	Cut, Fill, Ground level
4	Earthworks height	m
5	Width of Right of way	m
6	Surfacing type	Bitumen, Gravel, Concrete, Earthen, Paver block
7	Carriage way width	m
8	Shoulders	Left side: type, width; Right side: type, width (Paved/ Earthen)
9	Road Junctions	Type, Details
10	Drainage type	Left side: type, width; Right side: type, width (Lined/Unlined)
11	Drainage Condition	Existing Type of drain
12	Footpath Width	m
13	Median	Type and Width
B)	**Pavement Condition Survey**	
1	Pavement condition for every 100m	Cracking (Longitudinal, Transverse, Alligator, Block), Rutting, Potholes, Bleeding, Patching, Edge Cracking
C)	**Retaining structures and their condition**	
1	Roadside arboriculture	Yes / No
2	Utilities	Shifting required, if any
3	Critical structures	Nos.
4	Trees	Nos.

The codes used in the inventory are as follows:

Table 5-2: List of Road Inventory Codes

Terrain	**Land use**
P = Plain R = Rolling M = Mountainous S = Steep	AG = Agriculture C = Commercial BR = Barren Land BU = Built up Area IN = Industrial SBU = Semi built up FR = Forest
Signs	**Pavement/Carriageway**
I = Informatory R = Regulatory	B = Bituminous C = Cement Concrete

W = Warning	W = Water Bound Macadam
Median	**Road Junction**
1= Stone 2 = Steel 3 = Open 4 = Tapered	M = Multi leg junction T = T Junction R = Rotary Y = Y junction + - = 4 leg junctions
Drain Type	**Drain Condition**
E = Earth L = Lined P = Pipe	G = Good F = Fair P = Poor VP = Very Poor
Severity of Pavement Condition	**Shoulder Condition**
L – Low Severity M – Medium Severity H – High Severity	G = Good F = Fair P = Poor VP = Very Poor

Inventory Survey Results are attached in the ***Annexure 5-1: Road Inventory Survey.***

5.3.2 Inventory and condition survey of Structures

- **Condition survey of bridges & culverts**
  A project team carried out the visual condition survey of existing bridges and culverts as per guidelines stipulated in IRC-SP: 35-1990. The project team inspected all the culverts, bridges and other structures on the project road and recorded data using proforma prepared for carrying out the detailed condition survey. The deficiencies in the existing structures were noted to ascertain the measures required for strengthening of the structure.

- **Inventory survey of bridges & culverts**
  Bridge inventory surveys were carried out as per IRC SP: 19-2001. As per survey, it was found that there are 2 major bridges which are under Construction and 11 minor bridges out of which 2 are under construction present along the entire project road. The thickness of slab, span arrangement and total vent way, width of culvert, etc. was recorded in the prescribed format for culverts and other structures. List of bridges along with their configuration and inventory data for culverts and bridges has been presented in ***Annexure 5-2: Structure Inventory & Condition Assessment Survey*** at the end of the report**.**

5.4 Pavement condition surveys

5.4.1 General

Pavement Investigation is an important aspect of any highway improvement project, since the performance of highway directly depends on the performance of its pavement and the cost of improvement of pavement is equally important to arrive at the cost of project. The data collected in the survey is an important factor in economic analysis as it has an influence upon vehicle operating costs and is utilized to identify the stretches of reconstruction and rehabilitation. Detailed Pavement Condition Survey was carried out along the entire project road from 17th August 2020 to 20th August, 2020.

5.4.2 Survey Procedure

We carried out visual pavement condition survey/Road Inventory Survey on the project road to examine the functional efficiency of the existing pavement. Condition survey data have been collected at every 50 m interval with the help of straight edge and measurement scale for main carriageway and paved shoulder.

Based on the above site condition, the pavement condition analysis is carried out separately for main carriageway and earthen shoulder.

5.4.3 Major Distresses observed

The general characteristics of pavement distresses observed during the survey of the project road corridor are presented below. Poor workmanship is also a key factor contributing to the pavement failure at many sections of the project road.

- Alligator Cracking
- Longitudinal & Transverse Cracking
- Rutting
- Block Cracking
- Patching
- Raveling
- Bleeding
- Shoulder Drop off
- Edge Crack

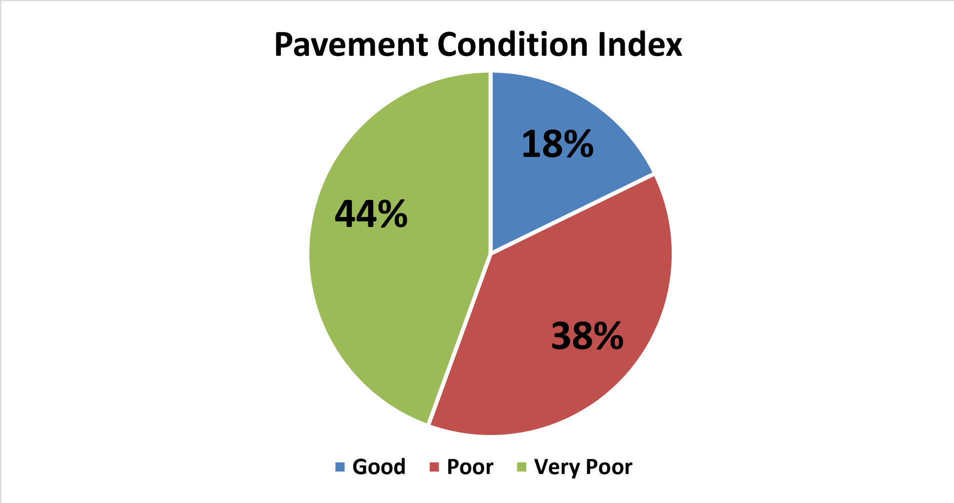
5.4.4 Pavement Condition Rating

5.4.4.1 Data Analysis

The key component of an effective pavement management system is an accurate assessment of the condition of the existing pavement network. The surface cracking of a pavement is represented by a Surface Rating and Dominant Distress for each section of the pavement network. Pavement condition Rating (PCR) is an indicator that rates the surface condition of the pavement. It is built based on visual inspection of road section. The survey for the project road was conducted on foot in order to map the type and extent of distresses in detail. The root causes of these distresses must be addressed in any comprehensive rehabilitation strategy PCR is used to quantify the road condition. A properly executed visual evaluation is one of the most reliable and efficient forms of pavement evaluation available. It is simple, inexpensive, and provides a great deal of valuable information about pavement condition. This method provides a comprehensive record of pavement distresses at the time of the evaluation and are highly repeatable. A visual inspection of the pavement surface can provide valuable information. Visual inspection data is used to evaluate current pavement condition, predict future pavement performance, determine and prioritize pavement maintenance and rehabilitation needs, estimate repair quantities, and evaluate the performance of different maintenance and rehabilitation techniques and materials. All the distress along the project roads were noted and mentioned in the Road Inventory Survey.

5.4.4.2 Pavement Condition

Pavement Condition of the project road was determined through visual pavement condition survey. The result of the survey is presented in ***Annexure 5-1: Road Inventory Survey*** and summary is presented in ***Figure*** 5-1***.***



Source: Road Inventory Survey

Figure 5-1: Pavement Condition Summary

From road inventory surveys as well as reconnaissance surveys, the road surface seems to be in poor condition. However, it can be easily identified that the existing pavement layer beneath the bituminous surface is undergoing distress. Due to absence of the most important granular subbase layer and non-treatment of the existing pavement layer, the distress will appear on the bituminous surface in due course of time. After Field observation, it is recommended to go for reconstruction with GSB and new pavement layer.

5.4.4.3 Photographs of Distresses

The following pictures give us an insight on the prevalent pavement condition.

5.4.4.3.1 Raveling

Raveling is due to wearing away from the pavement surface caused by the loss of asphalt binder and dislodged aggregate particles.

Figure 5-2: Raveling along Project Road

5.4.4.3.2 Potholes

The potholes are small (usually less than 3 feet in diameter), bowl-shaped depressions in the pavement surface. They generally have sharp edges and vertical sides near the top of the hole. The densities of potholes vary from Low to High Severity, but high severity cracks are lesser.

Figure 5-3: Potholes along Project Road

5.4.4.3.3 Edge Failure

Edge cracks are parallel to and usually within 1 to 2 feet of the outer edge of the pavement. This distress accelerated by traffic loading and can be caused by a frost-weekend base or sub grade near the edge of the pavement.

Figure 5-4: Edge Failure along Project Road

5.4.5 Highly Distressed Sections along the Project Road

The following figure shows the highly distress road along the project corridor respectively.

Figure 5-5: Photo of Highly Distressed Road along the stretch

5.4.6 Shoulders

5.4.6.1 Condition of Paved Shoulders

There are no paved shoulders along the entire project road stretch.

5.4.6.2 Condition of Earthen Shoulder

The condition of the earthen shoulders observed during road inventory survey varies between good to very poor.

From the overall PCI value of the corridor, it was understood that at some locations the condition of pavement is good, but to maintain the uniformity and as advised during kick off and other various meetings, the entire length of the corridor was identified for ***reconstruction using Flexible pavement.***

5.5 Axle Load Survey (Vehicle Damage Factor-VDF)

Axle load survey has been carried out to analyze the loading pattern and to estimate Vehicle Damage Factor (VDF) for use in design of new pavement. The Axle load survey was carried out as per IRC: 37-2012, 2018 and IRC: 81-1997 at Ghagrabasti to Hawajan near Alupara (Ch.13+600) & Sesamiri (Ch.18+960) locations, using portable weigh pads.

Figure 5-6: Axle Load Surveys at Alupara (Ch. 13+600 Km) & Sesamiri (Ch. 18+960 Km)

Axle loads of LCVs, Bus, Two & Three Axle Trucks and Multi Axle Vehicles are recorded on random sampling basis. The vehicles were stopped with the help of police and the drivers were directed to stop their vehicles in such a way that wheel of each axle can be weighed using the weighing pad. The readings were recorded by trained enumerators for each axle separately. The axle load survey was carried out as per the formats provided by the client. The summary of VDF results from the Axle Load Survey is given below in **Table 5-3** and ***Table* 5-4.**

Table 5-3: Summary of Axle Load Survey Results (VDF)-@ Alupara

VDF @ Alupara (Ch. 13+600) location at Ghagrabasti to Hawajan Road			
Vehicle Types	**Ghagrabasti to Hawajan**	**Hawajan to Ghagrabasti**	**Max Both Direction**
Bus	0.00	0.00	0.0000
LCV	0.1851	0.0000	**0.1851**
2 Axle Truck	0.00	0.00	0.0000
3 Axle Truck	0.00	0.00	0.0000
MAV	0.00	0.00	0.0000

Source: Consultant Estimates as per Axle Load Survey

Table 5-4: Summary of Axle Load Survey Results (VDF)-@ Sesamiri

VDF @ Sesamiri (Ch. 18+960) location at Ghagrabasti to Hawajan Road			
Vehicle Types	**Ghagrabasti to Hawajan**	**Hawajan to Ghagrabasti**	**Max Both Direction**
Bus	0.00	0.00	0.000
LCV	2.21	0.03	**2.212**
2 Axle Truck	0.00	0.00	0.000
3 Axle Truck	0.00	0.00	0.000
MAV	0.00	0.00	0.000

Source: Consultant Estimates as per Axle Load Survey

The VDF value of 2 Axle categories of vehicles are observed higher due to movements of the Food Grains & Food products, Wood & Wooden products, Jute, etc. heavy and bulky commodities along the project road corridor.

5.5.1 Million Standard Axles (MSA)

MSA is worked out on the basis of initial traffic in terms of CVPD, traffic growth rates during the design life, design life in number of years, vehicle damage factor (VDF) and distribution of commercial traffic over the carriage way for proposed project road. The summary of MSA results is given below in **Table** 5-5**.**

Table 5-5: Summary of MSA Results

MSA at Ghagrabasti to Hawajan Road (Both Directions)		
Years	**MSA @ Alupara (Ch. 13+600)**	**MSA @ Sesamiri (Ch. 18+960)**
08 years	0.000	0.03
10 years	0.001	0.04
15 years	0.001	0.07
20 years	**0.002**	**0.11**
30 Years	0.004	0.22

Source: Consultant Estimates

Based on the above analysis the recommended Vehicle Damage Factors (VDF) and Million Standard Axles (MSA) values are presented in the following ***Table 2-4***.

Table 5-6: Recommended VDF & MSA Values

VDF Values	MSA Values
2.21	**10**

Source: Consultant Estimates

5.5.2 Commercial Vehicles per Day (CVPD)

Based on the classified volume count traffic survey the commercial vehicles per day for the location (Alupara & Sesamiri) Ghagrabasti to Hawajan Road are calculated and CVPD for both directions at Ghagrabasti to Hawajan project road are presented in the ***Table*** 5-7***.***

Table 5-7: CVPD (Both Directions) on Ghagrabasti to Hawajan Road

Commercial Vehicle Per Day (CVPD) Both Directions AADT							
Location	**Buses**	**LCV**	**2 Axle Truck**	**3 Axle Truck**	**MAV**	**Total Vehicles**	**Total PCUs**
Alupara-Ghagrabasti to Hawajan & Hawajan to Ghagrabasti (BOTH DIRECTION)	00	01	01	00	00	**02**	**05**
Sesamiri- Ghagrabasti to Hawajan & Hawajan to Ghagrabasti (BOTH DIRECTION)	00	05	00	00	00	**05**	**08**

Source: Consultant Estimates based on Traffic Survey

5.6 Topographic survey

The main objective of the topographic survey is to capture the essential ground features at the study areas for working out improvements. Before starting topographic survey all the survey instruments were checked for errors and approved by the site engineer.

The surveyor was maintaining a field book in which all relevant observations would be noted along with field sketches. The methodology followed for the topographic surveys are the following.

- Identification of suitable location for DGNSS Control Points at an approximate interval of 5.00 km.
- Establishing survey networks by conducting horizontal and vertical traverse connecting all DGNSS Control Pillars. Ensuring survey networks are connected with an accuracy of 1:20,000 for horizontal and 12√K for vertical control.
- Conducting detailed topographic survey including longitudinal section at every 25m intervals and cross section at 50m intervals for a width of 30m on either side of the center line of the existing road.
- Collection of details of all physical features for a width of 30m or up to first row of buildings.

5.6.1 Detailed Topographic Survey

Topographic survey was commenced only after establishing the survey network and coordinates systems. Detailed survey was carried out generally up to a distance of 30 m on either side from the center of the existing road or building lines on either side of the center line of the existing road.

Landside features given below, but not limited to, were captured and presented in drawings.

- Electrical poles and lines, telephone pole and lines, high tension lines and towers, mast, transformers, water pipe lines above ground, manholes, and all OFC lines are shown in drawing.
- Locations where transmission lines cross the road are identified recorded and presented in the drawing. Elevation of transmission lines crossing the road was established.
- Tree position and girth of trees are measured.
- Building lines, type of buildings (kutcha / semi pucca / pucca / shops / houses etc.), wherever possible are captured.

- Existing road pavement edges, shoulders, median, center line of carriageway, footpaths, side drains, km / hectometer stones installed in earthen shoulder.
- Location of traffic islands, median, channelizing islands, traffic signals, traffic signs and police chokes with its locations.
- Places such as temples, temple mast, mosque, church, etc.; its location, boundary lines/compound walls, and entrances.
- Locations and width of drain clearly identify the type (open / closed / kutcha /pucca, with footpath), including the beginning and end of drain.
- Residential, commercial, shops and business established areas.
- All existing structures along the Project Corridor – including location, width of flyover / bridge / culvert (width of slab or diameter of pipe), position of piers / abutments, bed level, culvert, type of culvert, head wall, parapet etc. if available.
- High tension towers, transformers, lamp posts.
- Details of roads crossing the Project Corridor. All minor and major intersections were surveyed for 100m from the edge of existing road.
- For existing Road, the following details were collected
    - At center line of existing carriageways
    - Edges of carriageways
    - Median edges – top and bottom
    - Paved shoulder/ Earthen shoulder/Footpath edges
    - Top and toe of embankment
- For Culverts
    - Type of culvert, size of vent, span, soffit level of culvert

5.6.2 Generation of Topographic Drawing

While preparing the drawings, it was ensured that all lines are in 3D. All the topography features, reference pillars indicating complete details such as DGNSS control points, secondary control pillars and co-ordinates etc., were mentioned in the drawing. All key features captured in the survey were described with specified text height and style in the drawing.

5.7 Pavement investigation

The project road has been proposed for Widening and Strengthening to two lanes with paved shoulder. Hence, the project road has been investigated subjectively as well as objectively, for their structural and functional performance. The various surveys/ investigations of the pavement are discussed below:

- Roughness Survey
- Test pit Investigations

5.7.1 Road Roughness Survey

5.7.1.1 General

Roughness is an overall indicator of the quality of a pavement at a particular point of time and it adversely affects not only the vehicle riding quality but also the road user costs. Therefore, roughness surveys were conducted on the proposed project road using Bump Integrator to know the condition of existing pavement and to identify the maintenance requirements. Roughness data was also used to identify the homogenous sections for conducting Benkelman Beam Deflection studies which is further used to design the overlay on existing pavement.

5.7.1.2 Procedure

Roughness for the project road is measured using vehicle-mounted Bump Integrator or towed fifth wheel Bump Integrator in accordance with IRC: SP-16:2004 "Guidelines for Surface Evenness of Highway Pavements". Roughness survey was conducted on the project road stretch on 31st February 2020.

Figure 5-7: Roughness Survey at Ghagrabasti to Hawajan

5.7.1.3 Analysis

The condition of the pavement will be rated from 'Very Poor' to 'Good' based on the roughness value. The maximum Permissible values of roughness are given in **Table** 5-8**.**

Table 5-8: Maximum Permissible Values of Roughness (mm/Km)

Sr. No.	Type of surface	Condition of road surface			
		Good	Fair	Poor	Very Poor
1	Bituminous	<2000	2000-3000	3000-6000	>6000
2	Cement Concrete	<2200	2200-3000	3000-4000	>4000

Source: IRC: SP: 30-2009

5.7.1.3.1 International Roughness Index (IRI)

The following equation will used for the conversion of Bump Integrator Roughness to International Roughness Index.

$$BI=630 \times IRI^{1.12}$$

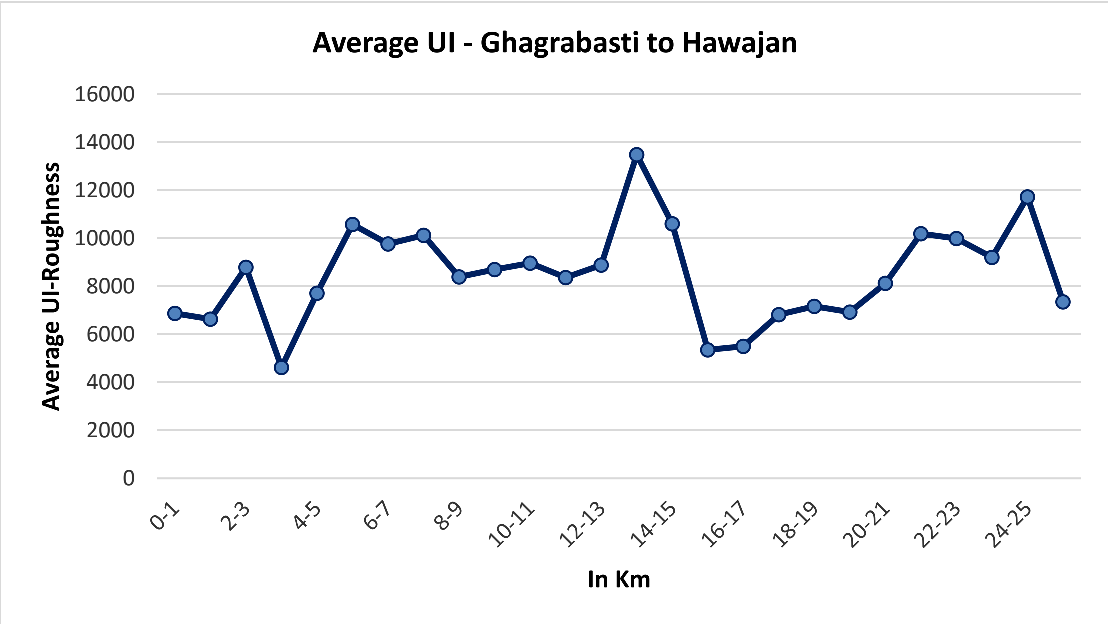
Where, IRI = International Roughness Index,

BI = Bump Indicator Roughness in mm/km

Table 5-9: Summary of Roughness Values of Project Road

Particular	Roughness Value	IRI	Condition
Maximum	13478	17	Very Poor
Minimum	4623	4	Poor
Average	8491	9	Very Poor

Source: As per Actual Roughness Survey



As per the roughness survey, the overall condition of the pavement is **"Very Poor".** The detailed roughness index is presented in ***Annexure 5-3: Roughness Survey.***

5.7.2 Test Pit Investigations

5.7.2.1 General

The objective of the investigations is to understand the composition and characteristics of the existing pavement subgrade and the scope of work includes:

- Study of Pavement Composition
- Study for existing Base Course & Sub Base Course
- In-Situ Density at Sub grade
- Dynamic Cone Penetrometer Test at Sub grade Level.
- Collection of Sub grade Samples for Laboratory Test

Some of the photographs of the tests conducted on the project road site are mentioned below in ***Figure*** 5-8***.***

Figure 5-8: Test Pit Investigations

5.7.2.2 Existing Pavement Composition

The existing pavement crust thicknesses for carriageway is recorded during the trail pits conducted for soil investigation survey and the details of the pavement composition is shown in ***Table*** 5-10***.***

Table 5-10: Crust Composition along the Project Road

Sr. No.	Field Work Chainage (km)	SIDE	Thickness of Pavement Crust Layer Composition (mm)		
			Surface Course (Bitumen)	Granular Base (WBM/WMM)	Total Thickness
1	0+500	LHS	20	60	80
2	1+500	RHS	20	50	70
3	2+500	LHS	200(P.B.)	-	200
4	3+500	RHS	200(P.B.)	-	200
5	4+500	LHS	20	50	70
6	5+500	RHS	20	80	100
7	6+500	LHS	30	70	100
8	7+500	RHS	-	30	30

Sr. No.	Field Work Chainage (km)	SIDE	Thickness of Pavement Crust Layer Composition (mm)		
			Surface Course (Bitumen)	Granular Base (WBM/WMM)	Total Thickness
9	8+500	RHS	-	30	30
10	9+500	LHS	-	-	-
11	10+500	LHS	-	60	60
12	11+500	RHS	-	40	40
13	12+500	LHS	-	70	70
14	13+500	RHS	-	-	-
15	14+500	LHS	150(P.B.)	-	150
16	15+500	RHS	150(P.B.)	-	150
17	16+500	LHS	30	80	110
18	17+500	RHS	-	60	60
19	18+500	LHS	20	80	100
20	19+500	RHS	20	120	140
21	20+500	LHS	-	120	120
22	21+500	RHS	20	90	110
23	22+500	LHS	20	50	70
24	23+500	RHS	25	80	105
25	24+500	LHS	20	60	80
26	25+500	RHS	20	60	80

Source: Pavement Investigation Survey

5.7.2.3 Details of the Test carried out

The details of all the tests carried out on subgrade for their Physical, Strength and Stability Characteristics are given in ***Table* 5-11*.***

Table 5-11: Different Tests carried out on Subgrade Soil

Sr. No.	Test Parameters	Method Reference
1	Dynamic Cone Penetration (DCP)	ASTM-D6951-03
2	Field Density	IS:2720 (Part 28)
3	Water Content	IS:2720 (Part 2)
4	Grain Size Analysis	IS:2720 (Part 4)
5	Atterberg Limits	IS:2720 (Part 5)

Sr. No.	Test Parameters	Method Reference
6	MDD-OMC(Compaction)	IS:2720 (Part 8)
7	CBR	IS:2720 (Part 16)
8	Free Swell Index	IS:2720 (Part 40)

The objective of the investigations is to understand the composition and characteristics of the existing soil:

- In-Situ Density of soil
- Characterization (Grain Size Distribution and Atterberg limit)
- Laboratory CBR
- Moisture-Density Characteristics

The results of the various lab tests conducted on the samples collected from trail pits (from existing subgrade pit) is shown in ***Table*** 5-12***.***

Table 5-12: Soil Investigations Test Results

Location km	Side	Nature of soil (Visual Identification)	Soil Classification as per IS 1498	FSI (%)	Sieve analysis % by weight passing			Sand Content (col. 7 Col. 9) (%)	Atterberg limits			Max. Dry density gm/cc.	OMC (%)	Field dry density at subgrade level (for existing roads on new roads in cutting	CBR of remolded soil sample tested without soaking	CBR of remolded soil sample soaked in water for 4 days	Remark
					4.75 mm sieve	0.425 mm sieve	Silt & clay		(LL) (%)	(PL) (%)	(PI) (%)						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ghagrabasti to Hawajan																	
0+500	LHS	Sandy Soil	SM-SC	12.50	95.02	58.86	42.55	52.47	26.60	20.48	6.12	1.990	9.80	1.908	10	7	
1+500	RHS	Sandy Soil	SC	6.67	94.76	83.47	39.28	55.48	27.80	18.47	9.33	1.980	8.60	1.895	12	8	
2+500	LHS	Sandy Soil	SC	7.69	85.63	35.48	22.76	62.87	24.80	16.47	8.33	1.998	8.75	1.915	9	6	
3+500	RHS	Sandy Soil	SM-SC	11.11	91.40	71.05	43.30	48.10	28.10	21.33	6.77	1.938	11.00	1.854	7	6	
4+500	LHS	Sandy Soil	SC	10.00	95.85	87.07	37.33	58.52	25.90	18.55	7.35	1.838	13.60	1.760	13	11	
5+000	RHS	Sandy Soil	SM	7.14	92.38	84.54	36.79	55.59	27.10	23.24	3.86	1.904	12.80	1.825	8	8	
6+000	LHS	Sandy Soil	ML-CL	12.50	96.67	91.22	55.10	41.57	28.50	22.00	6.50	1.924	13.80	1.841	7	4	
7+000	RHS	Sandy Soil	SC	7.69	93.49	81.28	40.43	53.06	25.80	18.33	7.47	1.813	11.10	1.735	12	7	
8+000	RHS	Sandy Soil	ML-CL	9.09	99.91	99.59	56.12	43.79	28.90	22.56	6.34	1.978	14.20	1.891	8	5	
9+000	LHS	Sandy Soil	SM-SC	8.33	96.16	90.38	48.56	47.60	27.30	21.45	5.85	1.900	11.30	1.820	12	8	
10+000	LHS	Sandy Soil	SC	7.14	96.46	89.67	40.21	56.25	25.70	18.32	7.38	1.816	11.80	1.740	14	10	
11+500	RHS	Sandy Soil	SM	6.67	97.28	92.44	35.72	61.56	27.50	23.54	3.96	1.912	11.80	1.831	14	10	
12+500	LHS	Sandy Soil	SM-SC	8.33	98.77	93.58	46.61	52.16	28.10	21.13	6.97	1.905	10.60	1.822	14	10	
13+500	RHS	Clayey Soil	CL	20.83	99.94	99.19	76.96	22.98	31.25	20.55	10.70	1.914	8.80	1.835	8	5	

Location km	Side	Nature of soil (Visual Identification)	Soil Classification as per IS 1498	FSI (%)	Sieve analysis % by weight passing			Sand Content (col. 7 Col. 9) (%)	Atterberg limits			Max. Dry density gm/cc.	OMC (%)	Field dry density at subgrade level (for existing roads on new roads in cutting	CBR of remolded soil sample tested without soaking	CBR of remolded soil sample soaked in water for 4 days	Remark
					4.75 mm sieve	0.425 mm sieve	Silt & clay		(LL) (%)	(PL) (%)	(PI) (%)						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
14+500	LHS	Clayey Soil	CL	15.38	99.30	93.65	61.24	38.06	29.50	20.06	9.44	1.938	12.60	1.856	6	5	
15+500	LHS	Sandy Soil	SC	9.68	98.87	93.48	40.55	58.32	27.40	18.36	9.04	1.805	9.60	1.738	13	8	
16+500	RHS	Sandy Soil	SM-SC	13.33	98.58	90.63	49.58	49.00	28.90	22.54	6.36	1.998	9.70	1.912	9	5	
17+500	RHS	Clayey Soil	CL	10.00	99.21	92.45	61.86	37.35	31.30	19.56	11.74	1.938	12.60	1.857	6	4	
18+500	LHS	Sandy Soil	SM-SC	7.14	98.56	91.37	45.12	53.44	26.90	19.96	6.94	1.896	9.40	1.817	9	6	
19+500	LHS	Sandy Soil	SM-SC	9.68	97.56	93.13	46.42	51.14	27.50	20.54	6.96	1.938	10.02	1.852	8	6	
20+500	RHS	Sandy Soil	SM-SC	12.50	98.65	92.47	43.15	55.50	26.20	20.21	5.99	1.903	10.00	1.822	14	11	
21+500	LHS	Sandy Soil	SM	12.50	99.86	97.27	41.06	58.80	25.20	22.62	2.58	1.840	10.00	1.761	15	13	
22+500	RHS	Sandy Soil	SM	8.33	98.67	93.55	39.44	59.23	25.40	21.44	3.96	1.820	9.60	1.744	13	11	
23+500	LHS	Sandy Soil	SC	11.11	97.84	95.33	44.35	53.49	26.80	18.42	8.38	1.880	10.60	1.800	10	8	
24+500	LHS	Sandy Soil	SC	13.33	98.24	93.61	46.07	52.17	27.40	17.60	9.80	1.905	11.00	1.824	9	6	
25+500	RHS	Sandy Soil	SC	14.29	97.55	92.31	47.13	50.42	25.50	16.32	9.18	1.818	15.20	1.740	10	6	
Sonapur to Holongi Airport																	
0+000	LHS	Sandy Soil	SC	7.14	98.56	93.45	43.56	55.00	26.80	19.76	7.04	1.820	13.60	1.778	10	7	
1+000	RHS	Sandy Soil	SC	9.09	99.31	95.78	45.19	54.12	27.10	18.25	8.85	1.844	12.80	1.796	11	7	
2+000	LHS	Sandy Soil	SC	12.50	97.46	92.01	41.78	55.68	27.60	18.67	8.93	1.836	13.20	1.795	10	8	

5.8 Sub- Soil Investigations

Sub- soil investigations are carried out in order to determine the nature of the soil through which the substructure and the foundation of the proposed bridge will pass and on which the foundations will rest. Both preliminary followed by detailed soil investigation are generally undertaken at each proposed bridge pier and abutment location. Soil investigation shall be carried out based on the ***Table*** 5-13***.***

Table 5-13: Locations of Boring

Sr. No.	Description	Location of Boring
1	Overall length = 6 to 30m	One abutment location and One abutment location and at least one intermediate location between abutments for structures having more than one span.
2	Overall length = 30 to 60m	One abutment location and at least one intermediate location between abutments for structures having more than one span.
3	Overall length >60 m	Each abutment and each pier locations.

Source: RFP

The process of exploring the soil includes number of steps and processes which has been described further below.

5.8.1 Drilling & In-Situ Tests

Wash/Rotary boring method was adopted to drill bore holes up to the required depth. UD sample was taken, and thereafter SPTs were conducted at regular intervals and the soil samples were brought to the laboratory with proper identification and labeling. Standard split spoon sampler method was used for conducting Standard Penetration Test. The number of blows required to drive the sampler for the 1st, 2nd & 3rd 15cm depths were recorded. The total number of blows required to drive the split spoon sampler due to the free fall of a 63.5kg hammer through a distance of 75 cm for the 2nd and 3rd 15cm penetration were taken together as the field 'N' value or the standard penetration test (resistance) of the soil as per IS code 2131. The field 'N' values are recorded in the bore hole log data. The laboratory test results of soil samples & their bore logs are presented separately in the subsoil report.

5.8.2 Sampling

Representative soil samples were collected from the borehole confirming to IS: 1892-1979. Collected samples were properly sealed in polythene bags and labeled for proper identification during testing. The samples (UDS/DS/SPT) were used for classification of soils as per IS: 1498-1970.

5.8.3 Laboratory Tests

A. Identification

Laboratory test conforming to relevant Indian Standard specifications were conducted on the disturbed soil samples collected from both the borehole as detailed below. All laboratory tests were conducted as per SP: 36 Part-1 1987 of BIS.

a) Sieve Analysis (PSD) (IS: 2720 Part 4)
b) Atterberg's limit (LL & PL) (IS: 2720 Part 5)
c) Density & Natural Moisture Content (NMC) (IS: 2720 Part 29)
d) Specific Gravity (G) (IS: 2720 Part 3)
e) Differential free swell test (DFS) (IS: 2720 Part 40)
f) Cohesion & angle of shearing resistance (C & Phi) (IS: 2720 Part 39)
g) Void Ratio
h) Classification of soil (IS: 1498-1970)

B. Final Logging

The logging of the boreholes as obtained during field work were checked with the disturbed and undisturbed soil samples and scrutinized with the findings of laboratory tests to avoid discrepancies, if any. The bore log & Pit log have been reported in the summarized data sheets.

The findings of various in-situ and laboratory tests conducted on subsoil i.e. UDS/DS/SPT samples have been reported in the summarized data sheet. The soil has been classified into different categories based on their Engineering properties. A careful study of the sub soil strata was made in accordance with the provisions of IS: 1498-1970 to find out their suitability as foundation materials.

The details of borelogs are mentioned in ***Table*** 5-14***.***

Table 5-14: Details of Borlogs

Sr. No.	Location (Name of River)	Design Chainage	No. of Bore Logs	Type of Structure	Improvement Proposal	Proposed Length of Structure	Completed Boring Depth (m)
1	Local Nallah	5+337	1	Minor Bridge	Proposed MNB (1x10)	10	21
2	Local Nallah	6+978	1	Minor Bridge	Proposed MNB (1x12)	12	21
3	Kakila River	7+325	1	Minor Bridge	Proposed MNB (1 x 30)	30	21
4	Local Nallah	7+550	1	Minor Bridge	Proposed MNB (1x12)	12	30
5	Local Nallah	15+230	1	Minor Bridge	Reconstruction of MNB (1 x 10)	10	21
6	Local Nallah	23+014	1	Minor Bridge	Proposed MNB (1x12)	12	30
7	Local Nallah	23+305	1	Minor Bridge	Proposed MNB (1x48)	48	30

Sr. No.	Location (Name of River)	Design Chainage	No. of Bore Logs	Type of Structure	Improvement Proposal	Proposed Length of Structure	Completed Boring Depth (m)
8	Local Nallah	23+650	1	Minor Bridge	Proposed MNB (1x15)	15	30

5.9 Material Investigation

Material investigations survey was carried out along the project road stretch from quarry site were collected to identify the potential sources of construction materials and to assess their general availability, engineering 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.

5.9.1 Investigation of Borrow Areas

Investigation of borrow area is done considering the future adverse impact during excavation of borrow pits. One borrows area location have been identified to supplement soil for the road works, this location is adequate enough to meet the quantity required for road construction from Ghagrabasti to Hawajan (L: 26.006 km) & Sonapur to Holongi Airport (2.130 km). Purbghagra majgown village is the Potential sources of soil for the construction of embankment and subgrade. The details of Borrow areas are presented in ***Table*** 5-15***.***

Table 5-15: Details of Borrow Areas

S. No.	Borrow area Number	Borrow area name village	Location	Lead in km	Area available for borrow material	suitability for embankment/ subgrade	Available quantity in Approx cum.	Required quantity in cum
01	BA-1	Purbghagra Majgown	26.9279158N, 93.6316443E	1+000	1423048	Suitable for subgrade and embankment	2134572	1173410.80

The details of the test results of Borrow Areas have been presented in **Volume III: Material Report**.

5.9.2 Investigation of Stone Quarries

Stone quarries have been primarily identified as stone aggregate source for construction of various road components, namely, Bituminous Concrete (BC), Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM) as well as for the cement concrete works.

Table 5-16: Details of Quarry Material Sources along the Project Corridor

Sr. No.	Location	Ref. Chainage	Side of Road (LHS/RHS)	Distance from Existing Road (Km)	Type of Material Available
1	Borgang Stone Quarry Location – [26.829405N, 93.31324E]	0+000	LHS	55	40mm, 20mm &10mm

Table 5-17: Quarry Sample & Suitability

Name of Quarry	Name of Crusher	Lead (km)	Suitability	Quantity Available in cum	Quantity required in cum
Borgang Stone Quarry	**Borgang Quarry**	55	Suitable for GSB, GSB, WMM, DBM, BC, RCC, PCC, also refer remarks and recommendations given in Aggregate test results sheet	2740464	183356

Figure 5-9: Stone Quarry Locations

The details of the test results of Aggregates have been presented in **Volume III: Material Report**.

5.9.3 Investigation of Sand Quarries

Sources of natural sand have been primarily identified at Borganga river for construction works and sufficient quantity of sand is available, the source of sand are shown in ***Figure* 5-10**. From these sources sand will be obtained from the bed of rivers and streams during dry periods. The sand found in this river zone is of good quality and can be used for road works. It is river sand and the quantity available is abundance and it can serve our purpose for the whole project road.

Figure 5-10: Borgang River Sand, Village – Borgang

The details of the test results of the sand located from the source have been presented in **Volume III: Material Report**.

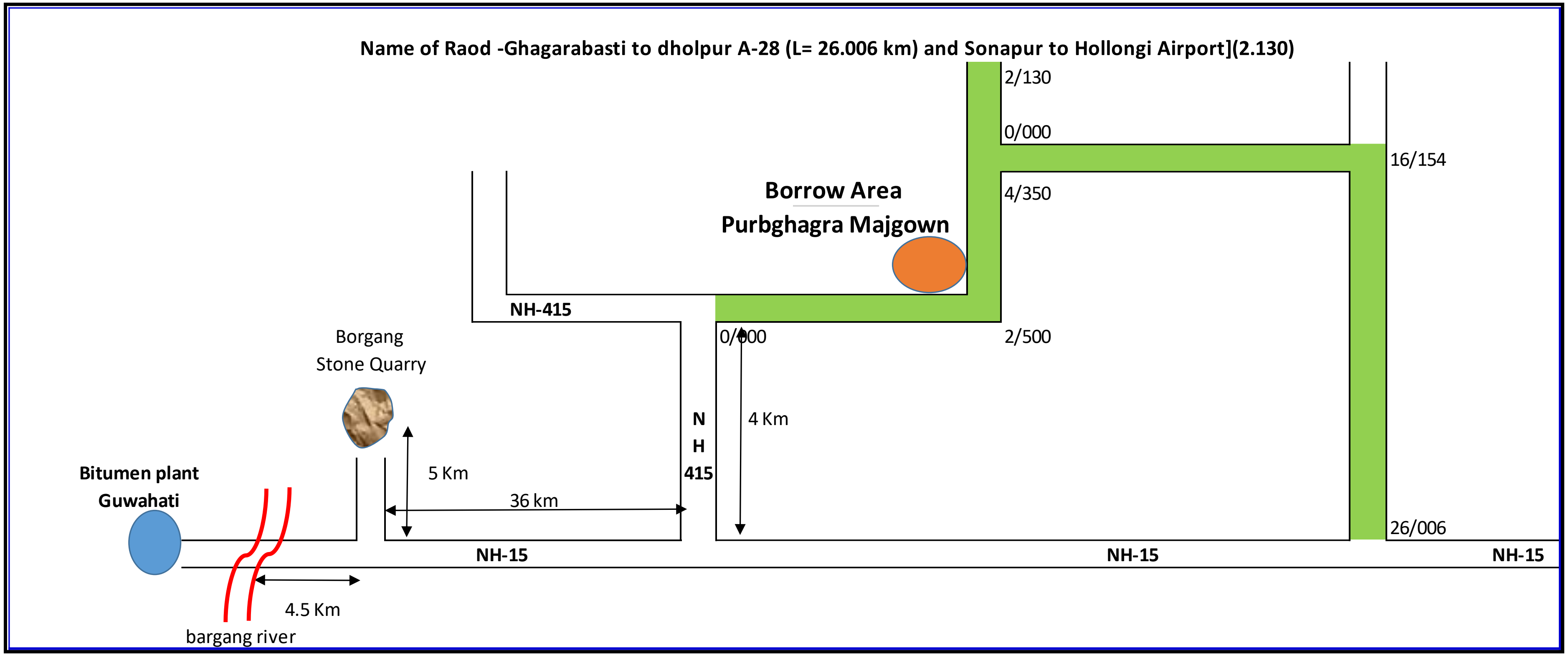


Figure 5-11: Location of Borrow area, Sand and Stone Quarry along Project Road

Figure 5-12: Picture of Laboratory testing for A28 road

CHAPTER 6

DESIGN STANDARDS & SPECIFICATIONS

6 Design Standards and Specifications

6.1 General

This section describes the design standards and principles based on which the various designs will be carried out. These proposed standards are consistent with the parameters recommended in the relevant standards of the Indian Roads Congress (IRC). The aim of this chapter is to evolve Design Standards and Material Specifications for the study primarily based on IRC publications and MORT&H circulars and relevant recommendations from the international standards and to recommend the same for concurrence/approval of PWRD, Assam.

6.2 Terrain Classification

The following terrain classification recommended by IRC: SP: 73-2018 is proposed to be adopted:

Table 6-1: Terrain classification

Terrain Classification	Percentage Slope of the Country
Plain and rolling	Upto 25 Percent
Mountainous and Steep	More than 25 Percent

The proposed alignment follows predominantly Plain terrain as per above classification and thus geometric designs is prepared based on IRC: SP: 73-2018 for plain terrain.

6.3 Guiding Principles

While doing the geometric design, the following are taken into consideration:

- The designed facility shall not become obsolescent before the design year.
- Design shall be consistent and the standards followed for different elements shall be compatible with one another.
- The design will be done aiming at minimizing the vehicle operating cost including initial cost, cost of maintenance etc.
- The design will take into consideration the environmental, aesthetic and landscaping aspects of the project road.

6.4 Design Speed

Design speed is the basic parameter, which determines the geometric features of the road. The proposed design speeds for Major District Roads in different terrain categories as per IRC:73-1980 are as follows:

Table 6-2: Design Speed

Terrain Categories	Design Speed (km/h)	
	Ruling	Minimum
Plain & rolling	100	80
Mountainous and Steep	60	40

As the project road is on plain terrain, for the section passing through open areas design speed of 80-100 Kmph has been considered while at stretches where it cannot be adhered to because of several constraints the traffic calming and control measures are adopted and consequently design speed is reduced.

6.5 Sight Distance

The sight distance is an important component of project highway which deals with the visibility of the project corridor. It is necessary that sight distance of adequate length is available if different situation, to permit drivers enough time and distance to control their vehicles so that chances of accident are minimized. As the project stretch consist of two lanes, at least twice the safe stopping sight distance shall be available throughout. The recommended sight distance for various speed is elaborated as below:

Table 6-3: Sight Distance for Various Speeds

Design Speed (km/hr)	Minimum Sight Distance (m)	Overtaking Sight Distance (m)
100	360	640
80	240	470
60	180	340
40	90	165

6.6 Horizontal Alignment

6.6.1 Radii of Curve

The minimum radii of the curve corresponding to the design speed would be applied as per IRC stipulations.

Absolute minimum and ruling minimum radii correspond to minimum design speed and ruling design speed respectively as per IRC SP 73: 2018 are as follows.

Table 6-4: Radius of Horizontal Curves

Terrain Categories	Radius of horizontal curves (m)	
	Desirable Minimum Radius	Absolute Minimum Radius
Plain & Rolling	400	250
Mountainous & Steep	150	75

At maximum location utmost attention is given to provide desirable radius on the curves.

6.6.2 Super-elevation

The guidelines issued by PWRD Assam namely "Guidelines for Preparation of Detailed Project Report Under Axom Mala Program" are followed for superelevation design. The same are elaborated as below,

- Maximum Superelevation shall be limited to 7% for the curve less than 400m radius (for plain and rolling terrain)
- Maximum Superelevation shall be limited to 5% if the radius of curve is more or equal to 400m (for plain and rolling terrain)
- For hilly and mountainous terrain, the maximum Superelevation shall be limited to 7%.
- Maximum Superelevation Shall be limited to 5% if the project corridor passes through an urban section or falls on major junction.

6.6.3 Transition Curves

The rate of change of super elevation should be such as not to cause discomfort to travellers. The same is considered not steeper than 1 in 150. The transition curve length is calculated as per IRC 73, the minimum length of transition curve is determined from the following consideration and subsequent formulae,

Ls = 2.7 V^2 / R   from IRC 73:1980

Ls = 0.0215 V^3/ CR

Ls = e x w x 150

considering rate of change of super elevation

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
e	-	Rate of change of super elevation
w	-	Width of road in m

6.7 Vertical Alignment

The vertical alignment of road is designed to provide the smooth longitudinal profile. Grade changes are kept as minimum as possible to avoid the kinks and visual discontinues in the profile. The gradient specified by IRC and followed to design the vertical profile is as follows:

Table 6-5: Gradients

Nature of Terrain	Ruling Gradient (%)	Limiting Gradient (%)
Plain and rolling	2.5%	3.3%
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

6.8 Vertical Curves

Vertical curves are designed to provide for visibility at least corresponding to the safe stopping sight distance. More liberal values are adopted wherever this is economically feasible. Valley curves are designed for headlight sight distance. The 'K' values for design control and the minimum length of vertical curves for the project road which is in plain terrain as per IRC 73 and IRC SP 23 are as follows:

Table 6-6: Vertical Curves

Design Speed (kmph)	'K' Value**			Minimum Length of curve (m)
	Summit Curves for Stopping Sight Distance (SSD)	Valley Curves for Headlight Sight Distance	Value for ISD	
80	33	26	60	50
65	19	18	35	40
50	9	10	15	30

6.9 Camber/Crossfall

Each carriageway is designed considering the unidirectional crossfall. The crossfall considered for the flexible pavement is 2.5% and for rigid pavement is 2%. The crossfall considered for earthen shoulder as 3%.

6.10 Geometric Design Control

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

- Horizontal alignment
- Longitudinal profile/Vertical alignment
- Cross-sectional elements
- Intersections etc

The detailed analysis of traffic flow and level of service for the existing road is made and traffic flow capacity for the project road is worked out and this analysis form the basis to establish the widening requirements with respect to the different horizon period.

6.11 Pavement Design

The guidelines comprise the following:

a) Flexible Pavement

Design will be primary in accordance with IRC guidelines. The recommendation given in IRC-37:2018 will be used for new carriageway and paved shoulders. The pavement will be designed for a service life of 10 years for Bituminous Layer & 20 years for Granular Layer.

b) Site Specific Data

The complete estimate data with temperatures and rainfall, as well as the road construction and maintenance history for the last 10 years will be considered.

6.11.1 Design Traffic

The design traffic shall be estimated in terms of cumulative numbers of standard axles (8160kg) to be carried by the pavement during design period. The general consideration shall include the Initial Daily Average Traffic Flow, likely changes due to development/improvement of project facility, change in land use etc. The following guidelines shall be followed for the consideration of Design traffic for pavement design,

- The guidelines issued by PWRD Assam namely "Guidelines for Preparation of Detailed Project Reports under Axom Mala Program".
- Minimum Design traffic stipulated by IRC specifications.

6.11.2 Pavement Performance Indicators and Requirements

The pavement performance and structural capacity shall be measured in terms of objective measurable performance and strength indicators, i.e., roughness, rutting, cracking and deflection.

6.12 Standards for At-Grade Intersections

The standards proposed in IRC SP: 41 "Guidelines for the Design of At-Grade Intersection in Rural and Urban Areas" and IRC SP 73: 2018 are applied for designing the intersections.

6.13 Traffic signs and Road Markings

The design of traffic signs and road marking shall be done according to the IRC standards.

Following is the list of IRC standards, which will be followed**:**

IRC: 30-1968	-	Standard letters and Numerals of different heights for highway signs
IRC: 35-2015	-	Code of practice for Road markings
IRC: 67-2012	-	Code of practice for Road Signs
IRC: 93-1985	-	Guidelines on Design and Installation of Road Traffic Signals
IRC: SP: 55-2014	-	Guidelines for Safety in Construction Zones

The detailed Design Standards are mentioned in **Volume II**: Part 1 – Roads

Design Standards for Structures

6.14 Introduction

6.14.1 General

This section deals with the standards to be adopted vis-à-vis for bridges and culverts. It also provides for the type of materials and their specifications that would be adopted for the structures, the loads and forces to be considered.

The design standards for bridges have been worked out on the basis of recommendations regarding loading and material strength characteristic contained in the current bridge design practices and are contained in the relevant IRC standards.

The preliminary design of bridges will be based on various parameters and data such as design discharge of stream, HFL, scour level, characteristic of stream/river, sub-soil type, selection of site, etc. The selection of proper bridge site, computation of design discharge, bearing capacity and characteristic of soil are required to conceptualize a new bridge. The carriageway width, footpaths, crash barrier are provided as per MORT&H guidelines. Based on all these data, type of bridge, length of bridge, height of bridge, type of foundation whether shallow or deep is decided. Two or three alternatives of bridge superstructure and sub-structure will be conceived and the cost of each alternative worked out, the most economical alternative will be selected. The various data required for bridge design, method of computation of these data and parameters of bridge design are also discussed.

6.14.2 Site Data

- **Topographical Data**

Site Investigation Report will include drawings (soft (AutoCAD) and hard copies) of site plan of all bridges with close contours and salient features-area 1 km^2 for major bridges, 0.25 km^2 minimum for others-around bridge center. Corresponding bed/ground profile drawings at cross sections and longitudinal section of stream will also be furnished. Other salient data like HFL from local witnesses, flood damage records as available will also be included in the report.

In addition, topographic maps of catchment area of rivers for estimating area, length, average slope (from source to bridge) will also be included in the DPR.

- **Hydrological Data**

Rational Formula, Dickens method, Ingli's method and Area Velocity method will be used for estimation of design discharge. The design discharge is defined in IRC 78 as 100-year flood with some mandatory increase for design of substructure. Catchment area characteristics will be derived from topographical data and Toposheets of Survey of India given in Site Investigation Report.

- **Hydraulic Data**

The objective of this investigation is to plan the structures so that the bridge/CD structure should pass safely the design discharge without disturbing the regime of river. The CD structure should not obstruct the flow of river and the length of bridge should be equal to regime width of the river as given by the formula for regime condition in IRC:5. It is necessary to access correctly the discharge of river, HFL, scour depth, flood frequency, intensity of rainfall and average velocity of flow.

Minimum waterway will be conformed to subject to review of bed profile data. For evaluation of scour, for rivers applicability of Lacey's formula shall be reviewed on the basis of topographical and bed material data. For other minor channels lowest bed level measured shall be deemed as design scour level.

Estimation of Discharge

The design discharge for which the waterway of bridge is to be designed shall be the maximum flood discharge on record for a period of 100 years for major bridges and 50 years for minor bridges.

Design discharge can be determined by following methods given below:

- Rational Formula
- Dickens methods
- Ingli's method
- Area Velocity method

In case where the discharges are not available it shall be calculated by various rational formulas and methods given in literature

Foundation Soil Data / Soil Investigation Report as per IRC: 78

Geotechnical Report forms part of Site Investigation Report and will contain evaluation of basic foundation design data like allowable bearing pressures, pile capacity, settlement. Data is evaluated in close consultation with PWD officials and reviewed for any modification needed. Besides, Geotechnical Report shall contain all soil profile data, classification and laboratory test data which is duly reviewed.

Condition assessment of Bridges

Structural assessment of the bridges is carried out as per IRC: SP: 35-1990 "Guideline for Inspection and Maintenance of Bridges" and our experience in the field for analyzing strength/Integrity of Structure. Structural assessment of Bridges is carried out when change in structural resistance, structural behavior and change in the loading on the structure. The main task of assessment is to identify the extent of damage/ deterioration of the bridges for its safety and serviceability of structure. While preliminary assessment of bridge chainage of the structure, type of structure, Dimension of structure and hydraulic details of structure is carried out.

In detailed assessment of structure any damages, cracks and condition of every component of bridge is inspect on site. From this inventory report and hydraulic design of every culvert including minor and major bridges improvement proposal is finalized.

After detail visual inspection of existing crossings, the proposed structure are categories as under:

I. Reconstruction
II. New construction
III. Widening
IV. To be retained with minor repairs.

- All RCW are proposed to be replaced by minor / major bridges and categorized as 'Reconstruction.'
- All structures having inadequate waterway proposed to be replaced as minor bridges and categorized as 'Reconstruction'.
- All-natural crossings are proposed for minor / major bridges and categorized as 'New Construction'.

- All bridges in good condition and having adequate waterway with minimum 7.00m roadway are proposed to be kept on it is with minor repairs / protection work and categorized as 'Retain with minor repairs.
- All bridges in good condition and adequate waterway but having roadway less than 7.0m are proposed for widening and categorized as 'Widening'.

6.14.3 Deck Configuration/Carriageway widths

New Construction Bridges / Culverts: - The bridges which having inadequate waterways, which are in deteriorate condition are to be dismantled. For all such bridge under Asom Mala Program new bridge has to be constructed on the road corridors the total width of bridge (outer to outer) shall be 12 m.

For all existing pipe culvert shall be replaced by Box Culverts. Carriage way width of existing slab culvert is less than 7m then new box culvert shall be constructed in full formation width.

Widening of Bridges: - For existing major and minor bridges having carriageway less than 7.0m, then new bridge shall be constructed parallel to the existing bridge.

6.14.4 Carriageway Drainage

Minimum cross fall / camber will be kept as 2.5% both sides for the deck drainage. Water will be taken down to ground/drainage courses through proper downspouts and take down pipes at the edge of carriageway shall be provided according to standard practice to provide efficient transverse drainage.

Longitudinal drainage is much more efficient and a minimum nominal longitudinal gradient of ± 0.5% to 1% may be proposed to minimize intrusion of drainage inlets. Road Side Drainage has been designed as per specifications of IRC SP 42-2014.

6.15 Hydrologic Design for Bridges

6.15.1 General

Hydrological inputs play an important role in planning, execution and operation of any hydraulic structures located along the road corridor. In most of the cases, sufficient hydrological & meteorological records are not available of the catchment areas are ungauged. This report covers the Methodology, Input data used and various method used to calculate required parameter for Hydrologic design of road bridges.

6.15.2 Objectives

The main objectives of the hydrologic study of bridges at preliminary project reports,

i) Deciding the bridge location on the proposed road alignment considering various factors.
ii) Determination of Linear waterway of the bridge for Design flood discharge
iii) Calculation of Afflux
iv) Scour depth Calculations 0

6.15.3 Input Data:

i) For deciding bridge location on the proposed road alignment following data was collected and some guidelines are used:

A. First the road alignment is marked on the Google earth and the location of crossing is identified. As most of the rivers in the region shows meandering and braiding characteristics, the river changes its width with due course of time. Therefore, historical data for river width is collected using google earth application. The river width as seen from historical images from google earth are marked till year 2008. And control points were identified where the river shows minimum meandering nature. The figure shows the example for the same.

B. Then for deciding the bridge location some guidelines from the book "River Behavior Management and Training" volume 1 published by Central board of Irrigation and Power are followed.

ii) Rainfall data: For finding design discharges of any given return period, input rainfalls for the design return period are required for all the cross-drainage structure. These data are taken from the 24-hour Isopluvial maps published by Indian metrological department (CWC flood estimation report Brahmaputra basin subzone 2a/2b). As per recommendations of the Indian Road Congress (IRC: 5-2015 and IRC: SP: 42-2014), these rainfall values of 24 hr. duration are adjusted for evaluating design storm corresponding to time of concentrations for all catchments. Rainfall values used for computing discharge is found from mean annual rainfall and 24-hour rainfalls for 25 years, 50 years and 100 years return periods.

iii) Toposheets for locating bridge location and determination of catchment area characteristics

iv) Cross section data of the river at bridge location, Upstream and downstream of the bridge location from site surveys, google earth and toposheets.

v) Reconnaissance survey data and photos collected during site visits.

vi) Flood estimation report for Brahmaputra basin (Subzone-2a/2b).

6.15.4 Methodology adopted for Hydrologic design of bridges:

All structures will be designed in accordance with the relevant codes, standards and specifications, Special publications and guidelines of the Indian Road Congress. Following steps are followed for hydraulic design of proposed bridges

6.15.4.1 Delineation of catchment

Catchment area delineation is done using the toposheet and location of bridge. The bridge location marked on the toposheet along with the road alignment. The toposheet and google earth imaginary have been studied with respect to proposed bridge location. The catchment area is marked based on the existing drainage network and ridge line identified in the toposheet. Then the longest stream is identified and its slope is determined using google earth. Also, the catchment characteristics are studied from the toposheet to get the run-off coefficient.

6.15.4.2 Calculation of peak discharge

IRC: SP:13-2004 has recommended various method for calculation of design discharge for the bridge location. Design discharge will be calculated in accordance with the guidelines given in the IRC: SP:13-2004. Data available for particular location governs the method to be used for calculation of discharge. Following are the method used for calculating the peak discharge.

i) Catchment area methods (Empirical and rational method)

ii) Area-velocity method

6.15.4.3 Determination of linear waterway and HFL:

a) Regime width of stream will be calculated based on Peak flow computed. This waterway will be compared existing waterway of nearby bridge at just u/s or d/s of proposed bridge. If existing waterway is greater than required waterway, existing waterway will be adopted for proposed bridge. As far as possible odd number of spans may be fixed from hydraulic and aesthetic point of view and to avoid placing of center pier at deepest location of the stream. Proposed waterway of bridge will be near to Regime width of stream or actual existing width of stream for design discharge.

b) Afflux will be calculated as per applicability for Weir flow condition or Orifice flow condition. If difference in upstream head and downstream head is not less than 0.25 times downstream head, afflux computed from weir flow formula will be adopted, otherwise afflux computed orifice flow formula will be used for HFL computation.

Then HFL will be calculated by adding afflux, total water head and bed level at just upstream of proposed bridge.

c) Scour depth will be computed by appropriately increasing design discharge as per IRC:78-2014. Design criteria and detailed hydraulic design calculations for proposed bridge structures are presented in subsequent sections.

6.15.5 Hydrologic design criteria

Sizing of proposed bridge structure involves estimation of peak flow, determination of linear waterway, Scour depth calculation, HFL calculations as stated in previous section. The bridges can be classified as minor or major bridges. Design standards for hydrologic study of bridges are discussed in subsequent Sub-sections. The term and important factor used in calculations are explained below.

6.15.5.1 Return period

Return period is the average interval, in year, between events which equals or exceed a given magnitude. It is usually designated as T. As per IRC: SP:13-2004, for sound economy the return period recommended is 50 years for small and medium structures. Also, as per IRC:5-2015 the return period for calculation of design discharge recommended is 100 years. As per IRC: SP:73-2004, all the structures shall have adequate waterway. The design discharge shall be evaluated for flood of 50-year return period.

Hence, Hydraulic design of structures will be for the flood of 50 years and this design discharge will be utilized for estimation of linear waterway and HFL calculations.

6.15.5.2 Estimation of design flood peak

Depending upon the size of catchment area, availability of field data and other related data of the project area and the purpose for which it to be used, various methods are available for design flood peak estimation which are described as follows:

6.15.5.2.1 Empirical Formulae

In this method area of a basin or a catchment is considered mainly. All other factors which influence peak flow are merged in a constant.

a) **Dicken's Formula**:
It was formerly adopted only in northern India but now it can be used in most of the States in India after proper modification of the constant.

b) **Ingli's Formula**:
This formula was devised for erstwhile Bombay Presidency. These empirical formulae involve only one factor viz. the area of the catchment and all the so many other factors that affects the run-off have to be taken care of in selecting an appropriate value of the co-efficient.

6.15.5.2.2 Rational Formulae

The rational formulae for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances, time of concentration and critical intensity of rainfall.

6.15.5.2.3 Area-velocity Method

The slope-area method based on the hydraulic characteristics of the stream is the reliable method. This method is based on conveyance factor (K) and the slope (S) of stream. For calculation of the conveyance factor, several cross-sections have been used. These are at bridge site, upstream of bridge site and downstream of bridge site at specified locations.

6.15.5.3 Final Design flood discharge:

After computing peak discharges of bridges by different methods as described above sections are compared with one another. As far as possible, maximum of peak discharges computed using rational formulae and Unit hydrograph methods are taken as Design Discharge.
When the variation between the highest two values of discharges computed by different methods is less than 50%, the highest discharge has been taken as design discharge. When the variation between the highest two values of the discharges computed by different methods is more than 50%, and then design discharge has to be taken as 1.5 times the lower of the two maximum values.

6.15.6 Linear Water way of the bridge:

When bridge is proposed crossing artificial channel for irrigation or navigation or when the banks of natural stream are well defined, linear waterway should be full width of the channel or stream. For alluvial stream with undefined banks, the required effective linear waterway/ regime width (W) of bridge can be determined using Lacey's formula:

$W = C (Q)^{1/2}$

Where, W= Liner water way in meters

C = A coefficient varying according to local conditions, the usual value adopted being

4.5 to 6.3 (for regime channel) and as per I.R.C: SP: 13-2004 C = 4.8

Q = Design flood discharge in cumecs.

When stream overflows their bank for carrying discharge of 100-year return period and creates wide surface width with shallow side sections, Engineering judgments have to be used. Based for existing width of natural stable stream at HFL, width of nearby existing bridge nearby site on the same stream, Regime width calculated, the clear linear waterway is fixed and then hydraulic flow condition around bridge is analyzed, If the chosen linear waterway is viable for hydraulic flow through the bridge without causing excessive afflux and exit velocity, then this waterway is adopted for HFL calculations.

Actual waterway provided for the bridge in the meandering and braiding flood plain of a river may be substantially different from Lacey's waterway. In some of the cases, Lacey's waterway has been provided but, in some others, waterway provided is found to be much more than Lacey's waterway.

6.15.7 Determination of Afflux

Afflux is the heading up of water over the flood level caused by constriction of waterway at the bridge location in the stream. It is equal to the difference in water levels at u/s and d/s of the bridge. Afflux will be calculated as per Molesworth's formula.

$$h = [V^2 /17.88 +.015] [(A/A1)^2 -1]$$

Where V is the mean velocity of flow in the river prior to bridge construction i.e. corresponding to normal HFL, A and A1 are the areas of flow section at normal HFL in the approach river section and under the bridge respectively.

6.15.8 Vertical clearance

In the case of a channel(stream), vertical clearance is usually the height from the design highest flood level with afflux of the channel to the lowest point of the bridge superstructure at the position along the bridge where clearance is being denoted. The minimum vertical clearance will be kept in accordance with the table 12.1 of IRC-13-2004. The minimum clearance is measured from the lowest point of the deck structure inclusive of main girder in the central half of the clear opening.

6.15.9 Scour Depth

Foundation and protection work of the structure should be designed for larger discharge by increasing design flood as per section 703.1.1 of IRC:78-2014.

As per IRC:5-2015, IRC: SP:13-2004 & IRC 78-2014, published by Indian Roads Congress (IRC), recommend use of Lacey's (1930) equations for estimating scour depth. IRC method does not distinguish between local scour, constriction scour and general scour. The normal scour depth (measured below HFL) is given by Lacey's equations below:

$$R = 0.473(Q/f)^{1/3}$$

when clear waterway of bridge is not less than regime width of the stream. When clear waterway ear width of bridge (Le) is less than regime width or and less than natural unobstructed width of the stream (W), following Lacey's equation is used for estimating normal scour depth as per IRC: 5-2015.

$R = 1.34 (q^2/f)^{1/3}$, when L/W is less than one.
Where,
R = the Lacey's regime scour depth, measured below HFL,
q = design discharge per unit width through bridge in m^3/s per meter
f = silt factor

The silt factor is calculated by the following equation:

$$f = 1.76 (d_{50})^{1/2}$$

Where, d_{50} is the mean size bed materials obtained up to deepest anticipated scour in mm and its value is to be obtained from sieve size analysis of the riverbed materials collected at the site.

The maximum depth of scour below the highest flood Level (HFL) at obstructions and configurations of the channel should be estimated from the value of 'd_{sf}' on the following basis:

a) For the design of piers and abutments located in a straight reach and having individual foundations without any floor protection works
   i. In the vicinity of piers = 2.0 * d_{sf}
   ii. Near abutments = 1.27 * d_{sf}
b) For bad sites on curves or where diagonal current exist or the bridge is multi-span structure, the maximum scour depth should be taken as two times the normal scour depth.

6.16 Design Hypothesis

This aims at providing the basic criteria for design of foundation, substructure, superstructure etc. for the various parameters of loads, stresses, materials, grades of concrete for various structural elements, exposure criteria, foundation designs, functional elements, finishing item etc. The structures have been modeled by grillage analysis or finite element Technique using **STAAD Pro V8i. or MIDAS Civil.** Analysis has been performed to get various output such as bending moment, shear forces and torsion values at various locations along the span of bridges/culverts. The detail design of super structure is performed as per IRC standards using in-house developed spread sheet programs.

The substructure components such as abutment, piers, pile foundation, well foundation and other miscellaneous structural elements have been designed by using in-house developed programs (spread sheets) based on various formulas, expressions & empirical equations to satisfy IRC codal stipulations. A modular standardized span design has been followed to reduce variation & ease in construction & maximum use of post-tensioned pre-cast members. For this corridor, box culverts, Minor Bridge and Major Bridge are designed by in house bridge experts, prepared corresponding design worksheets.

6.16.1 Design Philosophy

The Design philosophy shall be Limit State Philosophy of Design as per IRC-112-2019 and the Structure shall be checked for the following:

1. Ultimate Limit State
2. Serviceability Limit State

The Design Methodology adopted for Foundations shall be Limit State Method for Load Combinations mentioned in Annex-B of IRC:06-2017.

6.16.2 Material

The Stress deformation characteristics and Engineering properties of materials shall be considered as per IRC 112-2019.

6.16.2.1 Concrete Characteristics:

• Min Grade of Concrete (Pre-Stressed Girder)	-	M 50
• Minimum Grade of Concrete (Substructure)	-	M 35
• Minimum Grade of Concrete (Foundation)	-	M 30
• Minimum Grade of Concrete (Box Culvert)	-	M 30
• Poisson's Ratio of Concrete	-	0.15
• Coefficient of Thermal Expansion	-	$12 \times 10^{-6}/^{0}C$
• Modulus of Elasticity of Concrete	-	Table 6.5, IRC:112-2019, eq.-A2-5, IRC 112-2019

Note:

A. Concrete used for foundations, substructures and super structures from consideration of durability, sustainability, only.

B. Concrete strength can be considered as per IRC 112-2019 Clause No 6.4.1 (a) Note 3.

6.16.2.2 Reinforcing Steel Characteristics

• Characteristics Strength of Reinforcement	-	Fe500D
• Modulus of Elasticity	-	200 GPa
• Coefficient of Thermal Expansion	-	$12 \times 10^{-6}/^{0}C$

Reinforcements shall be thermo mechanically treated TMT deformed with corrosion resistance steel (CRS) bars of grade Fe 500D conforming to IS-1786:2008.

6.16.3 Stress Limitation

6.16.3.1 Allowable stress in concrete

As Per IRC-112-2019, Cl.12.2 Maximum compressive stress in concrete under rare combinations 0.48 f_{ck}. Where Compressive stress in concrete under Quasi-Permanent load is within 0.36 f_{ck}, linear creep may be assumed.

6.16.3.2 Allowable tensile stress in steel

Maximum tensile stress in steel under rare combinations 0.8 f_{yk}.

6.16.3.3 Pre-stressing Steel Limits

In exceptional conditions temporary overstressing during stressing operation is permitted up to 95% of 0.1% proof load, provided that the accuracy of measurement is ensured to be within +-5%.

Maximum Pre-stressing force P_0 applied to structure immediately after transfer shall not be greater than 75% of fpk or 0.85 X 0.87 = 0.739 whichever is less.

6.16.3.4 Pre-stressing Steel Characteristics

Pre-stressing Steel Characteristics is mentioned in VOLUME-II, Part -2, Design Report of Structures.

6.16.4 Stress Block Parameters

The Stress Check for members designed for axial compression and uniaxial bending shall be done using the equivalent Stress Block as mentioned in Annexure A-2 of IRC 112-2019.

6.16.5 Bearing Characteristics

Spherical Bearing shall be adopted as per requirement/design for all spans. Design of Bearings shall be as per IRC: 83.

6.16.6 Expansion Joint Characteristics

Strip-seal type Expansion Joint shall be adopted for all aforesaid categorized Superstructures conforming to IRC-SP 69-2011, maximum movement up to 100mm shall be considered for simply supported span.

6.16.7 Exposure

The type of exposure considered in design is severe. The Exposure condition shall be used to check the crack width in 'Limit State of Serviceability' for Frequent and Quasi Permanent Load Combinations as given in the Table 12.1 of IRC 112-2019.

6.16.8 Reinforcement Cover

Considering service Life of 100 yrs. minimum cover to the outermost reinforcements is,

Table 6-7: Minimum Reinforcement Cover

• Superstructure	50 mm
• Substructure	50 mm
• Foundation	75 mm
• Underpasses / Box Culvert	
• Earth Side / surface in contact with soil	75mm
• Non-Earth Side	50mm

Minimum Cover shown above can be reduced by 5mm in case of factory made precast concrete elements.

6.17 Load

The loads which are considered for design of structures is as per IRC:06-2017. The details of Load are elaborated in VOLUME-2, Part 2, of Design Report of Structures.

6.17.1 Load Factors and Combinations

6.17.1.1 Partial Safety factor for loads

The partial safety factors shall be used in combinations for Limit State Design shall be used as per Annex B of IRC-6:2017.

6.17.2 Partial Safety Factor for Pre-stress

The partial safety factors for pre-stressing shall be used as per Clause 7.9.5 of IRC: 112-2019.

6.18 Design Approach

6.18.1 Load Types Definitions

The underlying section depicts the Analysis and Design of the structure for the various loads and load combinations as mentioned in above section. The Analysis is carried out as following:

- Longitudinal analysis of the grillage systems for other superstructures (PSC Girder Systems)
- Transverse Analysis for Girder and Slab system
- Local Analysis for the End blocks, diaphragms (Areas of High Stress Concentration).

The Longitudinal Analysis, Transverse Analysis and Local Analysis is elaborated in VOLUME-II, Part 2, Design Report of Structures.

6.18.2 Analysis of Substructure

The Analysis of Pier & Pier Cap shall be carried out for the system of forces as shown in the figure above. The Portal frame fixed at the top of foundation shall be analyzed for:

- Dead Loads
- SIDL
- Bearing forces in Longitudinal direction
- Wind
- Seismic.
- Barage Impact

The analysis for the system of forces shall be carried out load combinations as mentioned in above section of Loads and Load Combinations. The Structural components shall be checked for Ultimate and Serviceability Limit States as per IRC:112-2019.

6.18.3 Bearing System

Each end of span of the bridge will be POT/PTFE or spherical bearing or elastomeric bearing is placed underneath end-diaphragm at pier location for transfer of vertical and horizontal forces.

6.18.4 Design of Foundations

The foundation system shall be designed as per Geotechnical Investigations carried out in the field for the load combinations as given Annex B of IRC-6:2017. The Foundations envisaged in the project mainly comprise of following Types:

1. Raft Foundation
2. Open Foundation
3. Pile Foundation
4. Well Foundation

The methodology of design of foundation is elaborated in VOLUME-II, Part -2, Design Report of Structures.

6.19 Relevant Codes

- IRC: 112 (2019) – Code of Practice for Concrete Road Bridges.
- IRC: 78 (2014) – Design Standard for Foundation and Substructure of Road Bridges.
- IRC: 5 (2015) – General Features of Design of Road Bridges.
- IRC: 6 (2017) – Loads and Stresses for Road bridges.
- IRC: 45-1972 – Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in Damage of Well Foundation of Bridge.
- IRC:89-2010 – Guidelines for Design and Construction of River Training,
- IS 1343-2012 – Code of Practice for Prestress Concrete.
- IS 14268-2017 – Uncoated stress Relieved Low Relaxation Seven Ply Strand for Prestress Concrete Specification.
- IS: 2911 (2010) – Design Standard for Pile Foundations.
- IS: 6403 (1981) – Determination of Breaking Capacity of Shallow foundation.
- IS: 13920 (2016) – Ductile Detailing Standard for RCC Structures.
- IRC: 83 Part III (2002) – Standard Specifications & Code of Practice for Road.
- IS: 800 (2007) – Design Standard for Steel Structures.
- IRC SP: 73 (2018) – Manual for Specifications & Standards for Two Laning of Highways with Paved Shoulder.
- IRC: SP:114-2018 – Guidelines for Seismic design of Road Bridges.
- IRC: SP:65-2018 – Guidelines for Design and Construction of Segmental bridges
- IRC: SP:66-2005 – Guidelines for the Design of Continuous Bridges
- IRC: SP:69-2011 – Guidelines and Specification for Expansion Joint
- MoRT&H – Specifications of Road and Bridge Work (Fifth Revision)
- Wherever IRC-112-2019 is silent, the latest revisions of the following codes shall be preferred.

CHAPTER 7

IMPROVEMENT PROPOSALS

7 Improvement Proposals

7.1 Introduction

This chapter deals with analysis of roadway geometrics, developmental aspects, traffic facilities, safety and road furniture requirements towards providing pleasant and aesthetic highway for road users. This chapter also discusses pavements, design and rehabilitation proposals of CD structures and bridges.

7.2 Selection of Widening Scheme

Based on the traffic movement survey at different location the consultant along with PWD officials had made the several site visit to finalize the type of roads & section accordingly the project stretch is proposed to be reconstructed/widening. The details of the reconstruction schedule are elaborated in ***Table* 7-1** and TCS drawings along with the details are presented in ***Annexure 7-1: Typical Cross Section.***

Table 7-1: Widening Scheme Details

Design Chainage		Length (m)	Proposal	Widening Scheme
From	From			
Ghagrabasti to Mazgaon (PKG-1)				
0+000	0+075	75	Concentric	2L+ES
0+075	0+098	23	Retained Minor Bridge	
0+098	2+000	1902	Concentric	2L+ES
2+000	2+130	130	Realignment	2L+ES
2+130	2+230	100	Under Construction Bridge	
2+230	2+410	180	Concentric	2L+ES
2+410	2+460	50	Under Construction Bridge	
2+460	4+775	2315	Concentric	2L+ES
4+775	5+332	557	Realignment	2L+ES
5+332	5+342	10	Proposed Minor Bridge	
5+342	6+200	858	Realignment	2L+ES
6+200	6+770	570	Concentric	2L+ES
6+770	6+978	208	Realignment	2L+ES
6+978	6+990	12	Proposed Minor Bridge	
6+990	7+312	322	Realignment	2L+ES
7+312	7+342	30	Proposed Minor Bridge	
7+342	7+554	212	Realignment	2L+ES
7+554	7+566	12	Proposed Minor Bridge	
7+566	7+750	184	Realignment	2L+ES
7+750	9+125	1375	Concentric	2L+ES
9+125	10+050	925	Realignment	2L+ES
10+050	12+300	2250	Concentric	2L+ES
12+300	13+740	1440	Realignment	2L+ES
13+740	14+800	1060	OUT OF SCOPE	
14+800	15+000	200	Realignment	2L+ES

Design Chainage		Length (m)	Proposal	Widening Scheme
From	From			
15+000	15+225	225	Concentric	2L+ES
15+225	15+235	10	Proposed Minor Bridge	
15+235	15+300	65	Concentric	2L+ES
Mazgaon to Hawajan (PKG-2)				
15+300	15+840	540	Concentric	2L+PS+ES
15+840	15+900	60	Concentric	2L+PS+ES
15+900	16+727	827	Out of Scope	
16+727	16+740	13	Concentric	2L+PS+ES
16+740	16+785	45	Concentric	4L
16+785	16+850	65	Taper from Tcs-I to Tcs-II	
16+850	16+950	100	Concentric	2L+PS+ES
16+950	17+700	750	Concentric	2L+PS+ES
17+700	18+200	500	Concentric	2L+PS+ES
18+200	18+405	205	Concentric	2L+PS+ES
18+405	18+605	200	Concentric	2L+PS+ES
18+605	20+500	1895	Concentric	2L+PS+ES
20+500	20+700	200	Concentric	2L+PS+ES
20+700	21+075	375	Concentric	2L+PS+ES
21+075	21+464	389	Concentric	2L+PS+ES
21+464	21+471	7	Level crossing	
21+471	22+000	529	Concentric	2L+PS+ES
22+000	22+350	350	Concentric	2L+PS+ES
22+350	22+370	20	Concentric	2L+PS+ES
22+370	22+375	5	LHS access road	
22+375	22+675	300	Concentric	2L+PS+ES
22+675	22+800	125	Concentric	2L+PS+ES
22+800	22+900	100	Concentric	2L+PS+ES
22+900	22+960	60	Concentric	2L+PS+ES
22+960	22+990	30	Concentric	2L+PS+ES
22+990	22+995	5	RHS access road	
22+995	23+008	13	Concentric	2L+PS+ES
23+008	23+020	12	Proposed Minor Bridge	
23+020	23+200	180	Realignment	2-lane + PS +ES
23+200	23+284	84	Realignment	2-lane + PS +ES
23+284	23+332	48	Proposed Minor Bridge	
23+332	23+623	291	Realignment	2-lane + PS +ES
23+623	23+638	15	Proposed Minor Bridge	
23+638	23+825	187	Realignment	2-lane + PS +ES
23+825	23+850	25	Concentric	2L+PS+ES
23+850	23+880	30	Concentric	2L+PS+ES
23+880	24+000	120	Concentric	2L+PS+ES
24+000	25+000	1000	Concentric	2L+PS+ES
25+000	25+700	700	Concentric	2L+PS+ES

Design Chainage From	From	Length (m)	Proposal	Widening Scheme
25+700	25+890	190	Concentric	2L+PS+ES
25+890	25+955	65	Taper from Tcs-II to Tcs-IX	
25+955	26+006	51	Realignment	4-L +ES
Sonapur to Holongi Chariali Airport Road				
0+000	1+814	1814	Concentric	
1+814	1+822	8	Retained Minor Bridge	
1+822	2+130	308	Concentric	

Note: 4L-Four lane, 2L-Two Lane, ES-Earthen Shoulder

7.3 Typical Cross-sections of road, bridges, ROB, RUB and culvert

The typical cross sections (TCS) proposed in the project stretch are detailed as in ***Table* 7-2**.

Table 7-2: Typical Cross Section Details

Design Chainage From	To	Length	Applicable TCS	Description
Ghagrabasti to Mazgaon (PKG-1)				
0+000	0+075	75	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
0+075	0+098	23	Retained Minor Bridge	-
0+098	2+000	1902	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
2+000	2+130	130	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
2+130	2+230	100	Under Construction Bridge	-
2+230	2+410	180	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
2+410	2+460	50	Under Construction Bridge	-
2+460	4+775	2315	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
4+775	5+332	557	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
5+332	5+342	10	Proposed Minor Bridge	-
5+342	6+200	858	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)

Design Chainage From	Design Chainage To	Length	Applicable TCS	Description
6+200	6+770	570	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
6+770	6+978	208	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
6+978	6+990	12	Proposed Minor Bridge	-
6+990	7+312	322	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
7+312	7+342	30	Proposed Minor Bridge	-
7+342	7+554	212	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
7+554	7+566	12	Proposed Minor Bridge	-
7+566	7+750	184	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
7+750	9+125	1375	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
9+125	10+050	925	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
10+050	12+300	2250	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
12+300	13+740	1440	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
13+740	14+800	1060	OUT OF SCOPE	-
14+800	15+000	200	II	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
15+000	15+225	225	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
15+225	15+235	10	Proposed Minor Bridge	-
15+235	15+300	65	I	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
Total Length		**15300**		
Mazgaon to Hawajan (PKG-2)				

Design Chainage From	Design Chainage To	Length	Applicable TCS	Description
15+300	15+840	540	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
15+840	15+900	60	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
15+900	16+727	827	Out of Scope	-
16+727	16+740	13	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
16+740	16+785	45	I	TYPICAL CROSS SECTION FOR 4 LANE DIVIDED HIGHWAY WITH RAISED MEDIAN AND BOTH SIDES FOOTPATH OVER DRAIN (BUILT-UP AREA)
16+785	16+850	65	Taper from Tcs-I to Tcs-II	-
16+850	16+950	100	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
16+950	17+700	750	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
17+700	18+200	500	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
18+200	18+405	205	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
18+405	18+605	200	III	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
18+605	20+500	1895	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
20+500	20+700	200	III	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
20+700	21+075	375	III	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
21+075	21+464	389	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
21+464	21+471	7	Level crossing	-
21+471	22+000	529	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
22+000	22+350	350	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
22+350	22+370	20	IV	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)

Design Chainage		Length	Applicable TCS	Description
From	To			
22+370	22+375	5	LHS access road	-
22+375	22+675	300	IV	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
22+675	22+800	125	IV	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
22+800	22+900	100	IV	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
22+900	22+960	60	V	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
22+960	22+990	30	VI	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS GEOBAGS WALL, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
22+990	22+995	5	RHS access road	-
22+995	23+008	13	VI	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS GEOBAGS WALL, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
23+008	23+020	12	Proposed Minor Bridge	-
23+020	23+200	180	VII	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, GEOBAGS (OPEN COUNTRY PLAIN/ROLLING TERRAIN)
23+200	23+284	84	VIII	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, GEOBAGS (HIGH EMBANKMENT NEW CONSTRUCTION OPEN COUNTRY PLAIN/ROLLING TERRAIN)
23+284	23+332	48	Proposed Minor Bridge	-
23+332	23+623	291	VIII	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, GEOBAGS (HIGH EMBANKMENT NEW CONSTRUCTION OPEN COUNTRY PLAIN/ROLLING TERRAIN)
23+623	23+638	15	Proposed Minor Bridge	-
23+638	23+825	187	VIII	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, GEOBAGS (HIGH EMBANKMENT NEW CONSTRUCTION OPEN COUNTRY PLAIN/ROLLING TERRAIN)
23+825	23+850	25	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
23+850	23+880	30	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
23+880	24+000	120	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)

Design Chainage From	To	Length	Applicable TCS	Description
24+000	25+000	1000	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
25+000	25+700	700	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
25+700	25+890	190	II	TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
25+890	25+955	65	Taper from Tcs-II to Tcs-IX	-
25+955	26+006	51	IX	TYPICAL CROSS SECTION FOR 4 LANE DIVIDED HIGHWAY (OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
Total Length		**10706**		
Sonapur to Holongi Chariali Airport Road				
0+000	0+400	400	III	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
0+400	1+100	700	Retained Minor Bridge	-
1+100	2+130	1030	III	TYPICAL CROSS SECTION FOR TWO LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)
Total Length		**2130**		

7.4 Summary of Pavement Design

Based on the existing pavement conditions, the entire project road was identified for reconstruction using flexible pavement. Flexible Pavement has been designed considering a design period of 10 years for Bituminous Layer and 20 years for Granular Layer with Design CBR value of 7% for entire section (Ch. 0+000 to Ch. 26+006) and (Ch. 0+000 to Ch. 2+130).

The proposed thickness of the different layers computed according to the guidelines of IRC: 37-2018 for flexible pavement. ***Table*** 7-3 represents the pavement composition proposed for the project stretch.

Table 7-3: New Flexible Pavement Composition

Homogenous Section	Design Period (year) Granular Course	Design Period (year) Bituminous Course	Design Traffic (MSA) Granular Course	Design Traffic (MSA) Bituminous Course	Design CBR (%)	Pavement Composition (As Per IRC: 37-2018)	Specification
	20	10	10	10	7	BC - 40mm	PMB 70

Homogenous Section	Design Period (year)		Design Traffic (MSA)		Design CBR (%)	Pavement Composition (As Per IRC: 37-2018)	Specification
	Granular Course	Bituminous Course	Granular Course	Bituminous Course			
0+000 to 15+300 and 0+000 to 2+130						DBM – 60mm	VG 30
						WMM – 250mm	-
						GSB – 200mm	Grading V

Source: Pavement Design

7.5 Profile Corrective Course and Pavement Composition for Raised Portion of Road

No Profile Corrective Course has been considered for the entire stretch.

7.6 Road Rehabilitation Proposals

As per the visual inspection and reconnaissance survey, it was observed that the condition of the project road was bad with most of the cracks being clearly visible. So, no overlay has been proposed along the entire stretch. Entire stretch is considered for reconstruction.

7.7 Intersection/Junction Improvement Proposals

There are 3 major and 7 minor junctions including earthen and gravel roads. Crossroads with paved carriageways are only considered for development. The details of existing junctions and proposed development are summarized in ***Table* 7-4**.

Table 7-4: Details of Junctions

S. No.	Chainage (Km)	Type	Location	Major/ Minor Junction	Side	
					L	R
Ghagrabasti to Mazgaon (PKG-1)						
1	0+000	T	Ghagarabasti	Major	Gohpur	Borbali
Mazgaon to Hawajan (PKG-2)						
2	16+725	4 Leg	Lakhimpur	Major	Simaluguri	Ganakdoloni
3	26+006	T	Howajan	Major	Lakhimpur	Guwahati
Sonapur to Holongi Chariali Airport Road						
NIL						

S. No.	Chainage (Km)	Type	Location	Major/ Minor Junction	Side L	Side R
Ghagrabasti to Mazgaon (PKG-1)						
1	2+550	T	Naya Ghagra	Minor	-	Rangajan
2	4+350	4 Leg	Sonapur	Minor	Santipur	Dholpur
3	6+370	T	Gohpur	Minor	-	Rangajan
4	6+760	4 Leg	Gohpur	Minor	Kakilamaj Gaon	Rangajan
5	9+120	4 Leg	Majgaon	Minor	Bijaypur	Alupara
6	13+745	4 Leg	Alupara	Minor	Alupara	Goraimari Shatra
Mazgaon to Hawajan (PKG-2)						
7	15+915	T	Bikrompur	Minor	Letekujan	-
Sonapur to Holongi Chariali Airport Road						
8	2+130	T	Hollongi Chariali	Minor	Towards NH-52	Papum Pare

Source: Design Report

7.8 Improvement Proposals for Existing Horizontal Curves

The improvement proposal for existing horizontal curves is presented in ***Table* 7-5**.

Table 7-5: Details of improvement proposal for existing curves

Sr. No.	Curve Direction	Survey chainage From	Survey chainage To	Existing radius (m)	Proposed radius (m)	Remarks
Ghagrabasti to Mazgaon (PKG-1)						
1	Right	2+000	2+125	60	110	Improvement considering Under Construction structure 2+187
2	Right	2+225	2+400	220	250	Improvement considering Under Construction structure 2+430
3	Left	4+950	6+500	-	250	Realignment
4	Right	6+950	7+350	-	2000	Improvement considering for deficient in geometry
5	Right	7+375	7+700	-	500	Improvement considering Proposed Bridge 6+978
6	Left	7+725	8+125	200	800	Improvement considering Proposed Bridge 7+325
7	Left	9+500	10+575	20	400	Realignment
8	Right	12+875	14+575	300	500	Realignment
Mazgaon to Hawajan (PKG-2)						

Sr. No.	Curve Direction	Survey chainage From	Survey chainage To	Existing radius (m)	Proposed radius (m)	Remarks
9	Right	15+550	15+775	220	400	Improvement considering for deficient in geometry
10	Right	23+850	24+625	250	1000	Improvement considering for deficient in geometry
11	Right	26+690	26+775	-	5000	Improvement considering for deficient in geometry

7.9 Proposal for Service Roads and Slip Roads

There is one slip road present along the project corridor and details of the proposals for slip road are presented in ***Table* 7-6**.

Table 7-6: Schedule of Service Road

SI. No.	Design Chainage		Side	Length (m)	Remarks
	From	To			
NIL					

7.10 Bypass and Realignment Proposals

The details of the Realignment proposals for the project road are presented in ***Table* 7-7**.

Table 7-7: Summary of Recommended Bypass/Realignments

SI. No.	Start Point		End Point		Length of Realignment (km)
	Place	Existing Chainage	Place	Existing Chainage	
Realignment no. 1					
Existing Alignment	Sonapur	4+950	Sonapur	6+500	1.550
New Alignment	Sonapur	4+950	Sonapur	6+140	1.190
Realignment no. 2					
Existing Alignment	Salbari	9+500	Daimalu	10+575	1.075
New Alignment	Salbari	9+125	Daimalu	10+050	0.925
Realignment no. 3					
Existing Alignment	Alupara	12+875	Alupara	14+575	1.700
New Alignment	Alupara	12+325	Alupara	13+740	1.415
4. Realignment no. 4					
Existing Alignment	Niran Chuba	23+850	Niran Chuba	24+625	0.775
New Alignment	Niran Chuba	23+000	Niran Chuba	23+725	0.725

7.11 Recommended Alignment of Project Road

The recommended alignment of the project road comprised of retained existing alignment, improved alignment at several locations considering the structures (retained and reconstruction) and realignments to improve the geometry of alignment at certain locations.

The project road alignment starts from existing Ch. 0+000 at Ghagrabasti and follows the alignment up to Ch. 2+000. At this point **Realignment-1** is proposed from Ch. 2+000 to 2+130**. Realignment-2 at Sonapur** is proposed that starts from existing Ch. 4+775 to Ch. 5+332 and 5+342 to 6+200. Total length of Realignment - 2 is 1.415 km. From Ch. 6+200 the alignment follows existing alignment upto Ch. 6+770.

After that, the **Realignment-3 at Salbari** is proposed that starts from existing Ch. 6+770 to Ch. 6+978 and from Ch. 6+990 to 7+312 and 7+342 to 7+554 and ch. 7+566 to 7+750. Total length of Realignment-3 is 0.936 km. From Ch. 7+750 to 9+125 the alignment follows existing alignment.

The **Realignment-4** is proposed from Ch. 9+125 to 10+060**. Realignment-5 at Alupara** is proposed that starts from existing Ch. 12+300 to Ch. 13+740 and from Ch.14+800 to 15+000. Total length of Realignment-5 is 1.640 km.

Based on the land and socio-economic parameters of Existing and New alignment options at six locations, it is observed that the Existing Alignment involves partial land acquisition as compared to new alignment. So, the cost incurred for land acquisition for Existing alignment will be minimal as compared to new alignment.
However, by considering the geometric deficiency of existing roads, safety and comfort of drivers, it is suggested to follow the New Alignment for all six locations.

7.12 Roadside Drains

No Earthen drain is proposed along the entire stretch whereas Built-up drains are proposed at settlements locations. The details of the roadside drains are presented in ***Table* 7-8**.

Table 7-8: Details of roadside drains

S. No.	Chainage		Length (m)	Built-up Drains		Earthen Drains	
	From	To		Left	Right	Left	Right
Ghagrabasti to Mazgaon (PKG-1)							
NIL							
Mazgaon to Hawajan (PKG-2)							
1	16+740	16+785	45	**1.5**	**1.5**	**-**	**-**
Sonapur to Holongi Chariali Airport Road							
NIL							

Source: TCS

7.13 Proposal for New Bridges

The improvement proposal for new bridges along the project road stretch are mentioned in ***Table* 7-9**.

Table 7-9: Improvement Proposal for New Bridges

Sr. No.	Design Chainage	Name of River / Bridge	Bridge No.	Total Length of Bridge	Span Arrangements	Structure type	Bridge Type	Improvement Proposal
1	6+978	Local Nallah	32	28	Timber Bridge		Minor	Proposed MNB (1 x 12) on New Alignment
2	7+325	Local Nallah	30	28.35	Timber Bridge		Minor	Proposed MNB (1 x 30) on New Alignment

Source: Structure Condition & Inventory Survey

7.14 Proposal for ROB and RUB

No ROB and RUB have been proposed along the entire project road.

7.15 Proposal for New Culverts

No new culverts have been proposed along the entire project road.

7.16 Proposal for Flyover

No Flyover has been proposed along the entire project road.

7.17 Proposal for New Vehicular Underpass

One Light Vehicular Underpass has been proposed along the entire project road and details of the same is mentioned in ***Table* 7-10**.

Table 7-10: Improvement Proposal for New Vehicular Underpass

Sr. No.	Design Chainage	Type of Structures	Span Arrangement and Total Vent way (No. x Length)	Width (m)	Improvement Proposal	
					Type	Size
NIL						

7.18 Improvement Proposal for existing bridges

The improvement proposal for existing bridges along the project road stretch are mentioned in ***Table* 7-11**.

Table 7-11: Improvement Proposal for Existing Bridges

Sr. No.	Design Chainage	Name of River / Bridge	Bridge No.	Total Length of Bridge	Span Arrangements	Structure type	Bridge Type	Improvement Proposal/ Remarks
Ghagrabasti to Mazgaon (PKG-1)								
1	0+087	Local Nallah	49	22.5	1 x 22.5	Slab Type	Minor	Retained with Repairs
2	2+187		43	Under Construction				
3	2+430		42	Under Construction				
4	5+337	Local Nallah	37	6.5	2 x 3.25	Slab Type	Minor	Proposed MNB (1 x 10) on New Alignment
5	7+550	Local Nallah	29	15	1 x 14.3	Slab Type	Minor	Proposed MNB (1 x 12) on New Alignment
6	13+882		16	Under Construction				
7	14+387		15	Under Construction				
8	15+230	Local Nallah	13	7.3	2 x 3.65	Slab Type	Minor	Proposed MNB (1 x 10)
Mazgaon to Hawajan (PKG-2)								
9	15+832	Local Nallah	11	6.7	2 x 3.35	Slab Type	Minor	Retained with Repairs
10	23+014	Local Nallah	5	9	1 x 9	Slab Type	Minor	Proposed MNB (1 x 12) on New Alignment
11	23+308	Local Nallah	4	25.1	1 x 25.1	Slab Type	Minor	Proposed MNB (1 x 48) on New Alignment
12	23+308	Local Nallah	3	12.4	1 x 12.4	Slab Type	Minor	Proposed MNB (1 x 15) on New Alignment
Sonapur to Holongi Chariali Airport Road								
13	1+818	Local Nallah	1	8	1 x 8	Slab Type	Minor	Retained with repairs

Source: Structure Condition & Inventory Survey

7.19 Improvement Proposal for existing culverts

The improvement proposal for existing culverts along the project road stretch are mentioned in

Table 7-12.

Table 7-12: Improvement Proposal for Existing Culverts

Sl. No.	Location (km)	Type of Structures	Span Arrangement and Total Ventway (No. x Length)	Width of Culvert (m)	Improvement Proposal	
					Type	Size
Pipe Culverts						
1	0+575	Pipe Culvert	2 x 900mm	6.1	Box Culvert	1 x 3.0 x 2
2	0+992	Pipe Culvert	3 x 1200mm	10.15	Box Culvert	1 x 4.0 x 2.75
3	2+050	Pipe Culvert	NV	NV	Box Culvert	1 x 3.0 x 3
4	2+064	Pipe Culvert	1 x 1000mm	7.65	Box Culvert	1 x 3.0 x 3
5	3+847	Pipe Culvert	1 x 900mm	7.5	Box Culvert	1 x 3.0 x 2
6	4+110	Pipe Culvert	1 x 1000mm	10.15	Box Culvert	1 x 2.0 x 1.75
7	5+952	Pipe Culvert	1 x 900mm	7.5	Box Culvert	1 x 3.0 x 2.25
8	6+724	Pipe Culvert	2 x 900mm	7.5	Box Culvert	1 x 3.0 x 2
9	6+777	Pipe Culvert	1 x 900mm	7.5	Box Culvert	1 x 3.0 x 1.5
10	7+165	Pipe Culvert	1 x 900mm	7.5	Box Culvert	1 x 4.0 x 3
11	8+214	Pipe Culvert	1 x 600mm	7.6	Box Culvert	1 x 1.5 x 1.5
12	9+113	Pipe Culvert	1 x 600mm	7.6	Box Culvert	1 x 1.5 x 1.5
13	10+569	Pipe Culvert	1 x 900mm	7.6	Box Culvert	1 x 3.0 x 2.25
14	11+328	Pipe Culvert	1 x 900mm	10.15	Box Culvert	1 x 2.5 x 2.25
15	12+467	Pipe Culvert	2 x 1200mm	10.15	Box Culvert	1 x 3.0 x 2.5
16	12+543	Pipe Culvert	1 x 1000mm	10.1	Box Culvert	1 x 1.5 x 1.5
17	12+810	Pipe Culvert	1 x 1000mm	10.3	Box Culvert	1 x 1.5 x 1.5
18	15+316	Pipe Culvert	1 x 1000mm	10.3	Box Culvert	1 x 4.0 x 3.75
19	15+449	Pipe Culvert	1 x 1000mm	10.15	Box Culvert	1 x 3.0 x 3.75
20	15+738	Pipe Culvert	1 x 1000mm	10.15	Box Culvert	1 x 3.0 x 3.25
21	16+460	Pipe Culvert	1 x 1000mm	10.15	Box Culvert	1 x 1.5 x 1.25
22	19+092	Pipe Culvert	1 x 1000mm	10.1	Box Culvert	1 x 2.5 x 3
Slab and Box Culverts						
1	1+350	Slab Culvert	1 x 3.2	7.05	Box Culvert	1 x 4.0 x 3
2	4+339	Slab Culvert	1 x 3.5	5.45/ 6.10	Box Culvert	1 x 3.5 x 1.75
3	4+375	Slab Drain	1 x 0.95	4.80	Box Culvert	1 x 2.0 x 1.5

Sl. No.	Location (km)	Type of Structures	Span Arrangement and Total Ventway (No. x Length)	Width of Culvert (m)	Improvement Proposal	
					Type	Size
4	5+505	Skew Slab Culvert	1 x 2.75	4.6/5.3	Box Culvert	1 x 3.0 x 2.25
5	9+800	Slab Culvert	1 x 1	7.65	Box Culvert	1 x 2.5 x 1.5
6	9+903	Slab Culvert	2 x 1.7	5.50	Box Culvert	1 x 4.0 x 2.5
7	10+321	Slab Culvert	1 x 2.5	6.00	Box Culvert	1 x 3.5 x 1.75
8	10+936	Slab Culvert	1 x 1.5	6.00	Box Culvert	1 x 2.0 x 2.25
9	12+064	Slab Culvert	1 x 3	6.85	Box Culvert	1 x 3.0 x 3.25
10	15+045	Slab Culvert	1 x 3.45	6.35	Box Culvert	1 x 4.0 x 2.25
11	16+509	Box Culvert	1 x 2	12.00	Box Culvert	1 x 2.0 x 1.5
12	22+064	Box Culvert	2 x 3	8.10	Box MNB	2 x 3.0 x 3.75
13	22+204	Box Culvert	1 x 3	8.10	Box Culvert	1 x 4.0 x 4.5
14	24+612	Box Culvert	1 x 3	8.20	Box Culvert	1 x 3.0 x 3.5
15	25+727	Box Culvert	2 x 3	8.15	Box MNB	2 x 3.0 x 3
Sonapur to Holongi Chariali Airport Road						
1	1+000	Box Culvert	1 x3	7.50	Box Culvert	1 x 4.0 x 3
2	1+500	Box Culvert	1 x 3	7.50	Box Culvert	1 x 3.0 x 3
3	2+125	Box Culvert	1 x 2	7.50	Box Culvert	1 x 2.0 x 1.5

Source: Structure Condition & Inventory Survey

7.20 Rehabilitation Proposal for existing bridges and culverts

Bridges that are in the project corridor are box type minor bridge, slab type minor bridge. The following repairs and rehabilitation measures have been considered:

1. Parapet walls/ railings/ crash barrier shall be repaired and painted.
2. All expansion joints are clogged. So, the expansion joints shall be cleaned at some locations and will be repaired at some portions.
3. Drainage spout of the bridge is choked up, so that needs to be cleaned.
4. Repairing or Replacement of Bearing if needed on minor bridges.
5. Repairing or Replacement of wearing coat if needed.

7.21 Traffic Facilities

7.21.1 Proposal for Bus Bays and Bus Shelter

The details of the Bus Bays and Bus Shelters are presented in ***Table* 7-13** and ***Table* 7-14** respectively.

Table 7-13: Bus Bay Details

Sl. No.	Location	Design Chainage (km)	Side	Remarks
Nil				

Table 7-14: Bus Shelter Details

Sl. No.	Location	Design Chainage (km)	Side	Remarks
Ghagrabasti to Mazgaon (PKG-1)				
1	MC Sonapur	3+575	Both Side	-
2	Doimalu	11+150	Both Side	-
3	Alupara	12+950	Both Side	-
Mazgaon to Hawajan (PKG-2)				
4	3 No. Simaluguri	16+870	Both Side	-
5	Futabhug	20+150	Both Side	-

7.21.2 Proposal for Truck Lay Byes

The details of the Truck Lay Byes are presented in ***Table* 7-15**.

Table 7-15: Truck Lay Byes Details

Sl. No.	Location	Design Chainage (km)	Remarks
Nil			

7.21.3 Proposal for Pedestrian and Cattle Crossing

The Pedestrian and Cattle Crossing has been proposed at junction location, bus bay location, bus shelter location, Start and end of the village.

7.21.4 Wayside Amenities

Wayside Amenities like Bus Shelters, Bus Bays are provided as mentioned in ***Table 7-13 & Table 7-14****,* Solar Street Lights are proposed at Major & Minor Junctions. Overhead Gantry is proposed at the start and end of the project road and Cantilever Gantry are proposed at all the Major Junctions.

7.21.5 Miscellaneous provisions for traffic guidance and safety

The road traffic signs, road markings and safety devices for the project are provided as per IRC standards.

- Cautionary / Warning sign boards at turning/bend, structure, junction, school and built-up locations.
- Regulatory Sign Board at speed restrict location and junctions.
- Informatory sign board at junctions, villages and existing facility locations.
- Chevron Board at curve locations.
- Hazard marker at structure, crash barrier location and island locations.

7.22 Road Furniture and Safety Measures

7.22.1 Introduction

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

- Road Markings

- Kilometre Stone
- 200m Stones and Boundary Stones
- Delineators and Object Markers
- Crash Barrier
- Rumble Strips
- Road Studs
- Traffic Control and calming devices
- Traffic Diversion Plan

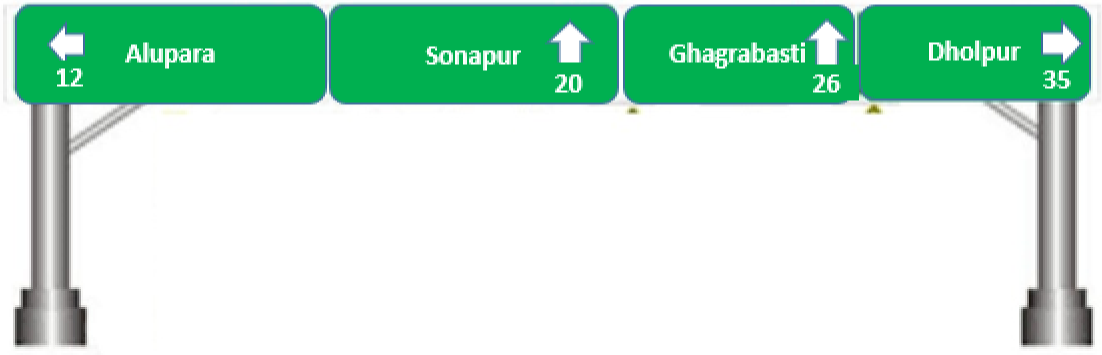
7.22.2 Road Markings

Road markings perform the important function of guiding and controlling traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. The Code of Practice for Road Markings, IRC: 35-2015 will be used in the study as the design basis.

The location and type of marking lines, material and color is followed using IRC: 35-2015 – “Code of Practice for Road Markings”.

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

Figure 7-1: Road Marking



7.22.3 Cautionary, Mandatory and Informatory Signs

Cautionary, Mandatory and Informatory signs are provided depending on the situation and function they perform in accordance with the IRC: 67-2012 guidelines for Road Signs. Overhead and Cantilever gantry sign boards are proposed at appropriate locations.

Figure 7-2: Road Signages

Figure 7-3: Schematic Gantry Signage's at Project Road

7.22.4 Kilometre Stone Details

The details of kilometre stones are in accordance with IRC: 8-1980 guidelines. Kilometre stones are located on the left-hand side of the road as one proceeds from the station from which the Kilometre count starts. On divided roads with a central median, kilometre stones should be provided at the left on both sides of the road i.e., independently for each direction of travel. Kilometre stones shall be fixed at right angles to the centre line of the carriageway.

Figure 7-4: kilometer stone details

7.22.5 200 m Stones and Boundary Stones

The details of 200m stones and boundary stones conform to IRC: 26-1967 and IRC: 25-1967 respectively. 200m stones are located on the same side of the road as the kilometre stones. The inscription on the stones shall be the numerals 2,4,6 and 8 marked in an ascending order in the direction of increasing kilometrage away from the starting station. The numerals shall be 80mm high. The colour of the numerals shall be black on a white background. Boundary stones shall be located on either side of the road opposite every 200m stone and kilometre stone. In addition, these shall be fixed at all angular points of the boundary. Where the boundary is on a curve or the land is of significant value and likely to be encroached upon, the boundary stones, as required, shall be installed at closer intervals.

7.22.6 Guard Rails

The guard rail is proposed at the built-up section where the pedestrian movement is predominant and need to bifurcate the road users among pedestrian and vehicular.

7.22.7 Crash Barrier

Metal Beam Crash Barrier is proposed at locations where the embankment height is more than 3.0m, at horizontal curves of radius less than 230m and also at major bridge approaches.

Figure 7-5: Crash Barrier

Wire Rope Crash Barrier are proposed for curve radii more than 450 m only. The barrier is extended at full height not less than 30 m in advance of the hazard on the approach side and shall continue at full height for 7.5 m beyond the hazard on the departure side.

Figure 7-6: Wire Rope Crash Barrier

7.22.8 Road Studs

Retro reflective studs are used to supplement longitudinal/transverse reflectorized marking, which would improve visibility at nighttime and adverse weather conditions. Road Studs are also used across the carriage way to serve as speed arrester coupled with eschewing warning through the creation of the rumbling sensation of the user. Following are the locations where road studs are proposed,

- At Junctions
- At Urban Portions
- At Structure Approaches
- Sharp Curves

7.22.9 Rumble Strips

The Road Humps are formed by providing a rounded hump of 3.7m width (17m radius) and 0.15m height for the preferred advisory crossing speed of 25kmph for general traffic as per the IRC: 99–1988 guidelines. The basic material for construction is open premix bituminous surfacing on minor roads or perpendicular arms about 25m away from the inner edge of the carriageway. Proper signs boards and markings are provided to caution the drivers in advance of the situation. Road humps are extended across carriageway up to the edge of paved shoulder.

Rumble Strips are formed by a sequence of transverse strips laid across a carriageway. Maximum permitted height of 15mm provided no vertical face exceeds 6mm. These rumble devices produce audible and vibratory effects to alert drivers to take greater care and do not normally reduce traffic speeds in themselves. The typical design details of rumble strips proposed are transverse strips of open premix bituminous surfacing 500mm wide and overall thickness 15mm laid across a carriageway up to the end of paved shoulder. There will be 6 such transverse strips spaced at 1.0m c/c. Rumble strips are proposed in advance of:

i. Sharp curves with radius less than 170m.

ii. Transition zones (speed limit zones).
iii. Village/urban approaches.

Proper sign boards and marking are proposed to advise the drivers in advance of the situation.

Figure 7-7: Rumbler Strip

7.22.10 Gabion Wall

River protection work, i.e. Gabion walls are proposed near pond locations. The treatment of slope Protection Work is provided with Dry Stone Pitching and Geobags.

Figure 7-8: Gabion Walls

7.23 Landscaping and Arboriculture

All cut trees will be compensated with preference to fast-growing local species which are more efficient in absorbing carbon emissions. Plantation of trees along the right of way shall contribute substantially to the reduction of air and noise pollution acting as sinks for air pollutants and barrier to noise. Afforestation programs and landscaping along the project road shall provide greenery which ultimately reduces pollution and improves the environmental quality. The tentative list of species that can be planted along the project road include Chatuani, Siris, Dhupi, Barna, Champa, Kanak Champa, Tamul, Kotal, Velow, etc.

CHAPTER 8

ENGINEERING DESIGN

8 Engineering Design

8.1 Objectives of Engineering Design and its Purpose

Engineering design of a road contributes in the process of optimized efficiency and safety while minimizing cost and environmental damages. Engineering design also focuses on designing roads to accommodate broader community goals, which leads to providing access to employment, schools, businesses and residences, accommodate a range of travel modes such as walking, bicycling and automobiles, and minimizing fuel use, emissions and environmental damage.

The objectives of highway design are broadly defined as follows:

- To provide Maximum efficiency in the traffic operation
- To provide maximum safety to the users
- To save time of travel
- To increase the travel speed of vehicles
- To increase no of vehicles on road
- To reduce the cost of transportation
- To provide comfort of travel to the users.

Pavement design focuses on sufficiently reducing the transmitted stresses due to wheel load, so that they will not exceed the bearing capacity of the sub-grade. Two types of pavements are generally recognized to serve this purpose, namely flexible pavements and rigid pavements. In this road, we would be proposing flexible pavement for the reduction of transmitted load.

The purpose of this chapter is to provide a brief introduction about the components included in the highway design, types, design principles, specifications and standards which would be used in the preparation of road design drawings and report.

8.2 Alignment & Geometry

The basic aim of highway design is to identify technically sound, environment-friendly and economically feasible highway alignment. The particular section of the report deals with the design methodology, design control, design values and design results associated with geometric design of project corridor.

The project road namely Ghagrabasti to Hawajan via Holongi Airport traverse through the plain terrain hence all the guidelines of IRC associated with the geometric design of road in plain terrain are followed.

The IRC SP 73-2018 (Manual of Specifications and Standards for Two Laning of Highway with Paved Shoulder) and Guidelines issued by PMU PWRD for Preparation of DPR (Detailed Project Report) has been followed for the design of geometrics.

The main components included in the highway design are:

- Cross-sectional elements
- Horizontal alignment
- Vertical alignment/profile

- Intersection/Junctions Design
- Miscellaneous items

The proper geometric design would play a pivotal role to ensure the proper functioning of the proposed facility. The design standards as described in the chapter namely Design Standard would be ensured with a realistic compatibility with the existing ROW, utilities and optimum land acquisition.

The preliminary geometric design has been duly updated in accordance with the road safety audit carried out at various stages as preliminary design and detailed design stage.

8.3 Cross Sectional Elements

8.3.1 Lane Width

Standardized lane width is followed with reference to IRC SP 73-2018. The width of a basic traffic lane is proposed to be 3.50m throughout the project stretch.

8.3.2 Earthen Shoulders

The guidelines issued by PMU PWRD Assam for preparation of Detailed Project Report Under Axom Mala has been followed for the provision of earthen shoulder. Due to the constraints in acquiring proposed ROW as 85% of the stretch passes through forest area, the width of earthen shoulders is kept 1.5m throughout the stretch.

8.3.3 Paved Shoulder

No paved shoulders are proposed in the project road due to ROW constraints.

8.3.4 Footpath

Footpath is not provided in the project road due to ROW constraints.

8.3.5 Utility Corridor

Utility corridor is not provided in the project road due to ROW constraints.

8.3.6 Side Slopes

The guidelines issued by PMU PWRD Assam for preparation of Detailed Project Report Under Axom Mala and IRC SP 73-2018 (Manual of specification and standards for two laning of highways with paved shoulder has been followed for the side slope specifications.

8.3.7 Crossfall

The guidelines issued by PMU PWRD Assam for preparation of Detailed Project Report Under Axom Mala and IRC SP 73-2018 (Manual of specification and standards for two laning of highways with paved shoulder has been followed for the crossfall. The crossfall for main carriage way is proposed as 2.5% in case of flexible pavement and 2.0% in case of rigid pavement. The crossfall for paved shoulder is kept same as flexible and rigid pavement as 2.5% and 2.0% respectively. The crossfall for the earthen shoulder is proposed as 3%.

8.3.8 Proposed RoW

The guidelines issued by PMU PWRD Assam for preparation of Detailed Project Report Under Axom Mala has been followed for the consideration in proposed right of way. The upgradation / rehabilitation of the project road has been envisaged within the available ROW of 25-52m in rural stretches and about 17-26m in built-up areas.

8.4 Alignment Design

8.4.1 General

The section of the report deals with the description of alignment design procedure, short description of pre-design activities, software adopted, control elements and other allied activities. The alignment design has been carried out as per IRC SP 73-2018 with due consideration to design speed, desirable radius and absolute minimum radius. The alignment design also considers the specifications stipulated in guidelines issued by PMU PWRD Assam.

8.4.2 Preparation of Base Plan

Base plan of proposed alignment showing all natural & man-made features is prepared using the topographical data on the basis of result of topographical survey. The topographical survey is carried out to collect three-dimensional data in cross sectional as well as longitudinal direction at suitable interval in the form of Northing, Easting and Altitude. All the features within the specified band width were captured with a unique “description code” during the survey. This data is downloaded into “Highway Design Software – AutoCADCivil3D” environment to prepare the base plans. These base plans well equipped with the 3D polyline is used for the preparation of Digital Terrain Model. The digital terrain model forms a basis for the geometric design and subsequent activities of the project.

8.4.3 Horizontal Alignment Design

The horizontal alignment design is carried out using AutoCAD Civil 3D Software on the basis of Digital Terrain Model. The horizontal alignment is designed freely along the centre of the specified band width by considering the constraints. Preliminary the horizontal alignment is designed in accordance with the design speed, desirable radius and desirable transition lengths. Further the alignment is reconciled/redesigned considering the constraints along the project stretch such as critical features, retained structures and any un-avoidable site features. Due consideration has been given for improvement to the geometric deficient portions, black spots, congested urban portion etc.

8.4.4 Vertical Alignment Design

The vertical alignment design has been carried out as per guideline issued by PMU PWRD Assam for preparation of Detailed Project Report under Axom Mala Program.

The vertical alignment of the project is being designed on the basis on designed horizontal alignment and digital terrain model. Efforts are taken to designed the vertical alignment of appropriate numbers of curves and grade change locations. Long length parabolic curves are incorporated at the locations of grade change. The vertical alignment is designed considering the ruling gradient as the project stretch passes through plain terrain. In addition to the standards and guidelines set a number of other considerations are made to design the vertical profiles, which are presented below:

- Minimum length of vertical curve as 50m.
- Maximum gradient of 2.0% at bridge approaches.

The top levels of the culverts, minor bridges and raising of the existing formation within the settlements are being considered as control points in design of vertical profile of the alignment. The vertical profile of the road at the locations of structures approaches is raised considering the deficiency of the existing vertical profile. The vertical profile is designed to provide the adequate safe sight distance throughout the project stretch. The vertical alignment controlling factors are elaborated in below table,

Table 8-1: Vertical Alignment Controlling Factors

Sr. No.	Particulars/Element/Control Factors	Unit/No
1	Structure (Reconstruction/ New Construction)	49
2	Structure (Retained)	03
3	Settlements (Major)	08
4	Settlements (Minor)	11
5	Railway Crossing	01

8.5 Pavement Design

Pavements shall be designed to accommodate current and predicted traffic needs in a safe, durable and cost-effective manner. As the pavement forms the basic support of the road, the analysis and design of pavement is very crucial. The structural models are analysis approaches to determine the pavement responses (stresses, strains and deflections) at various locations in a pavement due to the application of wheel load.

The most common structural models are layered elastic model and visco-elastic models. Layered elastic model: A layered elastic model can compute stresses, strains and deflections at any point in a pavement structure resulting from the application of a surface load. Layered elastic models assume that each pavement structural layer is homogeneous, isotropic, and linearly elastic. In other words, the material properties are same at every point in a given layer and the layer will rebound to its original form once the load is removed. The layered elastic approach works with relatively simple mathematical models that relate stress, strain, and deformation with wheel loading and material properties like modulus of elasticity and poissons ratio.

The section deals with the description of adopted methodology for pavement design of the project corridor, elaboration of input data as soil results, traffic data in terms of commercial vehicle per day & vehicle damage factors and design calculation of pavement design.

8.5.1 Design Principles

The section deals with the elaboration of principles and approach of design adopted for the project stretch pavement design. The pavement design is carried out to arrive at safe, economical and performing design of the section. It involves the pavement design for satisfactory functional and structural performance of the pavement during its intended service life of pavement. The detailed design involves the measuring the performance of the pavement by evaluating with certain pavement performance model such as fatigue and rutting model. The design procedure includes the adoption of mechanistic-empirical design approach for the pavement design which based on linear elastic layered theory which specifies the modelling of pavement as multi-layer system. The bottom most layer of the pavement is considered to be semi-infinite, and all upper layers are considered to be infinite in horizontal extent and finite in vertical extent. Elastic Modulus, Poisson's ratio and thickness of each layer considered to be the input for the pavement modelling and subsequently to the calculations of stresses, strains and defections produced by applied load at the top of pavement surface. IITPAVE software has been used for the analysis of pavement and calculation of each layer parameters.

The important consideration for critical evaluation of the pavement are considered are vertical compressive strain at the top of subgrade as a critical mechanistic parameter in controlling subgrade rutting and horizontal tensile strain at the bottom of bituminous layer as a critical parameter in controlling bottom up cracking of bituminous layer.

8.5.2 Design Input

The design input for the pavement design has range of values from traffic surveys to soil surveys. Specifically, the design input includes the values as commercial vehicles per day, vehicle damage factors (Weighted/Average), traffic growth rates, effective California Bearing Ratio values etc. Each of the input considered/accounted for the design of project corridor pavement is described in detailed in further section.

- Traffic
  - Commercial Vehicle Per Day

    For the purpose of structural design, only the number of commercial vehicles weight of three tones or more and their vehicle damage factors are considered. The commercial vehicle including buses, light commercial vehicles, two axle trucks, 3 axle trucks, multi axle vehicles are considered.
  - Vehicle Damage Factor

    Vehicle damage factor is a multiplier to convert the given numbers of commercial vehicles having different axle configurations and different axle weights into an equivalent number of standard axle load (80 KN Single axle with dual wheels) repetitions.
- Design Life

  The sub base and base layer of the pavement are designed for the period of 20 years whereas the bituminous binder course and wearing course are designed for 10-year design life from the year of road opening to traffic.
- Later Distribution Factor

  Lateral distribution of commercial traffic on carriage way is required for estimating the designed traffic (equivalent standard axle load applications) to be considered for the structural design of the pavement. As the project stretch falls under the category of two-lane two-way road, the distribution factor considered is 0.5 (50% of total number of commercial vehicles in both directions).

- Traffic Growth Rate

  Traffic growth rate can be defined as the projected rate at which the traffic will grow during design period to arrive at cumulative design traffic at the end of design period. The traffic growth is rate is projected for individual class of vehicle and projected generalized growth rate of 6.5% is considered for estimating the traffic for pavement design.
- Design Traffic

  The guidelines issued by PMU PWRD Assam for preparation of Detailed Project Report under Axom Mala Program are followed for design traffic. Following are the notable points which considered to arrive at design traffic.

  - If 20-year design life traffic (MSA) is less than 10 MSA, then consider 10 MSA for design of sub base and base layer.
  - If 20-year design life traffic (MSA) is more than 10 MSA, then consider actual MSA for design of sub base and base layer.
  - If 10-year design life traffic (MSA) is less than 10 MSA, then consider 10 MSA for design of bituminous binder layer and wearing course.
  - If 10-year design life traffic (MSA) is more than 10 MSA, then consider actual MSA for design of bituminous binder layer and wearing course.
- Pavement Layer Input

  Pavement composition with regards to the flexible pavements is consists of three functional layers above the subgrade. The layer composition is composed of sub base, base and bituminous layer.
- Subgrade

  Subgrade forms an important layer of pavement composition as deals with the structural support of the pavement. The design input of the subgrade depends upon the nature of material being used in embankment as subgrade. If the material representing the varying CBR used in the embankment subgrade then the combined effect of the both layer in terms of effective CBR calculated based resilient modulus of each layer shall be accounted in the design.

  The CBR values resulted from the soil investigation are considered for the design. The CBR values of the borrow area soil based on their result are considered for the subgrade soil. Following equations are adopted for the calculation of Resilient Modulus of the subgrade from CBR values
- Borrow Area CBR

  There is borrow area located along the project stretch nearby to the places namely Uttar Kamla Bari at approximate chainage of 0+500m. The CBR value of Uttar Kamla Bari borrow area is 8%. For the purpose of design in homogeneous section as previously explained the subgrade CBR value is considered as 7%. (Minimum of Two values).
- Sub Bases
- Bases

The base layer of the pavement consists of wet mix macadam confirming to MORT&H specifications. The proposed bases are falls under the nature of unbound granular layer, hence the combined effect of both sub base and base considering the granular layer is accounted in calculation of resilient modulus with the support modulus of subgrade.

8.6 Bituminous Layer

The bituminous layers are consisting of bituminous surface layers and bituminous binding layers. As the road categorized under Major District Road and design traffic falls under the range of 20 MSA to 50 MSA, bituminous concrete with VG40 grade considered as a part of surface course. The dense bituminous macadam is proposed with VG 40 ad a layer of binding course in the pavement.

Table 8-2: overview of IRC guidelines on recommendations on Bituminous layer

Sr. No	Traffic Level	Surface Course		Base/Binder Course	
		Mix Type	**Bituminous Type**	**Mix Type**	**Bitumen Type**
1	20-50 MSA	SMA	Modified Bitumen /VG40	DBM	VG40
		GGRB	Crumb Rubber Modified Bitumen		
		BC	Modified Bitumen /VG40		
2	<20 MSA	BC/SDBC/PMC/MSS/ Surface Dressing	VG40 / VG30	DBM/BM	VG30/VG40

Source: IRC 37

With reference to the decided homogeneous section and design input the pavement design is carried out in accordance with the IRC 37 by selecting trial section and assessing the suitability with respect to IITPAVE results and requirement of pavement performance models.

With reference to the structural catalogue of IRC specification for 7% CBR the trial thicknesses considered for the pavement design of entire corridor is elaborated in table below:

Table 8-3: Trial thickness

Sec. No	Project stretch Ch	Traffic [BT Layers]	Traffic [Granular Layers]	Trial Pavement Composition	Specification
1	0+000 to 26+006 & 0+000 to 2+130 m	10MSA	10MSA	BC 40mm	PMB 70
				DBM 60mm	VG 30
				WMM 250mm	-
				GSB 200mm	Grading V

Source: Design Catalogue IRC 37

8.7 Specifications

The section deals with the specifications and characterization of each layer. The material is standardized with the specifications of the Ministry of Road Transport and Highways with subsequent section. The general specification sections and characterization of proposed material is presented in below table:

Table 8-4: Materials Specification and Characterisation

Sr. No.	Pavement Layers	MORT&H Vth Rev Sections
1	Embankment Construction	Section 305
2	Subgrade	Section 305
3	Granular Sub-base	Section 401
4	Base Course-WMM	Section 406
5	Prime Coat	Section 502
6	Tack Coat	Section 503
7	Dense Bituminous Macadam	Section 507
8	Bituminous Concrete	Section 512
9	Prefabricated Vertical Drain	Section 314

With consideration to above specifications and guidelines stipulated for the pavement design, the material specifications proposed for the proposed are elaborated in table below:

Table 8-5: Proposed Materials Specification and Characterisation

Sr. No.	Pavement Layers	Specification
1	Embankment	CBR 8% Minimum and Non-Expansive Material with compliance to section 305 of MORT&H.
2	Subgrade	CBR 8% Minimum and Non-Expansive Material with compliance to section 305 of MORT&H.
3	Granular Sub Base	Grading V as per section 401 of MORT&H.
4	Wet Mix Macadam	Aggregate Gradation as per Table 400-13 of MORT&H.
5	Dense Bituminous Macadam	Grading 2 as per section 505 of MORT&H.
6	Bituminous Concrete	Grading 2 as per section 507 of MORT&H.
		Polymer Modified Bitumen

The details of the Engineering Design along with the Use of Modern Technique and Suitability of Local Materials are mentioned in **Volume II** Part 1 - Roads.

8.8 Deviation to Standards

The geometric design of the road is carried out in accordance with standards and specification stipulated in chapter namely Proposed Design Standards and Specifications. The guidelines issued by PMU PWRD for the preparation of DPR under Axom Mala has also been followed.

The project corridor passes through major as well as minor settlements, crosses to railway level crossing, also includes the retained structures as obligatory points to the alignment. The section deals with the deviations which occurs because of site and other constraints.

Following table elaborates the detailed summarized statement of deviation to standards which resulted because of several constraints,

Table 8-6: Deviation to Standards

Sr. No.	Item	Standards and Specification Reference	Proposed Provision	Remark/Constraint
1	Design Speed	Ruling 100kmph Minimum 80kmph	Designed the project stretch with 80-100 kmph except at few locations	
			• Project stretch from 1900 to 2550 is designed with 65 kmph.	Due to Under Construction bridge.
			• Project stretch from 7150 to 7300 is designed with 65 kmph	Section falling in urban location.
			• The project stretches from 20900 to 21320 is designed with 65 kmph.	Section falling in urban location.
2	Earthen Drain	Standard size of earthen drain 2.5m	No earthen drain is proposed along the project stretch	As instructed by PWRD Assam, there is no provision of earthen drain.

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CHAPTER 9

ENVIRONMENTAL ASSESSMENT & EMP

9 Environment Assessment & EMP

9.1 Introduction

This report summarizes the findings and results of the Environmental Assessment carried out for the **Ghagrabasti to Hawajan via Holongi Airport [A28]** road under Improvement and up-gradation of SH's and MDR's under Asom Mala. The Asom Mala Road Improvement Program will improve transport connectivity in the state by rehabilitating and upgrading Major District Roads (MDR's) and State Highways (SH's).

As a part of this strategy, improvement and up-gradation work for the Ghagrabasti to Hawajan via Holongi Airport [A28] of Asom Mala Group 3 is being undertaken. The project road is aimed at improving and strengthening the existing road which would facilitate safer and more efficient access to livelihood and socio-economic opportunities for the local communities in the region.

The Environmental Assessment Report (EAR) has been prepared in accordance with laws and regulations of the Ministry of Environment, Forest and Climate Change, India, and the Asian Infrastructure Investment Bank. The given project does not require Environmental Clearance under Environmental Protection Act, 1980. The project road is neither a new state highway nor a state highway expansion project in hilly areas (above 1000 MSL) and not located within any eco-sensitive area or eco-sensitive zone. Hence, Environmental Clearance from MOEFCC is not required as per EIA Notification 2006 (amended to date) and NOC from the Standing Committee of National Board for Wildlife is also not required. The road passes through the Gohpur Reserve Forest from Ch. 0+385 to Ch. 14+930 (Part-1 road) & Ch. 0+000 to Ch. 2+114 (Part-2 road), hence forest clearance is required.

9.2 Description of the Sub-Project

The project road **Ghagrabasti to Hawajan via Holongi Airport [A28]** lies in the district of Sonitpur and Lakhimpur, passes through various junctions, and spreads over the remote locations of the two districts. Lakhimpur is the administrative district in the state of Assam bounded on the North by Siang and Papumpare District of Arunachal Pradesh and on the East by Dhemaji District and Subansiri River whereas Majuli District stands on the Southern side and Biswanath District is on the West. Sonitpur lies on the plains between the foothills of the Himalayas and the valley of the Brahmaputra which forms its southern border.

The project road consists of two alignments wherein the first alignment originates from Ghagrabasti on NH-415 at Y-junction where the left side of the NH-415 goes to Itanagar and the right side to Gohpur. The project road ends at Hawajan on NH-15 making a T-junction. The second alignment initiates near Sonapur on Ghagrabasti to Hawajan section and traverses in the north direction to end at Proposed Holongi Airport. The road is well surrounded by SH's and NH's like NH-15, NH-415, NH-13, SH-43, SH-45. The project road experiences a good portion of the agricultural area on both sides of the road with the main crop sown being rice. Several Common Property Resources like schools, colleges, temples are observed along the project alignment depicting religious and social status. The project road has a single-lane configuration with poor to fair conditions.

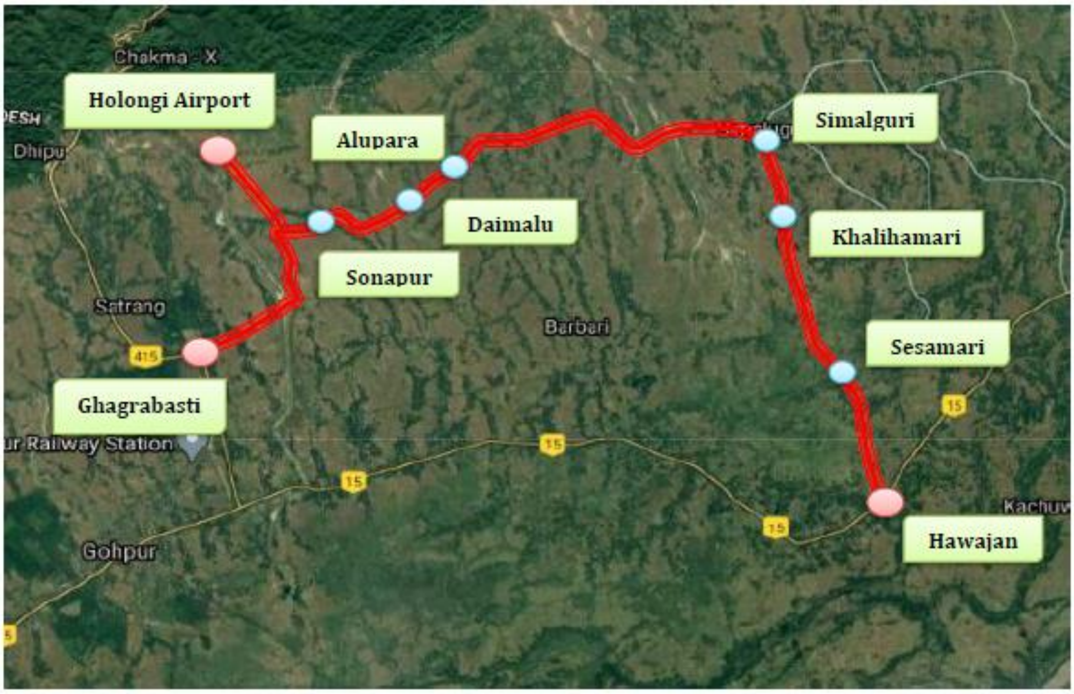


Figure 9-1: Map showing Ghagrabasti to Hawajan via Holongi Airport Road

9.3 Description of Environment

Meteorological Conditions: The high temperature is experienced during the South-West monsoon season which generally starts in June and lasts till the beginning of October every year. The cold season starts from the early part of November till late February. The winters are generally cold and foggy. The mean temperature (°C) data for the Lakhimpur district reveals that June is the hottest month with the mean temperature reaching up to 34°C while December is the coldest month of the year when the mean temperature dips down to 14°C. The mean maximum annual temperature as recorded in Lakhimpur is 29°C while the mean minimum annual temperature is 20°C. Lakhimpur is situated in the high rainfall zone with an annual average rainfall of 2809.90 mm received in the year 2018. The district normally receives 2 percent of rainfall in Winter Season (January-February), 20 percent in Summer Season (March-May), 55 percent in Monsoon Season (June-September), and 22 percent in the Post-Monsoon Season (October-December).

The mean temperature (°C) data for Sonitpur district reveals that June is the hottest month with the mean temperature reaching up to 32°C while December is the coldest month of the year when the mean temperature dips down to 13°C. The mean maximum annual temperature as recorded in the Sonitpur district is 28°C while the mean minimum annual temperature is 17°C. Sonitpur is situated in the high rainfall zone with an annual average rainfall of 1608.3 mm received in the year 2018. The district normally receives 2 percent of rainfall in Winter Season (January-February), 23 percent in Summer Season (March-May), 70 percent in Monsoon Season (June-September), and 5 percent in Post-Monsoon Season (October-December).

Topography: The district is mainly a flat alluvial tract; in its southern part, a few scattered 'inselbergs' of gneissic rocks not exceeding 90 to 140 m., high above mean sea level, lie along the north bank of the Brahmaputra. In the northern front along the base of the foothills of the eastern Himalayas, from where the alluvial plain gradually slopes down to the Brahmaputra, there are several low-lying mounds made up of unsorted river terraces. Some parts of the district are hills, covered with long grass jungle interspersed here and there with patches of rice fields.

Soil: Acidity is a general characteristic of the soil of the district and more so in the older alluvial soil. New alluvial soils representing the lands of the river banks are less acidic. There are often neutral and even alkaline. The phosphoric content is good in the riverside of the Brahmaputra where tea is grown. Acidic alluvial soils are suitable for the cultivation of tea. Heavy clay with a high percentage of nitrogen in low land areas gives a good return of rice, while sand looms above inundation level give a good yield of crops. Overflowing of the rivers replenishes the soil every year by depositing silt. The potash (k20) content is low in some soils and moderates in others. Soil is mostly found as sandy clay loam soil in the sampling locations and it is loaded with a sand percentage that varies from 48.94% to 48.97%. Nitrogen content varies from 2014 mg/1000g to 2015 mg/1000g and is poor in organic carbon content.

Land use: The existing land use along the subproject road is mostly agricultural and patches of rural residential areas. The land use abutting the project road is agricultural (60.95%). The built-up and semi built-up area is 3.45% and 35.61% respectively.

Water Resources and Hydrology: The purpose of the drainage is to serve by the principal rivers of the district. To name the principal river in the district Subansiri river figures are prominent. The river Subansiri has a direct link with the river. The whole drainage of the district ultimately finds its way into the Brahmaputra, which flows along the southern boundary of this district. The river here is wide and deep and remains navigable throughout the year. Its main tributaries in the district are the Burai, Bargang, Bharali, Gabharu, Dhansiri, Nanai, Noanadi and the Barnadi

The project road crosses the Solengi river at Ch. 2+400 and Sessa river at Ch. 14+900, and some nallahs are also observed crossing the alignment.

Air Quality: Ambient air quality for particulate matters (PM_{10} and $PM_{2.5}$), SO_2, NO_x & CO were monitored at Ganak doloni and Ghogra Majgaon. Ambient air quality parameters are well within the NAAQ standards prescribed by MoEF&CC and WHO air quality guidelines for residential areas. The maximum concentration of PM_{10} is 72.1 µg/m^3 found at Ghogra Majgaon, whereas the maximum concentration of $PM_{2.5}$ is 23.5 µg/m^3 found at Ghogra Majgaon. These levels are well within the standards prescribed by MoEF&CC & WHO for PM_{10} and $PM_{2.5}$ respectively. Other parameters monitored i.e. NO_x, SO_2, and CO were found within the permissible limits. Overall, the air quality along the subproject roads is not an issue.

Noise Quality: Ambient noise levels were monitored at Ganak doloni and Ghogra Majgaon and are well within the permissible limits for residential areas prescribed by CPCB and also by World Bank EHS standards of 55 dB(A) and 45 dB(A) for day time and night time respectively. The maximum recorded daytime noise level is 43.4 dB(A) at Ganak doloni and the night time noise level is 36.2 dB(A) recorded at Ghogra Majgaon.

Water Quality: To represent the true profile of the subproject area, samples from major surface water sources through which the subproject road runs were collected and analyzed as per IS- 3025. Surface water and groundwater samples were analyzed as per IS: 10500-2012.

The pH of the drinking water in the region is well within permissible limits (6.5–8.5). The level of total dissolved solids is found well within permissible limits, which varies from 77.2 mg/l to 162.88 mg/l at Ganak doloni and Naya Ghagara respectively. Other parameters analyzed like chloride, sulphate, fluorides are found well within standards. Overall, the groundwater and surface water quality in the project area is good.

Biological Environment: The subproject districts, in general, have a moderate to low percentage of forest cover. Field surveys have been carried out to identify the number and type of trees to be affected by the proposed improvement work. It is envisaged that 1652 trees existing within the proposed formation width of the subproject road. Subproject road sections do not pass through any protected area such as Wildlife Sanctuary, National park, or bio–reserve. The road passes through the Gohpur Reserve Forest from Ch. 0+385 to Ch. 14+930 (Part-1 road) & Ch. 0+000 to Ch. 2+114 (Part-2 road). No rare or endangered species are found in the corridor of impact along the subproject roads.

Socio-economic Environment: As per details from Census 2011, Assam has a population of 3.12 Crores, an increase from the figure of 2.67 Crore in the 2001 census. The total population of Assam as per the 2011 census is 31,205,576 of which males and females are 15,939,443 and 15,266,133 respectively. Lakhimpur district has a population of 1,042,137; out of which male constitutes 529,674 and female 512,463 of the total population. Sonitpur district has a population of 1,924,110; out of which male constitutes 983,904 and female 940,206 of the total population.

The project road initiates from Ghagrabasti and traverses through several important villages that are deemed important. The settlements like Ghagrabast, Nalbari, MC Sonapur, Madhya Sonapur, Narenguri, Sonarijan, Hoijangbari, 2 No. Bijaypur, Alaipur, Doimalu, Alupara, Simaluguri, Sesamiri, Futabhug, Niran Chuba, Khalihamari, Borthekerabari village have been given due consideration while designing the project road as these villages have been considered as important settlements along the project road. Agriculture is the mainstay of the people. No archaeological and historical monuments are located along the project roads. 8 schools and 12 religious structures lie in the vicinity of the project road; however, these structures will not be affected due to proposed improvement activities under the project.

9.4 Analysis of Alternatives

The existing road section has poor riding conditions with poor drainage and poor geometry which are seriously impacting and deteriorating the road surface. The poor road conditions, population growth, increase in traffic volumes and the economic development along the project corridor would continue to occur and will exacerbate the already critical situation. The existing unsafe conditions and the adverse environmental consequences, in terms of the environmental quality along the roads, would continue to worsen in the absence of the proposed improvements.

Detailed analyses of the alternatives have been conducted taking into account both with and without the project. The project road work involves improvement and up-gradation of the existing road. No alternate alignments were accessed for the Ghagrabasti to Hawajan via Holongi Airport road. 4 realignments have been proposed in the entire project stretch. The realignments have been proposed to improve the geometric design of the road and to achieve the design speed. The project road will provide a better level of service in terms of improved riding quality and smooth traffic flow. It will facilitate access to different parts of the region and improve the economic status of the region. The improvement of the existing road section is considered to be the best possible alignment. The proposed strengthening of the road is likely to have a positive impact on the economic value of the region. However, there is a certain environmental and social issue, these need to be mitigated for sustainable development.

9.5 Anticipated Environmental Impacts and Mitigation Measures

9.5.1 Design and Construction Phase

9.5.1.1 Physiography and Topography

Since the proposed project only involves widening and improvement of existing road within available ROW with minimum acquisition of additional land at some locations for improvement of road geometry, impacts on the physiography of the area would be insignificant during both construction and operation phases. The project design considered the improvement of roadside drainage conditions through the improvement of cross-drainage structures. The design of the cross-drainage structures followed IRC Guidelines.

9.5.1.2 Impacts on Soil

Since all activities will occur within the available RoW, no adverse environmental impacts are anticipated on the productive soil. Land taken on lease for access roads and construction camps will be restored to its original land use.

Land clearing and grubbing will remove vegetation and soil cover which may cause some soil erosion during monsoon. Excavations in borrow pits may lead to loss of topsoil and soil erosion. There is a risk of stream and riverbank erosion near bridges and cross drainage works. To avoid or minimize erosion, land clearing and grubbing will be conducted during the dry season, productive topsoils from borrow pits will be stored and reused in road embankment slope protection. Erosion control measures like silt screens will be installed along rivers and nallahs.

There is a risk of contamination of soil from construction material and oil spills. Contractors are required to ensure proper handling materials and able to implement spills containment. Oil contaminated waste will be properly collected, stored, and disposed of through 3rd party service providers. All fuel and lubricant storage and handling areas will be located at least 500 meters from the nearest water body and provided with perimeter interceptor drains. All construction debris will be disposed of by the Contractor on pre-designated areas as identified by the environmental specialist of the construction supervision consultant.

9.5.1.3 Water Resources and Drainage

Deterioration of water quality may occur near the construction camp and active worker's camps. This will be minimized by timing land clearing and earthmoving during the dry season;

proper handling of materials including oil, and lubricants; prohibiting the disposal of untreated sewage, and proper erosion control near rivers and nallahs.

9.5.1.4 Air and Noise Quality

A significant amount of dust will be generated during project construction. The following mitigation measures will also be undertaken:

- Asphalt and hot-mix plants will be located at least 1 km away from any inhabited urban and rural stretches along the road with the NOC from the State Pollution Control Board.
- Sprinkling of water on the active construction fronts and construction yard.
- Regular maintenance of machinery and equipment.

Substantial noise will be generated from the use of heavy equipment and the processing of rocks and asphalt. The adequate distance separating the rock crusher and hot mix plants will be required and the sourcing of "ready-made" gravel and asphalt will be promoted to avoid the establishment of these plants. Along the roads particularly near sensitive sites like schools and temples, the use of less noisy equipment, scheduling of noisy activities, and provision of noise barriers will be implemented by the contractor to minimize disturbance.

9.5.1.5 Flora, Fauna, and Ecosystem

The road passes through the Gohpur Reserve Forest from Ch. 0+385 to Ch. 14+930 (Part-1 road) & Ch. 0+00 to Ch. 2+114 (Part-2 road). No indigenous species are identified along the alignment. Compensatory plantation of **16520** trees in non-residential areas along both sides of the road will be done in place of trees felled (**1652**) as per the instructions of the forest department. Fast-growing local species of trees should be chosen for compensatory plantation in consultation with Forest Department.

9.5.1.6 Construction Workers' Camp

As the Contractors are required to source labor from the local communities along the subproject roads, the size of the construction camps will be relatively small. It is the contractual responsibility of the Contractors to maintain a hygienic camp with adequate water and electric supply; toilet facilities located away from the water bodies and wells; proper disposal of domestic refuse; temporary medical facilities; pest control; clean and adequate food; and security.

9.5.1.7 Social Environment

The construction and operation phases of the project road will have some beneficial impact on the social environment. Some increase in income of local people is expected as local unskilled, semiskilled, and skilled persons may gain direct or indirect employment during the construction phase. Since the immigration of the workforce during the construction phase is likely to be very small, the social impacts on literacy, health care, transport facilities, and cultural aspects are expected to be insignificant.

9.5.2 Operational Phase

An increase in vehicular emissions, noise level, road crashes due to higher speed vehicular speed, and oil contaminated road surface runoff will occur during the project operation phase.

The impact on air quality is not expected to be significant given the low projected traffic. Community safety is enhanced through the crash barriers, speed breakers, traffic signs, and pavement markers. Oil contamination will occur but is expected to be in trace amounts based on the low-level vehicular traffic. To control the anticipated increase in noise level measures such as good road surface will reduce the road-tire noise, prohibition of horns along with sensitive areas, road widening will increase capacity and decrease congestion of vehicles, and compensatory tree plantation near sensitive areas will be implemented.

9.6 Public Consultation

Objectives of the Consultations

The process of public participation/ consultations was taken up as an integral part of the project in accordance with environmental assessment requirements. The objectives of these consultations are:

- To inform and educate the general public, especially potentially impacted communities/ individuals and stakeholders about the proposed project activities;
- To familiarize the people with technical, environmental, social, and economic issues of the project for better understanding;
- To solicit the opinion of the affected communities/ individuals on environmental issues and assess the significance of impacts due to the proposed development;
- To foster co-operation among officers of PWD, the communities, and the stakeholders to achieve a cordial working relationship for smooth implementation of the project;
- To identify the environmental issues relating to the road improvement work;
- Assess the views of the beneficiary communities and their willingness to participate in the project in a bottom-up planning and decision-making process;
- To secure people's inputs in respect of project planning, selection of mitigation measures, and monitoring strategies;
- To ensure lessening of public resistance to change by providing them a platform in the decision-making process;
- To inculcate the sense of belongingness among the public about the project.

Consultation

Public consultations were held, as part of the Environmental Assessment study. The consultation was undertaken with project beneficiaries in the corridor of impact, and people likely to be affected due to the project on various issues affecting them and incorporation of various measures pertaining to environmental issues based on the responses from the people.

Both formal and informal modes of consultation were used in the public consultation process for the project. Consultation with the stakeholders, beneficiaries, and community leaders were carried out using standard structured questionnaires as well as unstructured questionnaires. Besides, focused ground discussions (FGDs) and personal discussions with officials, on-site discussions with project-affected stakeholders, and reconnaissance visits have also been made to the project areas. The attempts were made to encourage participation in the consultation process of Government officials from different departments that have relevance to the project.

Result of Consultation

In accordance with AIIB's ESP and ESS and Environment Impact Assessment Notification of GoI (2006), public consultations were conducted, as part of the environmental assessment study. Public Consultations were carried out at **Naya Ghagara F.S. Grant 26/31** and **Naya Ghagara** on **8th December 2019** and **Hawajan, Simaluguri, Alupara centre** and **2 No. Phutabhug** on **4th November 2020** along the proposed road alignment. A total of **35 participants (24 Male & 11 Female)** attended the consultation sessions.

Public consultation has been done in the project area during the feasibility study as well as the detailed design stage. Key issues raised during the consultation are:

- Provision of suitable drainage in the settlement areas.
- Provisions of safety measures in school and settlement areas.
- Suitable mitigation measures to address air and noise pollution.
- Provision of safety signs near the school.
- Avoid sourcing water for construction from public water sources.
- Minimize the cutting of trees.
- Construction Labor camps should not be located near settlement areas.
- Avoid borrow of earth near settlement and schools.
- Start tree plantation during the construction phase.

Most of the people interviewed strongly support the project. The people living in the entire project area expect the different project elements to facilitate transport, employment, boost economic development, and thereby provide direct, or indirect, benefits to themselves.

Figure 9-2: Public consultation at Naya Ghagara F.S. Grant 26/31

Figure 9-3: Public consultation at Naya Ghagara

Figure 9-4: Public consultation at Hawajan

Figure 9-5: Public consultation at 2 No. Phutabhug

Figure 9-6: Public consultation at Simaluguri

Figure 9-7: Public consultation at Alupara Centre

9.7 Environmental Management Plan

Civil works contract package-specific fully budgeted environmental management plan has been prepared for mitigation/ management/ avoidance of the potential adverse impacts and enhancement of various environmental components along the project road section. For each mitigation measure to be carried out its location, timeframe, implementation, and overseeing/ supervising responsibilities have been identified. The monitoring plan for the construction and operation phase has been framed to ensure the effective implementation of EMP.

The monitoring program included performance indicators for water, air, and noise level monitoring, frequency of monitoring, and institutional arrangements of the project in the construction and operation stages, along with the estimated cost. The reporting system included roles and responsibilities of each party involved in the project implementation i.e. PIU, Supervision Consultant and Contractor, and reporting mechanisms during implementation and operation phases.

9.7.1 Environmental Monitoring Plan

Environmental monitoring will be done during the construction and operation phase of the project. The objectives of the environmental monitoring plan are to a) ensure project components are compliant with all laws and approval conditions; b) measure the success of proposed mitigation measures; c) continue baseline monitoring and d) facilitate a continual review of postconstruction and operation activities.

Construction Phase

The focus of monitoring during the construction phase will be to implement systematic observations to periodically measure the success of proposed mitigation measures and continue baseline data collection. Environmental sampling during the construction phase will be done by the Environmental Unit of the contractor or appointed by the PMU. Specific monitoring aspects to be addressed during construction include:

- Air quality
- Noise quality
- Water quality and water resources
- Sedimentation and erosion
- Physical cultural resources
- Resettlement of displaced persons
- Reclamation and revegetation

Oversight and performance assessment of monitoring activities shall be carried out by the PMU or the PMC.

Operation Phase

Monitoring during the operation phase shall be conducted to reflect the environmental and socio-economic issues that may persist upon completion of construction activities. Monitoring shall focus on evaluating the effectiveness of project mitigation measures and continue baseline monitoring and sampling. Monitoring activities should focus on the following:

- Hydrology
- Water quality
- Sedimentation
- Soil Quality
- Resettlement of displaced persons
- Air and Noise Quality
- Growth of Trees planted under compensatory afforestation

9.8 Cost of Environmental Mitigation Measures

An environmental management budget of **INR 25,920,651** has been estimated for the implementation of the environmental management plan.

Table 9-1: Summary of Environmental Management Budget

Sr. No.	Component	Cost (INR)
Civil Cost		
1	Environmental Monitoring Costs	596,400
2	Mitigation / Enhancement Cost	1,119,784
Non-Civil Cost		
3	Pre-construction Activity (Tree Cutting)	941,474
4	Compensatory Plantation	19,658,800
5	Administrative Charges including logistics	524,980
6	Environmental Awareness and Training	302,000

Sr. No.	Component	Cost (INR)
	Total Cost	**23,143,438**
	Total Cost @12% GST	**25,920,651**

9.9 Conclusion and Recommendations

The proposed project road **Ghagrabasti to Hawajan via Holongi Airport [A28]** falls under Category B as per AIIB's ESP and ESS. The project road corridor is neither a new State Highway nor a State Highway expansion project in hilly areas (above 1000 MSL) and not located within any eco-sensitive area or eco-sensitive zone. Hence, Environmental Clearance from MOEF&CC is not required as per EIA Notification 2006 (amended to date) and NOC from the Standing Committee of National Board for Wildlife is also not required. The road passes through the Gohpur Reserve Forest from Ch. 0+385 to Ch. 14+930 (Part-1 road) & Ch. 0+000 to Ch. 2+114 (Part-2 road), hence forest clearance is required. The project is unlikely to cause any major significant environmental impacts, few impacts are identified, all of which are localized, temporary, and easy to mitigate. Most of the impacts are short term and limited to the construction stage. Key conclusions on the environmental implications of the project are given in the paras below.

9.9.1 Environmental Gains Due to Proposed Work Justifying Implementation

The project entails various impacts on the project setting. There are many positive impacts bearing benefits to the area against the limited number and magnitude of negative impacts. These include (i) The project will substantially improve the transport efficiency on the roads. (ii) The project once implemented will improve the overall environmental conditions with better roads, fuel efficiency, and environmental protection measures (iii) will reduce traffic congestion particularly at junctions hence, air pollution due to the idling of the vehicles.

9.9.2 Potential Impacts and Mitigation

The finding of EAR indicates that the project is unlikely to cause any significant adverse environmental impacts. While some of the minor impacts are negative, there are many bearing benefits to the area. Most of the impacts are likely to occur during the construction stage and are temporary. Anticipated minor impacts will be mitigated through the implementation of mitigation measures summarized in the Environmental Management Plan.

Factors contributing to minimal impacts include the widening of the project road confined within the available RoW with minimum land acquisition at some locations. Although the project road passes through the Gohpur Reserve Forest, the impacts would not be severe and will be mitigated as per the Environmental Management Plan (EMP). However, some of the impacts are unavoidable. These impacts with mitigation measures are indicated below:

- **1652** trees will need to be cut with the prior permission of forest authorities. Compensatory Tree plantation of **16520** trees in non-residential areas along the project road on both sides as per the direction of the forest department will be made to compensate for this loss. Preventive measures shall be taken during the construction phase especially in rainy months, to prevent soil erosion because of tree cutting and alteration of ground flora.

- Air pollution due to construction activities and operation of hot mix plant will be controlled through the adoption of dust suppression measures and provision of the high stack for good dispersion of gaseous emission from hot mix plants.
- Noise levels may increase during the construction phase due to the operation of construction machinery. All the construction equipment and DG set will be well maintained and fitted with silencers.
- Waste materials generated during the construction phase may contaminate soil, surface, and groundwater resources. Waste shall be segregated and reused or disposed of in an environmentally safe manner.
- Along the project stretch, few schools, hospitals, and religious structures are located. Appropriate design options are exercised to minimize the loss of such structures.
- The social issues are addressed through Social Safeguards Due Diligence reports prepared as per AIIB's ESP and ESS.

Application of these measures in parallel with MoRTH environmentally friendly road construction practices will reduce significantly any potential environmental impact. Impacts remaining on the physical environment (air and water pollution) are temporary and often occur away from the presence of people.

9.9.3 Irreplaceable Resources

The project road does not pass through any protected areas or eco-sensitive areas. However, the project road passes through the Gohpur Reserve Forest from Ch. 0+385 to Ch. 14+930 (Part-1 road) & Ch. 0+000 to Ch. 2+114 (Part-2 road). Appropriate mitigation measures as suggested in the Environmental Management Plan must be taken to prevent any harm to the wildlife. The construction material will also be sourced from identified and approved sources.

9.9.4 Post EAR Surveillance and Monitoring

While an EAR is meant to provide a comprehensive understanding of the environmental status of the area under the study, post surveillance is the means to ensure that the significant impacts identified are adequately mitigated as per the proposed mitigation plan. A detailed monitoring plan has been provided as part of the Environmental Management Plan. Air, water quality, noise, soil erosion, and tree survival rate monitoring and reporting along with the follow-up actions in case of deviation from the norms have been detailed out. The frequency has been set in consideration of the likely impacts.

9.9.5 Recommendations

Adequate mitigations shall be taken up both during the construction and operation stage of the project road to avoid/minimize adverse environmental impacts due to this event and any such event in the future as suggested in the EAR.

Effective EMP implementation is essential for the elimination or minimization of the identified impacts. The PWRD shall ensure that EMP and EMoP are included in the Bill of Quantity (BOQ) and forms part of the bid document and civil works contract. The same shall be revised if necessary, during project implementation, or if there is any change in the project design.

PWRD needs capacity building and practical exposure. Adequate training shall be imparted as proposed under the environmental management plan to enhance the capability of concerned EA officials.

CHAPTER 10

SOCIAL ASSESSMENT & EMP

10 Social Assessment & RAP

10.1 Project Background

In Group 3 there are 11 sub project roads which is spread in different districts. The proposed road section Corridor Number A28 from Ghagrabasti to Hawajan via Holongi Airport of length 28.136 km is falling in District of Sonitpur and Lakhimpur. As per the Terms of Reference (TOR), the Consultant is required to carry out the Social Impact Assessment (SIA) studies & prepare the Social Management Plan (SMP) as per the requirements and R&R policy of the GoI and GoA and in line with relevant safeguard policies of Multilateral Funding Agency.

The approach and methodology have been followed for Collection of Primary, secondary survey and consultations. The primary census socio economic survey has been conducted with the help of pre designed questionnaire provided by the client for the land &/ or structure impacted, CPRs or the identified or of the likely impacted. Door to Door in personnel interview the survey have been conducted and the surveyors were given training regarding the filling and completion of the form. Secondary data of the project site pertaining to the districts, villages, states, crime records, features etc. have been extracted from authentic websites and furnished in the report. Stakeholder consultations have been conducted at the project site with regards to the identified stakeholders. Focused Group discussions with the help of personal interview, informal consultations have been conducted.

10.2 Need of the Project

- The immediate benefits of road construction and improvement will come in the form of direct employment opportunities for the roadside communities and specially those who are engaged as wage labourers, petty contractors and suppliers of raw materials.
- Improved road network provides for improved linkages between the village communities and urban centre, which provides wider marketing facilities;
- Road networks not only links the village communities to better markets, but also opens up wider work opportunities in distant places. People can shuttle to distant work sites and towns and engage in construction, factories, business as well as domestic works.
- Improved road networks encourage urban entrepreneurs to invest in far and remote areas in commercial farming and industrial activities.
- Improved roads also help people building strong institutional network with outside agencies. Essential and emergency services can be availed fast like schools, health centre, public distribution system etc.
- Better amenities on the proposed road will help in the commuters and road user's ease

These details of the social assessment have been provided in **Volume IV B: Social Impact Assessment and RAP** of the DPR.

CHAPTER 11

COST ESTIMATE

11 Cost Estimates

11.1 Introduction

Cost estimation is a vital input for assessing financial and economic viability of the project. This chapter presents cost estimation for **"Improvement and upgradation of the existing Ghagrabasti to Mazgaon vai Holongai Airport (A-28)(PKG-1) to two lane with paved shoulder"**. The total length of the project section is **16.370 km** Total project cost includes construction of all civil works and non-civil cost. Each of those components are discussed in the following sections.

11.2 Cross Section

Existing road consists of single lane sections Improvements proposed for the existing road are widening and reconstruction of the existing pavement, widening of intermediate lane / 2-lane to 2-lane with earthen shoulder/paved shoulder configuration. The total length of the project section is 16.370 km. The pictorial representation of Typical cross section with details are presented in ***Annexure 7-1: Typical Cross Section*** of this report.

11.3 Methodology

- Quantities of various components are worked out based on preliminary engineering.
- Rate analysis template published by MORTH is used.
- Unit rates considered are as per "Schedule of Rates for the year 2018-19, published by Public Works Road department, Assam"
- Entire project road corridor is considered for reconstruction with flexible pavement.
- Unit rates for key materials have been referred from SOR & market rates.
- GSB mixing Methodology - The GSB Material is spread with the help of motor grader on the approved layer of Sub-grade in single layer of 200 mm with Grading V. During spreading and mixing by grader in site, water is sprinkled over the material by water browser mounted on water tanker. Refer: -Clause-401(As per Morth)
- WMM mixing Methodology- Wet Mix Macadam consist of laying spreading and compacting of clean, crushed, well-graded granular materials on a prepared and approved Granular sub-Base. The material is well mixed with water and rolled to a dense mass. It shall be laid on two layers as per line and level, grade and cross section shown in the drawing or as directed by the Engineer. The thickness of single compacted Wet Mixed Macadam (WMM) Base shall 125 mm. Maximum thickness of compacted layer base 250 mm approval of Engineer. Refer: -Clause-406(As per Morth)
- DBM mixing Methodology- This work shall consist of laying in a single course 70 mm – thick layer of DBM on a previously primed and approved Wet Mix Macadam Layer, as per specified lines & grades and in accordance with clause 505 of MORT&H specification or project specification. DBM should be produced on batch basis by weight in Hot Mix Plant. The mixing will be done in a twin shaft pug-mill, which will

produce a homogeneous mix. The mixture shall be transported from the batching plant in tippers covered with tarpaulin (if required) so as to maintain the temperature and dust.

- BC mixing Methodology- The temperature of bitumen is controlled through the digital display of temperature in the control cabin. The batch weight as per JMF is fixed in the control cabin to get the mix as per the approved job mix formula. The bitumen content is set by calibrating the plant by extraction test and feeding the resulting correction to the plant value. Mixing time of 12 seconds is fixed so that the all the aggregates and bitumen are thoroughly mixed and all aggregate are coated with bitumen content.

Aggregate mixing	= 170 - 185 ^{o} C
Bitumen mixing	= 170 - 175 ^{o} C
Mix temperature	= 170 - 175 ^{o} C
Laying	= 160 – 165 ^{o} C
Rolling	= 150 -160 ^{o} C

11.4 Lead Chart of Construction materials

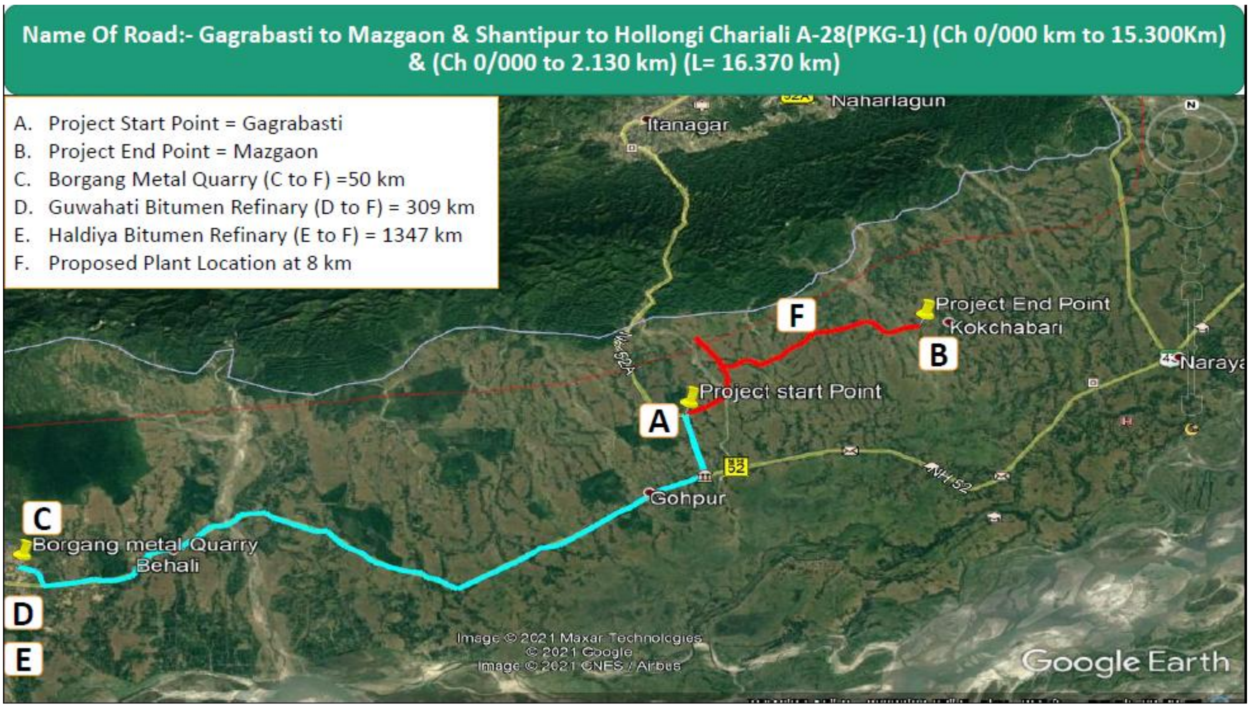


Figure 11-1: Lead Chart (Google)

11.5 Unit Rates of Materials

Stone/metal quarries have been identified nearest to the road and average lead has been worked out as **50 km**. The rates for cement, bitumen and steel have been taken as Schedule rates. Rates of important items Excluding in GST are given in **Table** 11-1**.**

Table 11-1: Rates if Important Items

Sr. No.	ITEM	Rate (in Rs.)
1.	Cement (MT)	7200
2.	TMT-IS 1786 (Fe-500 D) Primary Producer (TATA/ SAIL/ Esser Steel/ Jindal Panther steel/ Shyam steel or equivalent) (MT)	53667
3.	Bitumen (VG-30), MT	32627
4.	Bitumen (Cationic Emulsion) (CSS-1h) (MT)	38530
5.	Bitumen (Cationic Emulsion) (CSS-1) (IS:8887-2004) (MT)	36950
6.	Bitumen (Polymer modified graded) PMB	33280
7.	PCC Grade M15 (cum)	6128
8.	RCC Grade M20 (cum)	8127
9.	RCC Grade M25 (cum)	9209
10.	RCC Grade M30 (cum)	9245
11.	RCC Grade M35 (cum)	10014
12.	PSC Grade M-40 (cum)	10110
13.	PSC Grade M-50 (cum)	12336

11.6 Estimation of Quantities and Cost

The quantities of major items of works have been worked out based on developmental proposal, inventory, condition surveys, and other pavement investigations data. The pavement quantities have been worked based on the typical cross section and widening schedule prepared for project road

11.6.1 Site clearance and dismantling

Site clearance includes the dismantling of pavement courses, drains, kilometer stones, hectometer stones, road signs, metal beam crash barriers etc. The area considered for Site Clearance is the area within the proposed Right of Way minus the existing carriageway area.

11.6.2 Earthwork

Earthworks includes items like excavation necessary for roadway construction, embankment construction with excavated and/or borrow materials, construction of sub-grade and earthen shoulder with selected materials from borrow, median fill materials etc.

The total earthwork in cut-and-fill has been determined from computerized CAD software ("Road Estimator").

11.6.3 Pavement Works

a) Sub-Base and Granular Base Course

GSB and WMM for the main road are billed under this heading.

b) Bituminous Course and Cement Concrete Pavement

This covers all items of bituminous courses and surfacing for flexible pavement considered.

11.6.4 Structure and CD Works

a) Rehabilitation of structures

Repair and rehabilitation of all type of existing retained structures is included.

b) New construction / reconstruction

Cost towards construction of all type of new structures including minor / major bridges, box culvert, and slab culvert is considered.

11.6.5 Drainage and Protective Work

Lined drains are proposed to be constructed in the settlement areas and unlined drains are proposed to be constructed in the open areas. Stone pitching will be provided for embankment height more than 3m. Metallic crash barriers are proposed at embankment height more than 3 m.

11.6.6 Road Appurtenances

Appurtenances are accessories to roadways, not part of their travelled portions. They include curbs and gutters, sidewalks, driveways, drainage structures, signs, guardrail, bridge railing, traffic signals and light poles. They are all important components of roadways.

11.6.7 Road Safety Measures

The road traffic signs, road markings and safety devices for the project are provided as per IRC standards. This includes the quantities of road markings, road signs (all kinds), crash barriers required for smooth functioning of roads.

11.6.8 Wayside Amenities

The Government intends to develop the following types of Wayside Amenities Projects to include Bus Shelter &Bus Bay, Solar Street Lights on Highways for road users.

11.6.9 Utility Services

The cost is considered for affected services like water pipes, sewers, oil pipelines, cables, gas ducts etc.

11.6.10 Miscellaneous

All other necessary provisions such as Footpath, Solar Street Lighting. have been made for all the items present along the project corridor.

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

a) Road Markings
b) Kilometer Stone
c) 200m Stones and Boundary Stones
d) Chevron and Object Markers
e) Crash Barrier

11.6.11 Environmental Mitigation

Environmental management plan has been prepared for mitigation/management/ avoidance of the potential adverse impacts and enhancement of various environmental components along the project road. For each mitigation measure to be carried out its location, time frame, implementation and overseeing/ supervising responsibilities have been identified. Monitoring plan for construction and operation phase is being framed to ensure effective implementation EMP.

11.6.12 Land Acquisition and R&R

Resettlement & Rehabilitation approach is based on the requirement of the ROW and Available ROW. The proposed road project will acquire land or structure by recognizing the social issues that may arise due to the proposed project. The land acquisition for the proposed project will be as per RFCTLAAR 2013 & its amendments for the proposed land and structure to be acquired.

11.7 Non-Civil Cost

Cost towards relocation of utilities shifting & tree cutting are received from respective government agencies and included in estimates. However, cost towards implementation of Environmental management plan, implementation of Resettlement plan, land acquisition is worked out as per prevailing procedures and included in estimate.

Provisions for overhead and administrate expense are considered in total project cost as per prevailing procedure of ASSAM PWRD.

11.8 Cost of Civil Works and Total Project Cost

Cost of civil work, (i.e. Cost of Road work + Cost of Structure work + Cost of Drainage and Protection Work + Cost of Traffic Sign and Road Appurtenances + Environmental Mitigation Cost) and Total Cost (i.e. Total Civil Cost + Price adjustment) and Total Project Cost,(i.e. Total Cost + GST, Assam building and other construction workers welfare cess and Swatch Bharat Cess + Contingencies+ Provisional Sum for Day Work + Tree Cutting Cost, Afforestation, Training and Administrative charges + Forest Clearance Cost + Utility

Shifting Cost + Land Acquisition and R&R Cost)+ Maintenance Cost after construction for the recommended alignment is presented in ***Table** 11-2*.

Table 11-2: Cost of Civil Works, EPC Cost and Total Project Cost

Length of Recommended Alignment as per Design Chainage (km)	Cost of Civil Works (Rs. Cr.)		Total Cost (Rs. Cr.)		Total Project Cost (Rs. Cr.)	
	Total Cost	Per km Cost	Total Cost	Per km Cost	Total Cost	Per km Cost
16.370	63.81	3.90	67.63	4.13	122.25	7.47

11.9 Summary of Cost Estimate

A summary of total project cost is presented in ***Table* 11-3**.

Table 11-3: Summary of Cost Estimate

ABSTRACT OF COST		
Sr.No.	**Description**	**Amount (INR)**
	Road Works	
1	A) Site Clearance and Dismantling	48,20,528.00
	B) Earthwork	8,89,10,577.00
	C) Bus bays, junction improvement including widening for auxiliary lanes	4,47,208.00
	D) Sub-Base and Base Courses (GSB, WMM)	19,91,56,852.00
	E) Bituminous Course	12,75,78,884.00
	F) Concrete pavement	-
	G) Service Road	-
2	**Structures**	
	A) Culverts (Pipe/Box culverts)	9,06,74,682.00
	B) Bridges (Major/Minor/ROB/RUB/VUP/Foot Over)	8,31,19,409.00
	C) Repair and Rehabilitation of Poor Bridges	18,02,067.00
	D) Retaining wall	-
	E) Bus Shelter	23,22,948.00
3	**Drainage and Protection Work**	
	A) RCC Drain	-
	B) Protection Work	-
	C) Others	-
4	**Traffic Sign and Road Appurtenances**	
	A) W Beam Crash barrier & Flexible Crash Barrier, Wire Rope Safety Barrier	1,68,04,321.00
	B) Traffic Signs	52,66,009.00
	C) Pavement Marking	79,38,238.00
	D) Pedestrian Guard Rail	-
	E) Paver block	-

ABSTRACT OF COST		
Sr.No.	**Description**	**Amount (INR)**
	F) Others (km stones, studs, solar blinkers, delineators, RPC, Street Light etc.)	83,93,945.00
5	**Environmental Mitigation Cost**	8,29,030.00
6	**Total Civil Cost (1+2+3+4+5)**	**63,80,64,698.00**
7	Price adjustment @ 4% Per Annum on 6 *(18 months)*	3,82,83,882.00
8	**Total (6+7)** (Price adjustment + Civil Work Cost)	**67,63,48,580.00**
9	GST, Assam building and other construction workers welfare cess (13%) on 8	8,79,25,315.00
10	Provisional Sum for Day Work (including Tax @13%)	59,98,447.00
11	Contingencies @ 5% on (6+Taxes)	3,60,50,655.00
12	Tree Cutting Cost, Afforestation, Training and Administrative charges (including GST12%)	8,17,35,301.00
13	Forest Clearance Cost (as per actual)	5,53,62,779.00
14	Utility Shifting Cost (as per actual) (including GST)	2,11,27,581.00
15	Land Acquisition and R&R Cost (as per actual)	22,19,78,116.00
16	Maintenance Cost after construction (0.5% for 1st year,1% for 2nd year, 1% for 3rd year, 1% for 4th year and 1.5% for 5th year) on Cost put tender	3,60,50,655.00
17	**Total Project Cost**	**1,22,25,77,429.00**
	Cost per KM w.r.t (with Taxes)	**4,40,44,784.00**
	Cost per KM w.r.t (Put tender cost+17) Including taxes	**4,62,47,023.00**
	Cost per KM w.r.t 18 (including all cost) (18/L)	**7,46,84,021.00**
	Cost put to tender (Including taxes)	**72,10,13,109.00**

11.10 Summary of bypass cost estimate

Realignment is proposed on **Ghagrabasti to Mazgaon vai Holongai Airport** project road as per the discussion with the PWRD officials. However, centerline to be shifted at horizontal curve improvements & one side widening wherever necessary.

11.11 Implementation Schedule

The proposed road shall be implemented in 18 months.

11.12 Operation and Maintenance Cost

The Concessionaire shall, at all times, operate and maintain the Project in accordance with the provisions of the Agreement, Applicable Laws and Applicable Permits. In particular, the Concessionaire shall, at all times during the Operation Period, confirm to the maintenance requirements.

CHAPTER 12

ECONOMIC ANALYSIS AND RECOMMENDATIONS

12 Economic Analysis and Recommendations

12.1 General

Any publicly funded project must be economically viable, which implies that the said project is beneficial to society. The main purpose of the economic analysis is to identify all the direct and indirect benefits and to compare them over the economic life of the project to justify the implementation of the project based on its benefits/ profits to the economy/ nation. This necessitates consideration of different streams of cost and benefits over time. In this chapter, the economic viability of the project is assessed and presented.

This cost benefit study is carried out using the overall guidelines stipulated by the Indian Roads Congress (IRC) and World Bank in Economic Evaluation of Highway Projects in India (SP-30, 2009) and HDM-4 Version 2 (World Bank) respectively, as accepted by International Funding Agencies, Ministry of Road Transport & Highways (MoRT&H), National Highways Authority of India (NHAI) and State PWDs for highway projects in India.

The cost – benefit analysis is carried out by using the discounted cash flow (DCF) technique to obtain the economic internal rate of return (EIRR) and economic net present value (ENPV) for the proposed investments linked with the project. This is followed by a ‘sensitivity analysis’ carried out by increasing or decreasing the critical factors affecting the cost and benefit streams of the proposed project, to ascertain their effect on the economic feasibility indicators i.e. ENPV, EIRR.

The results are expressed in terms of Economic Internal Rate of Return (**EIRR**) and Net Present Value (**NPV**) at the discounted rate of 09 & 12 percent. Economic analyses are worked out based on considering the two scenarios i.e. without project- do nothing, and with project-do something (for Flexible Pavement).

12.2 Objectives and Approach of Economic Analysis

12.2.1 Objectives

The objective of the cost benefit economic analysis is to identify and quantify the benefits and costs associated with the project (with respect to Preparation of Detailed Project Report (DPR) for improvement and upgradation of 2 lane with paved/earthen shoulder for A-28 Ghagrabasti to Hawajan Road in the State of Assam to select the optimum solution along with the economic viability in terms of its likely investment return potential. This is carried out to test the economic feasibility of the identified improvements to the project road and assist PWRD Department, Government of Assam in taking decision.

The economic evaluation has been carried out within the broad framework of social cost-benefit analysis assuming the project life for an operation period of 20 years excluding 02 years of construction period. The economic feasibility of the project has been sought to maximize the economic returns on investment. There will be a reduction in road user costs of Motorized Traffic (MT) on the existing parallel roads, which are likely to be affected in consequence of construction of Ghagrabasti to Hawajan road in Assam. The economic savings at significant level in the following areas are expected to occur due to introduction of the Ghagrabasti to Hawajan road.

- Vehicle Operation Cost (VOC)
- Journey time of passengers and goods

The economic analysis has been based on comparison of costs and benefits under two scenarios 'without the Ghagrabasti to Hawajan road project' and 'with the Ghagrabasti to Hawajan road project'. All costs and benefits are valued in monetary terms and expressed in economic prices to have the analysis on resource-based framework. The analysis is made corridor-wise as well as project-wise. The results are expressed in terms of Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV).

12.2.2 Approach

The approach of the cost-benefit economic analysis is to identify and quantify the benefits and costs associated with the project in respect to introduction of the Ghagrabasti to Hawajan road. The following steps have been followed:

1st Step	:	Identification of Homogeneous Sections.
2nd Step	:	Data Collection & Analysis.
3rd Step	:	Running of **Improvement** Module of HDM-4 version 2.11 model to determine trade off from traffic benefits between improved Ghagrabasti to Hawajan road and the unimproved Ghagrabasti to Hawajan road.
4th Step	:	Determination of EIRR and NPV

12.2.3 Methodology

The economic analysis is carried out following external funding agencies guidelines and using the HDM-4 model by comparing transport costs for road agency and transport users under with- and without-project scenarios. The without-project scenario includes minimum routine and periodic maintenance for the project road and no capacity improvement whereas the with-project scenario includes rehabilitation or up-gradation to the specified standard together with required routine and periodic maintenance.

The economic analysis for the project roads has been done by using the Project/section Analysis facility of HDM 4. This has enabled the Consultants to estimate the economic internal rate of return (EIRR), net present values (NPV) and cost benefit ratio. The details on economic analysis have been provided in the subsequent sections of this chapter. The methodological frame has been illustrated in the below as Chart.

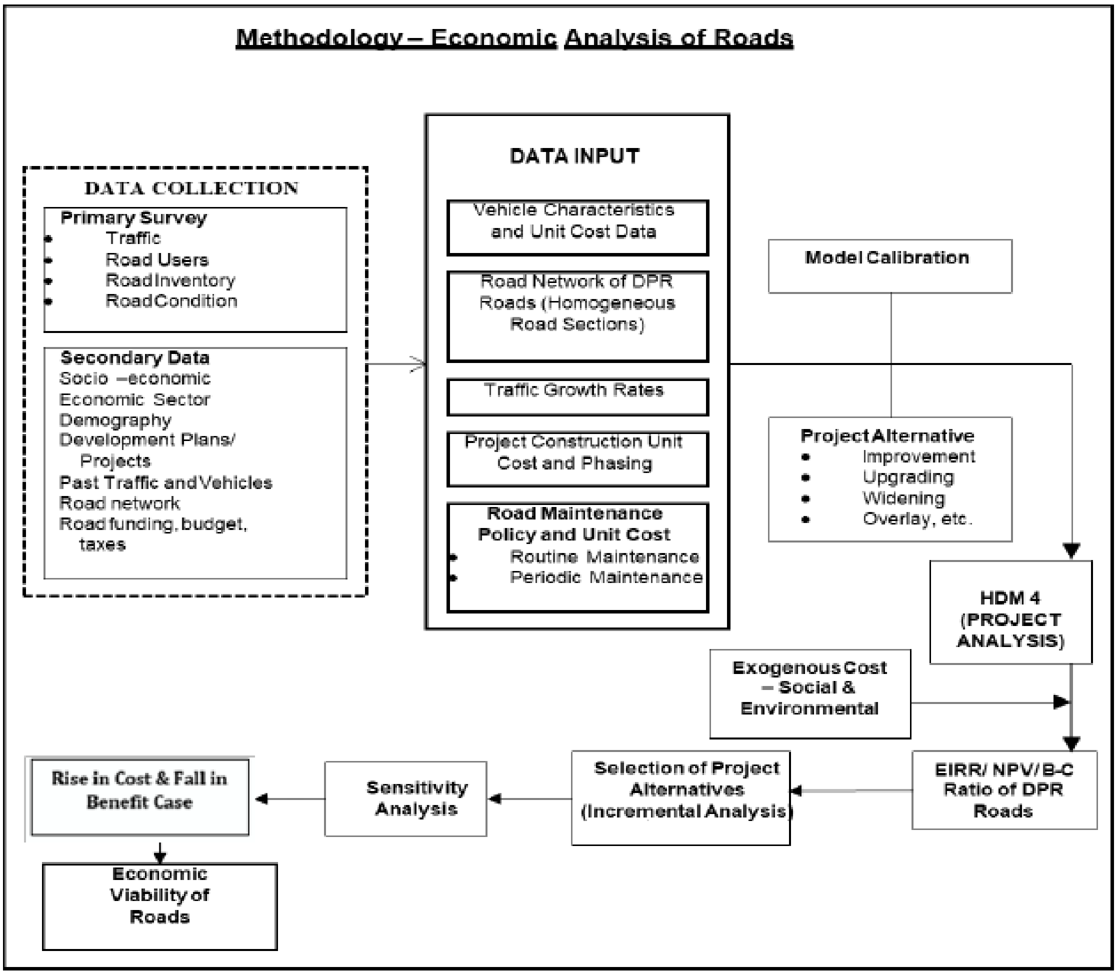


Figure 12-1: Chart Showing Methodology for Economic Analysis

The analysis period of the project has been taken as 22 years (02 years for construction and 20 years of operation period) from 1st April 2025, the year from which construction is expected to start. The ***Table*** 12-1 give the details of construction program.

Table 12-1: Construction & Operation Program

Item	Year/Value
Cost Estimation Year	December -2024
Total Evaluation Period (Years)	22 (2+20)
Construction Period (Months)	**18 Months (02 Years Considered)**
Construction Start Year	1st April 2025
Construction End Year	31st March 2027
Operation Period (Months)	**240 Months (20 Years)**
Open to Traffic	1st April 2027
Operation End Year	31st March 2047
Phasing of Construction Cost (%)	
Year 1 (1st April-2025 to 31st March-2026)	40% (12 Months)
Year 2 (1st April 2026 to 31st March 2027)	60% (12 Months)
Note: Actual Construction Period is 18 Months, but for HDM Economic Analysis it is Considered 24	

Source: Consultants proposed program in Consultation with Public Work Road Dept (PWRD)

12.3 Study Road Network

Details of the new corridors of the A28 Ghagrabasti to Hawajan road project considered for the analysis are detailed below in ***Table*** 12-2***.***

Table 12-2: Ghagrabasti to Hawajan Project Road

Road No.	From- (Place)	To (Place)	Road Code	Length (Km) Before Improvement
01	Ghagrabasti	Hawajan	G3-A28	**28.404**
Changes in Length after Improvement				
Road Code	**From- (Place)**	**To (Place)**	**Length (km) Before Improvement**	**Length (km) After Improvement**
G3-A28	Ghagrabasti	Hawajan	28.404	**28.136**

Source: As per Site Surveys & PWRD Consultations

12.4 Homogeneous Road Sections

Determining the homogeneous sections is one of the key tasks of economic analysis as it is a requirement of HDM-4 analysis and would have implications on selection of improvement treatment. The project roads are divided into homogeneous sections, mainly based on three parameters-traffic, pavement width and road condition (roughness of the road defined by IRI). The details of name of the road, the corresponding homogeneous section and length of road section are presented in ***Table*** 12-3.

Table 12-3: Homogeneous Road Section

Sec No	Starting		Ending		Length (Km)
	Chainage	Place	Chainage	Place	
01	00+000	Ghagrabasti	07+100	Sonarijan	07.100
02	07+100	Sonarijan	14+800	Alupara	07.700
03	14+800	Alupara	28+404	Hawajan	13.604

Source: As per Site Surveys & PWRD Consultations

Influence Corridor (IC) to Project Road

There is one influence corridor to project road are considered in this economic analysis namely.

- IC1: Hawajan-Gohpur-Ghagrabasti (NH-15 and NH415)

Traffic will divert from this influence corridor to project road corridor once it gets operational. Due to decongestion in influence corridor the benefit will get added into the project road. Also, these will lead to benefitting the residual traffic on the influence corridor in terms of VOC and VOT. Due to proposed Airport at Hollongi (Arunachal Pradesh) near to project road traffic will get divert on the project road in near future.

12.5 Project Alternatives

The following Map showing sections for Economic Analysis for without and with project scenario. It also shows neighboring road sections from where the traffic is getting diverted into the project corridor.

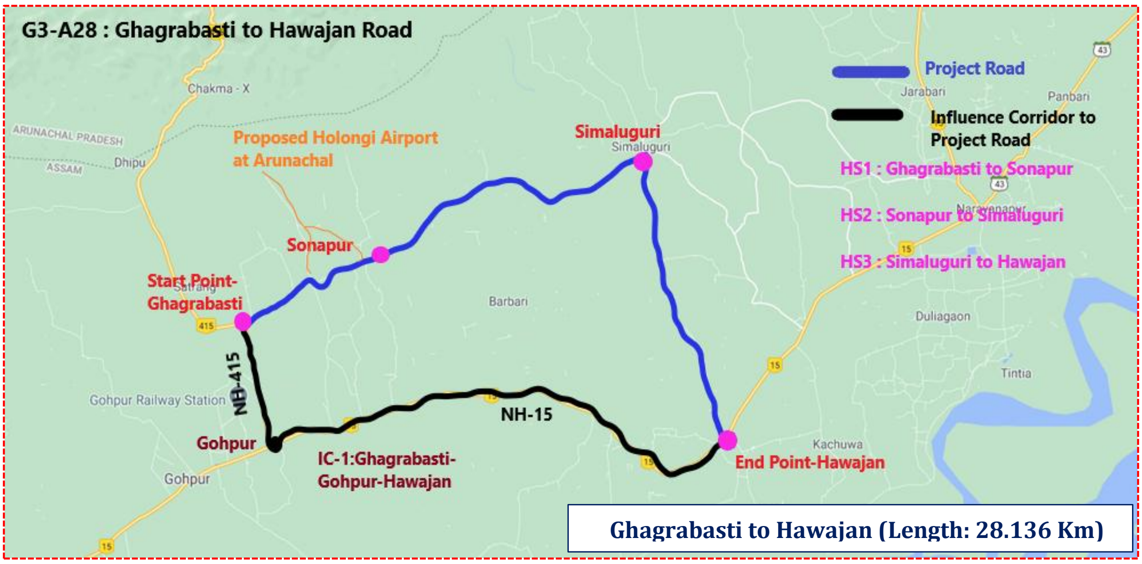


Figure 12-2: Map Showing Project Road Alignment

The following alternative scenarios are considered for the economic analysis.

- **"Without improvement of** Ghagrabasti to Hawajan **Project" (Base Strategy):**

This is the 'without Ghagrabasti to Hawajan road project' situation where the traffic on the existing roads single / intermediate lane project road is considered as such in its present condition and without improvement, which are likely to continue. In the analysis, this is the base strategy against which the new construction is compared.

- **"With improvement of** Ghagrabasti to Hawajan road **in Place"**

This is the 'with Ghagrabasti to Hawajan road project' situation where the traffic on the existing roads, which is likely to be affected for the introduction of the Ghagrabasti to Hawajan road. In this case the future traffic volume on the roads is assumed to grow as per estimated growth rates to flow along the existing roads. In the analysis, this alternative is compared against the base strategy. The 'with Ghagrabasti to Hawajan road project' situation helps to determine the highest levels of benefits. The same growth rates assumptions are applied in the with/without improvement cases. The corresponds to the widening the existing road sections of the project road to two lane carriageways (7m) with paved and Earthen shoulders and appropriate other improvement works like alignment correction, pavement reconstruction, widening / reconstruction of CD structures.

- **Benefits Calculation**

The latter comprises the strategy of the 'with project' situation in the HDM model. To arrive at the net benefits associated with this strategy, these are compared to the 'do minimum' / 'without project' alternative separately. By comparing the above alternatives, the net agency costs, and net user costs and finally net project benefits associated with the project during its analysis period are calculated for the proposed improvement options separately, to arrive at their economic internal rate of return (EIRR) and economic net present value (ENPV). The reductions in dis-benefits lead to savings. The total savings expressed in quantitative terms are the total benefits arising from the Ghagrabasti to Hawajan road. The total quantitative benefits and costs at economic prices determine EIRR and NPV of the Ghagrabasti to Hawajan road project.

12.6 Project Options

Formulation of project improvement options is one of the important aspects in the economic analysis of the state road projects. The key parameters to be considered while formulating the project improvement alternatives are:

- Topography of the project area & weather conditions
- Traffic Volume – Capacity Ratio (V/C) of the project roads
- Road condition/ roughness (IRI)
- Cost of the intervention
- Connectivity and linkages of the road section

In line with the requirements the authority have formulated various improvement options after having detailed interaction on the engineering, traffic volumes and capacity limits (C/V ratio), environmental and the social aspects that were recorded in various surveys and the analysis of the same.

The improvement options are:

Base Case this corresponds with 'no-project' (do-nothing or do-minimum) situation where in, the current practices that are adopted by the PWD for the routine and periodic maintenance of the state and major district roads forms the part of the works, without any new investments on the roads.

Improvement

Option-1	:	7m Carriageway + 2 x1.5 m Paved Shoulder + 2 x 1m Earthen Shoulder (Formation Width = 12 m) – **2LPS**
Option 2	:	7m Carriageway + 2 x 2.5 m / 2 x 1.5 Earthen Shoulder (Formation Width = 12 m / 10 m)-**2LES**
Option 3	:	Considering Option 1 and **Removing ROB**/ any Heavy **Structure Cost**
Option 4	:	Considering Option 2 and **Removing ROB**/ any Heavy **Structure Cost**

Depending upon the structural strength, pavement conditions, V/C ratio, road width, road connectivity, etc., for road section, the improvement options defined above were applied and accordingly the economic analysis is undertaken.

In this road corridor only the first two options are worked out because of the absence of RoB/Heavy Structures.

12.7 Demand Analysis

Traffic demand estimate consists of (a) normal traffic passed along the project road despite any intervention made or not; (b) diverted traffic shifted from another route in competition; and (c) generated traffic occurred additionally in response to road improvement. Base year traffic only consists of normal traffic while future traffic, estimated over the project benefit period, includes all three categories.

12.7.1 Base Year Traffic

Base year traffic (2019-2020) revised to 2024-25 for the project road was estimated based on the results of classified traffic counts conducted for consecutive 7 days at a station close to the mid-point of the road section. These field counts were first averaged to estimate average daily traffic (ADT) and then converted to annual average daily traffic (AADT) by multiplying with an appropriate seasonal factor. An analysis of fuel sale data in project influenced area, has estimated seasonal factors for petrol and diesel vehicles. The estimated motorized AADTs for the project road are summarized in the ***Table*** 12-4**.**

Table 12-4: AADT: Traffic on Project Road (Year-2024-2025)

Vehicle Type	Base Traffic AADT (in Vehicles)			Diverted / Generated / Induced (AADT)
	2024-2025			2027-2028
	HS-1: Sonarijan	HS-2: Alupara	HS-3: Sesamiri	IC-1: NH15 & NH415
Two Wheelers	511	448	1126	318
3 Wheelers	084	034	041	024
Car/ Vans/ Jeeps	154	147	139	068
Minibuses	000	000	000	000
Standard Buses	003	000	000	000
Tempo	032	036	091	025
LCV's (Goods)	000	001	007	001
2-Axle Trucks	014	001	000	003
3-Axle Trucks	000	000	000	000
Multi-Axle Trucks	000	000	000	000
Tractors with Trailer	010	008	012	005
Tractors	007	001	003	002
AADT (Motorized Traffic-MT)	**814**	**677**	**1419**	**445**

Source: As per Actual Traffic Surveys, 2019- 2020.

It is observed that there is much intersectional diversion of traffic along the Ghagrabasti to Hawajan Road project corridor. Mostly, it is local traffic observed along the project road and few inter & intra state traffic is observed. Therefore, in consultation with PWRD and site observations, Consultant has adopted Annual Average Daily Traffic (AADT) (for Sonarijan, Alupara & Sesamiri locations section) for the entire project stretch.

The estimated non-motorized AADTs for the project road are summarized in the

Table 12-5.

Table 12-5: Non-Motorized Traffic (NMT) AADT: Traffic on Project Road

Vehicle Type	Base Traffic AADT (in Vehicles)			Diverted / Generated / Induced (AADT)
	2024-2025			2027-2028
	HS-1: Sonarijan	HS-2: Alupara	HS-3: Sesamiri	IC-1: NH15 & NH415
Bicycle/ Cycle	262	490	662	283
Cycle Rickshaw	000	000	000	000
Animal Drawn	000	001	000	000
Others Cart	000	000	000	000
AADT (Non-Motorized Traffic-NMT)	**262**	**491**	**662**	**283**

Source: As per Actual Traffic Surveys, January, 2019-2020.

12.7.2 Traffic Forecast

Future traffic is an aggregation of normal, diverted, and generated traffic growing over time in response to socio-economic development of the project influenced area. The normal traffic is forecasted to future by applying derived growth rates to base year traffic. Diverted and generated traffic are added to forecast as a percentage of normal traffic in respective years. As there are routes in competition with selected project roads, diverted and generated traffic of 10% respectively applied as on road improvements would (a) strengthen the public transport services facilitating passenger movements, (b) encourage inhabitants to go for attractive jobs in urban areas, (c) open-up new markets for inhabitants to sell their agricultural production in competitive prices and in turn increasing level of production, and (d) motivate inhabitants to receive better health and educational facilities available in urban centers. The detailed traffic data provided in the **Annexure-12-2**.

- **Normal Traffic**

  Normal Traffic is the traffic which is already playing on the project road sections and continues to use the project road after improvement.

- **Induced Traffic**

  Induced Traffic represents the new traffic because of new travelers making use of the improved or new facility. The induced traffic is 10% of the normal traffic.

- **Diverted Traffic**

Diverted traffic is the traffic which would be diverted to the project road sections from the alternative routes and the traffic which might divert away from the project road due to toll. Traffic to be diverted on the project road is considered at the rate of 10% of the normal traffic. It will be added after commencing the facilities in the year 2027-2028.

- **Developmental Traffic**

Developmental traffic is the one which would be generated from the proposed developments in the immediate influence area of the project road, and which are considered as the normal growth.

With traffic diversion to the project corridor there is also benefit VOC and VOT to the existing road sections from where the traffic is getting diverted into the project corridor. There are alternative and parallel routes/roads, NH15, SH-415, etc. from where traffic will divert on this project road.

12.7.3 Traffic Growth Rates for Motorized Vehicles

Traffic movement on the project road as observed from OD surveys show that, major influence of Assam sate is predominant. Accordingly, traffic projections have taken into consideration the transport demand arising out of future economic development in the contributing state of Assam. The Elasticity approach is used for determining the growth rates of future traffic. This involved establishing a quantitative relationship between traffic growth as the dependent variable and growth in NSDP/NDDP or sectoral income, PCI and Population as the independent variable. The estimated growth rates based on this approach for motorized traffic (MT) vehicles are given below in ***Table*** 12-6***.***

Table 12-6: Adopted MT Traffic Growth Rates (in %)

Vehicle Type	Period 1 (2020-25)	Period 2 (2025-30)	Period 3 (2030-35)	Period 4 (2035-40)	Period 5 (2040-45)
Two Wheelers	7.08	7.25	6.38	5.83	5.55
3 Wheelers	6.96	7.13	6.27	5.72	5.45
Car/ Vans/ Jeeps	6.76	6.91	6.07	5.53	5.26
Minibuses	5.89	6.01	5.24	4.74	4.47
Standard Buses	5.89	6.01	5.24	4.74	4.47
Tempo	6.70	6.86	6.02	5.48	5.21
LCV's (Goods)	6.70	6.86	6.02	5.48	5.21
2-Axle Trucks	5.50	4.17	2.40	0.92	-0.46
3-Axle Trucks	6.64	6.92	6.08	5.54	5.26
MAV	6.73	6.89	6.05	5.51	5.24
Tractors + Trailer	6.70	6.86	6.02	5.48	5.21
Tractors	6.70	6.86	6.02	5.48	5.21

Source: Consultant Estimates based on available Secondary Data of Assam State

For the detailed computational process of growth rates estimation, refer the **Annexure-12.1:** Growth Rates Estimation.

12.7.4 Traffic Growth Rates for Non-Motorized Traffic

Slow-moving vehicles essentially cater to short haul traffic, meeting localized demand for transportation of passengers and goods from rural areas in the country to the nearest market towns and urban centers. These are gradually being replaced by motorized vehicles. The slow-moving traffic is not expected to have high growth rates on MDRs/SHs/NHs. As such, slow moving traffic of animal drawn vehicles and cycle rickshaws is likely to be growing on the project road by a low growth rate of 2 percent per annum. However, the cycles and animals drawn are likely to increase by 2 percent per annum. This would be on account of educational, recreational (including social) and work trips. The estimated growth rates based on this approach for non-motorized traffic (NMT) vehicles are given below in ***Table*** 12-7***.***

Table 12-7: Adopted NMT Traffic Growth Rates (in %)

Vehicle Type	Period 1 (2020-25)	Period 2 (2025-30)	Period 3 (2030-35)	Period 4 (2035-40)	Period 5 (2040-45)
Bicycle/Cycle	2.16	2.21	1.96	1.94	1.55
Cyc Rickshaw	2.16	2.21	1.96	1.94	1.55
Animal Cart	2.16	2.21	1.96	1.94	1.55
Pedestrian	1.00	1.00	1.00	1.00	1.00

Source: Adopted value based on Various Secondary Data & Reports of Assam Motor Transport Dept.

The adopted MNT growth rates are based on the various reports of Assam Motor Transport Department, for detail refer the **Annexure-12.1: Growth Rates Estimation**.

12.7.5 Capacity Analysis

The capacity analysis of the project road was done based on level of service for Ghagrabasti to Hawajan Road section. As per the projected traffic volume, Ghagrabasti to Hawajan road section with its current intermediate lane configuration, this project road section will remain its design service volume with LOS-A by 2052 at Sonarijan section, with LOS-A by 2054 at Alupara section and with LOS-A by 2042 at Sesamiri section respectively. Therefore, due to better road network & connectivity in the state there is a need to improve the proposed project road to cater to the growing traffic demand soon. For more detail regarding the capacity analysis and level of service refer to the Chapter-4 Traffic Studies and Demand Forecasts, Section-4.5: Capacity and Level of Service (LOS) analysis.

12.8 HDM Model Input Data and Analysis

The economic analysis is carried out following World Bank/ADB's guidelines and using the HDM-4 model by comparing transport costs for road agency and transport users under with- and without-project scenarios. The following model has been employed to estimate the aforesaid benefits.

1. Identification of homogeneous sections of project road.
2. Data collection and analyses
3. Estimation of present traffic volume on the project road

4. Estimation traffic growth rate
5. Estimation of diversion potential of traffic to project road from alternative roads.
6. The time values are used in the VOC estimation.
7. Usual maintenance provisions and costs in with and without conditions have been considered.
8. The model used for analysis is **Improvement** module of HDM-4 version 2.11.
9. These help to estimate total road user costs with project road in terms of lesser congestion cost, time cost, etc.
10. EIRRs of the sections have been estimated with HDM-4 but the EIRR of the entire project has been obtained also taking together all the sections.
11. EIRR and NPV Estimation with the sum of benefits from
    - VOC savings which include congestion, fuel, etc.
    - Time savings
12. The standard conversion factor (SCF) 0.90 is used for Capital cost and 0.98 for Maintenance cost.
13. Standard Wage rate factor 0.61 is worked out and same has been used in the analysis.

All together give Total Net Benefits for the Ghagrabasti to Hawajan road project. The Total Net Benefits is considered against economic cost of project to determine on Economic EIRR and ENPV at 12% and 9%.

12.8.1 Calibration Level

The scope of Ghagrabasti to Hawajan road project does not provide moderate (Level 2) or major (Level 3) HDM4 calibrations; so, it has been tasked with basic (Level 1) level of configuration and calibration. The L_1 level of calibration is mandatory for HDM analysis. The basic level of calibration has been done undertaking the followings:

- The values of basic input parameters are determined from local conditions.
- Default values have been adopted in those cases which have low sensitivity or no sensitivity with VOC or road deterioration.
- The most sensitive parameters have been calibrated with best estimates.

12.8.2 Assumption

It has been assumed that the default HDM model parameters are appropriate for local conditions so only the most critical ones have been addressed. Since the project is a planning one so the absolute magnitude of the RUE parameters of calibration and road construction costs deserve to represent local costs and conditions very closely; the sensitivity of RUE parameters to road conditions, particularly roughness, and the road deterioration parameters have been considered.

12.8.3 Rainfall and Humid Area

The entire project road is passing through tropical monsoon rainfall type with high levels of *humidity* and heavy rainfall area.

12.8.4 Steps of Calibration

The following steps have been followed to complete the calibration process:

1. Identification of concerned parameters both for RUE and RD calibration
2. Assessment of critical parameters based on their sensitivity with VOC
3. Replacement of values with local values
4. Examination of appropriateness of default values

12.8.5 Calibration Parameters

The RUE and RD calibration parameters and their sensitivity level are adopted as per state conditions. This is to be noted that in the Ghagrabasti to Hawajan road, where level 1 calibration has been carried out for an MDR/SH in Assam, India. The climatic condition of the site is humid and heavy rainfall. Economic analysis has been carried out taking default calibration factors and level 1 calibration factors. Level 1 Calibration involved desk study and many default values have been adopted. Level 2 & 3 calibration is not possible due to lack of the required long time series data. Therefore, in this project study is to find out level 1 calibration factors for a region / project based on very limited available data.

12.8.6 Configuring HDM

The configuring is the first step towards developing calibration set. The configuring areas are:

- Traffic Flow Pattern
- Speed Flow Pattern
- Accident Class
- Climate Zone

12.8.7 Calibration Factors Adopted New Roads

The following ***Table* 12-8** calibration coefficient values have been used for new road after construction.

Table 12-8: RD Model Calibration Coefficients

Input	Particulars
Pavement	Asphalt Mix on Stabilized Base
Surface Material	Asphalt Concrete
Shoulder Number	2
Elevation difference from Pavement to Shoulder	5cm
NMT Lane	0
Construction Defect for Base	0
Cracking Retardation Time	0
Raveling Retardation Factor	1
Structural Cracking Initiation	1
Structural Cracking Progression	1
Wide Structural Initiation	1
Wide Structural Progression	1
Thermal Cracking Initiation	1
Thermal Cracking Progression	1
Raveling Initiation Factor	1
Raveling Progression Factor	1

Input	Particulars
Pothole Initiation Factor	1
Pothole Progression Factor	1
Roughness-age-environment Factor	1
Roughness Progression Factor	1
Cracking Initiation	1
Cracking Progression Factor	1
Drainage Factor	1
Vehicle with Studded Tyres	0
Seasonal Effect on SNP	1
Environmental Roughness	1
Other Parameters	Default Values

Source: Based on Site Surveys, Default Values and PWRD Consultations

12.8.8 RUE Priority Parameters

The Road User Effects (RUE) model calibration focuses on ensuring that the key RUE model parameters and calibration factors are appropriate for the conditions under which the model is to be applied. The following table shows the recommended priorities for the RUE calibration. The priority parameters for RUC calibration are:

- Aerodynamic Drag Coefficient
- Projected Frontal Area
- Driving Power
- Braking Power
- Engine Speed
- Tyre Rubber Volume
- No. Retreads
- Vehicle Mass
- Road Capacity
- Free Speed
- Service Life
- Annual Utilization
- Tyre Type

The values in ***Table*** 12-9 have been collected from secondary sources and used for calibration for RUC parameters.

Table 12-9: Vehicle Calibration Coefficients

Vehicle Make	Car	Pick Up	Mini-Bus	Large Bus	Light Truck	Med. Truck	Heavy Truck	Artic. Truck
Aerodynamic Drag Coeff.	0.5	0.55	0.55	0.65	0.7	0.9	0.85	0.86
Projected Frontal Area, m^2	2.4	04	04	6.8	06	07	07	7.5

Vehicle Make	Car	Pick Up	Mini-Bus	Large Bus	Light Truck	Med. Truck	Heavy Truck	Artic. Truck
Driving Power, mhp	75	88	88	180	100	168	240	240
Braking Power, mhp	25	30	30	160	120	250	250	500
Paved Desired Speed, kph	120	95	95	90	85	85	80	75
Unsealed Desired Speed	50	30	30	30	30	30	30	30

Source: https://www.araiindia.com

12.8.9 Road Conditions HDM Model Inputs

HDM inputs used for existing and improved road conditions are given in ***Table* 12-10**

Table 12-10: HDM Inputs Used for Existing & Improved Road

Parameters	Base Case	Improved Case
General		
ID	G3-A28	G3-A28
Length (Km)	28.404	28.136
Carriageway Width (m)	3.11	7.0
Paved Shoulder Width (m)	0.0	1.5
Earthen Shoulder Width (m)	1.0	1.5
Surface Class	Bituminous	Bituminous
Speed Flow Type	Single Lane	2 Lane Standard
Traffic Flow Pattern	Commuter	Commuter
Flow Direction	2-Way	2-Way
Accident Class	SL	2L
Climate Zone	Rainy, Hot-Humid	Rainy, Hot-Humid
Road Class	Secondary	Secondary
Length Adjustment Factor	-	01
Improvement Type	-	Upgradation
Construction Period	-	02 to 03- Years
Operation/Design Period	-	20- Years
Geometry		
Rise and Fall (m/Km)	06	01
No. of Rise and Fall	04	01
Super-Elevation (%)	05	02
Average Horz. Curvature	05	03
Adral	0.1	0.1
Speed Limit (Km/Hr.)	25	80
Speed Reduction Factor	0.60	01

Parameters	Base Case	Improved Case
Altitude	100	100
XNMT	01	01
Roadside Friction	0.9	01
XMT	0.9	01
Pavement		
Pavement Type	Bituminous	Asphaltic Concrete
Surface Thickness (mm)	30	40
Previous Surfacing Thickness (mm)	20	-
Last Construction/Reconstruction Yr.	2011	-
Last Rehabilitation (Overlay) Yr.	2016	-
Last Resurfacing (Resealing) Yr.	2016	-
Last Preventive Treatment Yr.	2016	-
SNP (dry)	1.33	-
DEF (mm)	0.69	-
Sub-grade CBR (%)	04	-
Structural No.	0.95	04
Intervention Years	-	05
Economic Cost (Rs Cr.)/Km	-	**6.65**
Annual Cost Stream (%)	-	-
Salvage Value (%)	-	30%
Bituminous Surfacing, CDS	01	01
Base CDB	00	00
Surface Material	Bituminous	Bituminous Concrete
Condition		
Year	2019	-
Roughness (IRI) (Average)	09	2.0
All Structural Cracking Area (%)	30%	-
Wide Crack Area (%)	10%	-
Thermal Crack Area (%)	15%	-
Ravelled Area (%)	25%	-
No of Potholes (No/Km)	03	-
Edge Break Area (m^2/Km)	100	-
Mean Rut Depth (mm)	10	0
Rut Depth Standard Deviation	01	-
Skid Resistance (SCRIM 50Km/Hr.)	0.8	0.55
Surface Texture	-	0.7
Texture Depth (mm)	0.35	-
Drainage Condition (Excellent/Good/Bad)	Poor	Good
Relative Compaction (%)	85	97

Source: As per Site Surveys & PWD Consultations

12.9 Project Cost and Phasing

Economic analysis has been carried out using world price numeraire presented in domestic currency. The construction cost for the project road is based on its engineer estimates. The estimated cost includes those for civil works, environmental impact mitigation (to control dust, noise, waste, and traffic disruption caused by construction), shifting utilities, quality control, construction supervision, project management, land acquisition, contingencies, taxes, and duties. The estimated financial cost of the construction was converted to economic cost by leaving out financial contingencies for price escalation first and then applying the shadow exchange rate factor (SERF) and shadow wage rate factors (SWRF) to the remainder as stipulated in the guidelines. A standard conversion factor (SCF) of 0.98 estimated from trade data was used for approximating the border price equivalent of nontraded inputs and outputs. A shadow wage rate factor (SWRF) of 1.0 for skilled and semiskilled workers and 0.61 for unskilled labor was used.

12.9.1 Capital Cost

The Capital Costs of the proposed Ghagrabasti to Hawajan Road Project including the phasing of investment during the construction period have been considered in this report. The components of costs include the following:

- Corridor-wise construction cost including soft costs.
- Material Cost
- Equipment Cost
- Labor Cost
- Land Cost
- R & R cost
- Taxes and Duties
- Environment Management Cost during Construction
- Others

The financial costs of the project road have been converted into economic costs by using a standard conversion factor of 0.90, to construction costs (road works and structures).

Economic costs are based on the "opportunity cost" of each of the constituent costs such as labour, material, equipment’s, and machinery. In order to derive the economic costs, these constituents have to be isolated, quantified and adjusted on the basis of certain principles, such as minimum wages especially of unskilled labour, foreign exchange, adjustments needed in the prices of goods and wages to make them reflect truly their market value, fuel oil, taxes (import duty, excise duty, sales tax, etc.) on a number of items of goods which are inputs to the cost of road/highway project, transfer payments within the economy, license fees, subsidies, escalation and inflation, interest charges, etc.

The economic cost of land acquisition, R & R, environment coat and utility shifting has been taken as the same as financial cost, without resorting to shadow pricing or assessing opportunity cost in any other alternative. In this case the provisional sum for road facilities and amenities day work, tree cutting cost, afforestation, training and administrative charges, utility shifting cost, etc. are adjusted with the economic cost by applying the conversion factor. The project costs, over the construction period, for both the packages combinedly are shown in the tables given below.

The summary of Project Cost at Economic Prices is given in ***Table* 12-11 *and Table* 12-11 .**

Table 12-11: Project Cost (at Economic Prices) (Option-1) (Paved Shoulder)

Sr. No.	Description	Road Length (in Km)	28.136
		Amount (In INR Crores)	
1	**Road Works:** Site Clearance and Dismantling, Earthwork, Bus bays, junction improvement including widening for auxiliary lanes, Sub-Base and Base Courses (GSB, WMM), Bituminous Course, Concrete pavement, Service Road, etc.	86.80	
2	**Structures:** Culverts (Pipe/Box culverts), Bridges (Major/Minor/ROB/RUB/VUP/Foot Over), Repair and Rehabilitation of Poor Bridges, Retaining wall, Bus Shelter, etc.	44.13	
3	**Drainage and Protection Work:** RCC Drain, Protection Work, Others, etc.	4.31	
4	**Traffic Sign and Road Appurtenances:** W Beam Crash barrier, Traffic Signs, Pavement Marking, Pedestrian Guard Rail, Paver block, Others (km stones, studs, solar blinkers, delineators, RPC, Street Light etc.)	7.37	
5	Environmental Mitigation Cost	0.16	
6	**Total Civil Cost (1+2+3+4+5)**	**142.78**	Cost Considered for EA
7	Price adjustment @ 4% Per Annum on 6 (18-30 months)	10.15	
8	**Total (6+7) (Price adjustment + Civil Work Cost)**	**152.92**	
9	GST, Assam building and other construction workers welfare cess (13%) on 8	19.88	
10	Provisional Sum for Day Work	1.20	Cost Considered for EA
11	Contingencies @ 5% on (6+Taxes)	8.05	
12	Tree Cutting Cost, Afforestation, Training and Administrative charges	9.37	Cost Considered for EA
13	Forest Clearance Cost (as per actual)	5.54	Cost Considered for EA
14	Utility Shifting Cost (as per actual)	2.90	Cost Considered for EA
15	Land Acquisition and R&R Cost (as per actual)	53.79	Cost Considered for EA
16	Maintenance Cost after construction (0.5% for 1st year,1% for 2nd year, 1% for 3rd year, 1% for 4th year and 1.5% for 5th year) on Cost put tender	8.07	
17	**Total Project Cost (8 to 16)**	**261.71**	
	Cost per KM w.r.t (with Taxes)	10.00	
	Cost per KM w.r.t (Put tender cost+17) Including taxes	10.32	
	Cost per KM w.r.t 18 (including all cost) (18/L)	16.00	
	Cost put to tender (Including taxes)	**161.00**	
	Financial Cost (6+10+12+13+14+15)	**215.57**	
	Economic Cost	**194.01**	**SCF 0.90 Considered**
	Financial Cost per Km	7.66	
	Economic Cost per Km	6.90	

Source: Consultant Estimates Cost based on Government of Assam, Public Works roads Department (PWRD), Schedule of Rates (SoR), 2019-20

Table 12-12: Project Cost (at Economic Prices) (Option-2) (Earthen Shoulder)

Sr. No.	Description	Road Length (in Km)	28.136
		Amount (In INR Crores)	
1	**Road Works:** Site Clearance and Dismantling, Earthwork, Bus bays, junction improvement including widening for auxiliary lanes, Sub-Base and Base Courses (GSB, WMM), Bituminous Course, Concrete pavement, Service Road, etc.	81.31	
2	**Structures:** Culverts (Pipe/Box culverts), Bridges (Major/Minor/ROB/RUB/VUP/Foot Over), Repair and Rehabilitation of Poor Bridges, Retaining wall, Bus Shelter, etc.	44.13	
3	**Drainage and Protection Work:** RCC Drain, Protection Work, Others, etc.	4.31	
4	**Traffic Sign and Road Appurtenances:** W Beam Crash barrier, Traffic Signs, Pavement Marking, Pedestrian Guard Rail, Paver block, Others (km stones, studs, solar blinkers, delineators, RPC, Street Light etc.)	7.37	
5	Environmental Mitigation Cost	0.16	
6	**Total Civil Cost (1+2+3+4+5)**	**137.29**	Cost Considered for EA
7	Price adjustment @ 4% Per Annum on 6 (18-30 months)	9.71	
8	**Total (6+7) (Price adjustment + Civil Work Cost)**	**147.00**	
9	GST, Assam building and other construction workers welfare cess (13%) on 8	19.11	
10	Provisional Sum for Day Work	1.20	Cost Considered for EA
11	Contingencies @ 5% on (6+Taxes)	7.75	
12	Tree Cutting Cost, Afforestation, Training and Administrative charges	9.37	Cost Considered for EA
13	Forest Clearance Cost (as per actual)	5.54	Cost Considered for EA
14	Utility Shifting Cost (as per actual)	2.90	Cost Considered for EA
15	Land Acquisition and R&R Cost (as per actual)	51.59	Cost Considered for EA
16	Maintenance Cost after construction (0.5% for 1st year,1% for 2nd year, 1% for 3rd year, 1% for 4th year and 1.5% for 5th year) on Cost put tender	7.76	
17	**Total Project Cost (8 to 16)**	**252.21**	
	Cost per KM w.r.t (with Taxes)	9.00	
	Cost per KM w.r.t (Put tender cost+17) Including taxes	9.96	
	Cost per KM w.r.t 18 (including all cost) (18/L)	15.00	
	Cost put to tender (Including taxes)	**155.00**	
	Financial Cost (6+10+12+13+14+15)	**207.89**	
	Economic Cost	**187.10**	**SCF 0.90 Considered**
	Financial Cost per Km	7.39	
	Economic Cost per Km	6.65	

Source: Consultant Estimates Cost based on Government of Assam, Public Works roads Department (PWRD), Schedule of Rates (SoR), 2019-20

A cost of material, labor, equipment, machinery is considered in the civil cost. The Civil cost is worked out based on published source by Government of Assam, Public Works Roads Department (PWRD), Schedule of Rates (SoR), 2019-20. The cost of Land Acquisition (LA), Rehabilitation & Resettlement (R&R) & Environmental is worked out separately by obtaining the information from various government agencies, i.e. Forest department, Revenue department, Patwaris, Tehsil office, etc. The summary of cost for different options are presented below in the ***Table*** 12-13**.**

Table 12-13: Project Cost with Different Options

Options	Financial Cost (Per Km) (in Rs Cores)	Economic Cost (Per Km) (in Rs Cores)
Potion-1 (2L+PS)	07.66	06.90
Option-2 (2L+ES)	07.39	06.65
Option-3 (2L+PS-Structure)	NA	NA
Option-4 (2L+ES-Structure)	NA	NA

Source: As Estimated by the Consultant, Note: NA-Not Applicable for this project corridor.

The estimated financial and economic construction costs per km for the project road account for Rs. 07.66 crores/km and Rs. 06.90 crores/km respectively for paved shoulder and Rs. 07.39 crores/km and Rs. 06.65 crores/km respectively for earthen shoulder. The disbursement of construction cost is predicted at 40% for 2025-26 and 60% for 2026-27 years.

12.9.2 Maintenance Cost

The maintenance works considered in the analysis include:

- Annual *"Do Minimum"* maintenance before improvement.
- Periodic maintenance for flexible pavement

Details of the maintenance program followed for the project roads under different situations along with their unit rates, followed in the analysis, are summarized in ***Table* 12-14**

Table 12-14: Maintenance Program & Cost

Years	Type of Maintenance	Maintenance Cost
First 4 years (from opening of road to traffic)	Routine Maintenance	Without Improvement Case Rs.1.50 Lakhs/ Km/ Annum, and With Improvement Case Rs.2.00 Lakhs / Km/ Annum
5th Year (from opening of road to traffic)	**Mix Seal Surfacing (MS)** shall be provided on the carriageway & paved shoulder as **Periodic Renewal Layer/Coat**	Without Improvement Case Rs.12.62 Lakhs/ Km and With Improvement Case Rs.25.23 Lakhs / Km
6th to 9th Year (from opening of road to traffic)	Routine Maintenance	Without Improvement Case Rs.1.50 Lakhs/ Km/ Annum, and With Improvement Case Rs.2.00 Lakhs / Km/ Annum
10th Year (from opening of road to traffic)	· As per calculated MSA for next 10 years (20th Year MSA minus 10th year MSA) the strengthening layer (i.e. overlay) in the form of BC **or** BC+DBM as required shall be provided on the	Without Improvement Case Rs.23.10 Lakhs/ Km and With Improvement Case Rs.46.20 Lakhs / Km

Years	Type of Maintenance	Maintenance Cost
	carriageway & paved shoulder as **Periodic Strengthening Layer.** · If 20th year MSA is less than or equal to 10 MSA, then provide 40mm BC.	
11th year to 14th year (from opening of road to traffic)	Routine Maintenance	Without Improvement Case Rs.1.50 Lakhs/ Km/ Annum, and With Improvement Case Rs.2.00 Lakhs / Km/ Annum
15th Year (from opening of road to traffic)	**Mix Seal Surfacing (MS)** shall be provided on the carriageway & paved shoulder as **Periodic Renewal Layer/Coat**	Without Improvement Case Rs.19.00 Lakhs/ Km and With Improvement Case Rs.37.99 Lakhs / Km
16th to 19th (from opening of road to traffic)	Routine Maintenance	Without Improvement Case Rs.1.50 Lakhs/ Km/ Annum, and With Improvement Case Rs.2.00 Lakhs / Km/ Annum
20th Year (from opening of road to traffic)	**Mix Seal Surfacing (MS)** shall be provided on the carriageway & paved shoulder as **Periodic Renewal Layer/Coat**	Without Improvement Case Rs.23.76 Lakhs/ Km and With Improvement Case Rs.47.52 Lakhs / Km

Source: As per PWRD, Assam and worked out based on BoQ estimations year 2019-2020.

As per the PWRD Assam annual routine maintenance cost for existing road and improved road is estimated at Rs. 1.00 lakh/Km and Rs. 2.00 lakhs/Km respectively for the project road. The periodic overlay/renewal cost for existing road and improved road is estimated as per the above table. In both cases, the periodic overlay/renewal is assumed to apply in 5-year time intervals. The standard conversion factor for maintenance cost is used 0.98.

- **Regular or Standard Maintenance**: Applied to repair defects on the pavement surface such as cracking, raveling, potholes, etc. with and without project, and

- **Periodical Maintenance**: Applied to preserve the structural integrity of the pavement for example, surface treatments, overlays, etc. with and without project.

12.9.3 Road User Cost

The following ***Table*** 12-15 **to**

Table 12-19 economic unit costs parametric values in consultations with the design consultants, used as HDM Model inputs for carrying out economic analysis. The vehicle price conversion factor is 0.90 since road tax, insurance etc. are included. Shadow wages found by 0.61 factor. Annual overhead is taken as 5% and conversion factor is 0.90. The following ***Table*** 12-15 gives the economic values of vehicles and travel time values for passengers and goods vehicles.

Table 12-15: Vehicle Economics Prices

Vehicle Costs at Economic Prices									
Vehicle type	Unit Cost (Rs.)			Percent	Time Value (per Hour) in Rs				
	Vehicles	Tires	Annual Overhead	Annual Interest	Maintenance Labor	Crew Cost	Passenger Working	Passenger Non-working	Cargo Time
Car	405000	3330	20250	9%	46.00	0.00	**81.0**	**24.0**	0
2-Wheeler	43200	1530	2160	9%	32.00	0.00	**58.0**	**17.0**	0
3-Wheeler	70000	1530	3500	9%	32.00	50.00	**58.0**	**17.0**	0
Minibus	720000	4050	36000	9%	42.00	120.00	**46.0**	**14.0**	0
Bus	1350000	7000	67500	9%	42.00	120.00	**46.0**	**14.0**	0
LCV	495000	4050	24750	9%	42.00	50.00	0	0	**3.0**
2 Axle Truck	1440000	8730	72000	9%	42.00	60.00	0	0	**7.0**
3 Axle Truck	1620000	8730	81000	9%	42.00	60.00	0	0	**7.0**
MAT	2250000	8730	112500	9%	42.00	60.00	0	0	**16.0**
Tractor-Trailer	600000	10000	30000	9%	42.00	50.00	0	0	**3.0**
Petrol or Fuel (Rs/ltr.)	32.00								
Diesel (Rs/ltr.)	34.00								
Lubricant (Rs/Litre)	102.00								

Source: Assam Transport Department and Assam Commercial Tax. (Adopted Time Value Rates Based on Assam State), 2019-2020, Market Survey at Assam, 2019.

Table 12-16: Estimation of Passenger Time Value (in Rs)

Passenger Time Calculation		Working Passenger Time (Rs)				
Items	Working Time Value per Hour	Vehicle Category	Occupancy	Weightage (Times Higher)	Working Passenger Time	Non-Working Passenger Time
Per Capita NSDP (Rs.) Assam (2019)	74204	Car	02.50	0.330	**81.0**	**24.0**
Population (Crore) (2019)	03.39	2-Wheelers	01.50	0.541	**58.0**	**17.0**
NSDP (Rs Crore)	251589	3-Wheelers	01.50	0.541	**58.0**	**17.0**
Economically Active (%)	53.0%	Minibus	25.00	0.130	**46.0**	**14.0**
Unemployment Rate (%)	04.0%	Std Bus	30.00	0.130	**46.0**	**14.0**
Employed Share (%)	50.88%					
Income / Employed Person (Rs)	145841					
Working Hour/Year	2080	52 Weeks x 5 Days in a Week x 8 Hours per Day				
Average Working Time Value (Rs)/Hour	**70.0**	145841/2080=70.0				
Estimated Factor for Bus	1.54	0.145 B + 0.208 x 1.25 B + 0.647 x 1.75 B = 1.54				
Time Value for Bus Passenger Rs/Hour	**46.0**	70.0/1.54 = **46.0** (for Bus)				
Time Value of Motor Cyclist of Bus Pax	1.25	46.0 x 1.25 = **58.0** (for 2W & 3W)				
Time value of Car User of Bus Pax	1.75	46.0 x 1.75 = **81.0** (for Car)				

Passenger Time Calculation		Working Passenger Time (Rs)				
Items	**Working Time Value per Hour**	**Vehicle Category**	**Occupancy**	**Weightage (Times Higher)**	**Working Passenger Time**	**Non-Working Passenger Time**
Value of Non-Working Time	30.0%	of Working Time Value (46.0 B x 30% = **14.0**)				

Source: Economic Survey of Assam (2019), Statistical Abstract & Internet

Table 12-17: Estimation of Cargo Time Value (in Rs)

Estimation Cargo Time Value (Rs)				
	CARGO =	**(PCTCGT. OPC. VALCAR)/(365X24)**		**Economic Prices**
CARGO	Cargo Time Value (LT)	03.00	Light Truck	**03.00**
	Cargo Time Value (MT)	07.00	Medium Truck	**07.00**
	Cargo Time Value (HT)	16.00	Heavy Truck	**16.00**
PCTCGT	Fraction of Vehicles Whose Cargo to be Benefited	67%	Multi Axle Truck	**16.00**
OPC	Opportunity Cost of Cargo	12%		
		Light truck	Medium Truck	Heavy Truck
VALCAR (INR)	Value of Cargo (Respective Payload of each MT Vehicle Multiplied by Average Cost of Commodity)	3,00,000	8,12,500	18,00,000
Average Cost of Commodity (INR/Tons)		1,00,000	1,25,000	1,50,000
Average Light Truck Payload (Tons)		03.00		
Average Medium Truck Payload (Tons)		06.50		
Average Heavy Payload (Tons)		12.00		

Source: Assam Motor Transport Department, Economic Survey of Assam & A Guide to Calibration and Adaptation-HDM-4 Manual (Volume 5, Pg. 187,188), Market Survey at Assam-2019.

The following ***Table*** 12-18 gives the characteristics of motorized vehicles as per the categories of vehicles used in the analysis.

Table 12-18: Characteristics of Motorized Vehicles per Category

Vehicle Type	Operating Weight (Tones)	ESAL Factor	No. of Axles	Type of Tires	No. of Passengers	Private use (%)	Work related passenger-trips (%)	Service Life (Year)	Hour Driven/ Year	Km Driven/ Year	PCSE
Car	01.40	0.00	2	4	3	100	75	10	1950	30000	1.00
2-Wheeler	00.20	0.00	2	2	1.5	100	75	10	800	21000	0.50
3-Wheeler	00.30	0.00	2	3	3	10	60	10	600	15000	0.75
Mini Bus	05.00	0.10	2	4	20	0	75	10	1500	60000	1.50
Bus	13.50	0.70	2	6	40	0	75	10	2250	70000	3.00
LCV	03.50	1.35	2	4	0	0	75	10	1600	60000	1.50
2 Axle Truck	15.50	3.36	2	6	0	0	75	10	2100	85000	1.60

Vehicle Type	Operating Weight (Tones)	ESAL Factor	No. of Axles	Type of Tires	No. of Passengers	Private use (%)	Work related passenger-trips (%)	Service Life (Year)	Hour Driven/ Year	Km Driven/ Year	PCSE
3 Axle Truck	25.00	7.86	3	10	0	0	75	10	2200	85000	3.00
MAV	35.10	6.09	5	18	0	0	75	8	2100	77500	4.50
Tractor-Trailer	04.00	0.02	2	4	0	0	75	10	2000	50000	4.50

Source: Standard Parameters, Site Surveys.

The following

Table 12-19 gives the characteristics of non-motorized vehicles as per the categories of vehicles used in the analysis.

Table 12-19: Characteristics of NMT Vehicles per Category

Parameters	Animal Cart	Bicycle	Cycle Rickshaw
Wheel Type	Wooden	Pneumatic	Pneumatic
No. of Wheels	02	02	03
Wheel Diameter (m)	1.0	0.7	0.7
Operating Weight (Kg)	1200	100	150
Payload (Kg)	900	35	100
Average Life (Year)	03	10	06
Annual Working Hour	1300	150	500
Annual Km	4000	2500	4500
Passenger	00	01	2.5
Purchase Cost (Rs.)	20000	2700	10000
Crew Wage (Unit Cost)	40	50	40
Passenger Time Cost (Unit Cost/Hr.)	00	00	30
Cargo Holding Time per Hr.	05	00	00
Energy Used per MJ	00	00	00
Annual Interest (%)	9%	9%	9%
PCSC	4	0.5	0.75

Source: As per Standard Parameters and Current Market Rates in India & Assam.

Considering the remaining life of the construction items, the Residual value (30% salvage value) has been assessed at the end of the analysis period. For structures, the life is assumed to be 40 years. Values of the selected construction items such as LA, structures, sub-base, social displacement cost etc. are included in the economic analysis as residual values at the end of the analysis periods. These residual values are considered as benefits to the project in the analysis. The value has been taken as 30%.

An economic analysis has been carried out for the project road sections. On the benefit side, only vehicle operating cost savings and travel time savings are quantified and included. The proposed project will improve road condition and reduce the roughness index as well as improve the average speeds with widening.

12.10 Project Benefits

The economic analysis presented herein estimates two categories of tangible benefits: (a) savings in vehicle operating costs due to improved road conditions, (b) savings in travel time due to increased travel speeds. In addition to tangible benefits, the project will accelerate the economic growth of project influenced rural areas as it provides improved access to social, health, education, market, employment facilities for the inhabitants. Moreover, there may also be a reduction in road accidents following the improvements in road geometry, pavement, road signs and markings. Excluding these intangible benefits suggests that the project's feasibility indicators are certainly stronger than those derived and reported.

12.10.1 Vehicle Operating Cost Savings

The model comprehensively predicts the performance and operating costs of motorized vehicles in the selected fleet. Motorized vehicle performance predictions include speeds (free flow and congested conditions) and consumption. Predictions for vehicle operating costs include fuel, oil, tire and parts costs, crew and maintenance labour costs, capital depreciation, borrowing costs, and overhead costs.

HDM-4 is used to estimate the Vehicle Operating Costs (VOC) for traffic in each vehicle category on each selected road *with* and *without improvement*. The model estimates VOC in both the with- and without-project situations considering the speed and travel time including surface quality and road congestion.

VOC will vary from vehicle type to vehicle type and according to road roughness, alignment (vertical and horizontal), average speed and congestion. Improving the roughness or alignment of the road will reduce VOC. VOC are measured in resource prices and not at market rates. Parameters such as fuel and tyre costs have been adjusted to eliminate the effect of taxes and charges on unit values and are subsequently represented in resource prices. With respect to fuel for example, the unit values are expressed in net of excises and levies. The resulting VOC values for each road and section can be found in the HDM results.

The vehicle operating cost savings for NMT used in the study are based on actual differentials in charges between existing poor roads and improved roads, as they substantially reflect the cost variations due to greater exertion, time, and additional food for higher level of effort and energy needed for plying on rougher roads.

The HDM-4 is used to estimate the vehicle operating cost (VOC) for the traffic under the with- and without-project scenarios. The model estimates VOCs considering the speed; travel time; surface quality; road congestion; and vehicles characteristics together with their utilization and economic prices (including capital cost, maintenance cost, crew cost, fuel, and lubricants). The net reductions in VOCs are presented as savings. The vehicle characteristics are as per the manufacturer's specifications while their utilizations and economic prices as per the recent road user studies and market surveys. The economic prices of fuels are estimated based on the published data by Petroleum Planning & Analysis Cell of Ministry of Petroleum & Natural Gas.

12.10.2 Travel Time Saving

The average operating speed on the project roads is currently about 25-30 Km/h and anticipated to double after proposed rehabilitation. The HDM-4 assesses the value of time saved by comparing travel times in the with- and without-project scenarios weighted with unit time values of passengers. The time values are estimated relating per capita income of project influenced state to their employed population and estimated number of work hours per year (2080 Hrs.). Such calculated average unit time value was equaled to Rs. 70.0/hour. The unit time values for three different user categories of (i) Two-wheeler & Three wheelers; (ii) Car, Jeep and Van; and (iii) Bus are established by solving three equations derived by equaling: (i) average unit time value to the aggregation of unit time values of different vehicle users weighted with their relevant passenger compositions (ii) 1.25 times of unit time value of a Bus passenger to that of Two and Three-wheeler; and (iii) 1.75 times of unit time value of a Bus passenger to that of Car, Jeep and Van users. Solving these three equations provides unit values for worktime for three vehicle user categories considered. In this analysis the unit value for non-work time is estimated at 30% of work-time value of respective categories. The value of cargo delay per hour was derived as the opportunity cost of capital tied up in delayed cargo (value of cargo multiplied by the interest rate) and was estimated at Rs. 3.0 for light trucks, Rs. 7.0 for medium trucks and Rs. 16.0 for heavy and multi-axle trucks based on inventory cost method and considering 9% interest rate as the opportunity cost of capital. The shadow wage rate factor for unskilled workers is applied to public transport users' time value, assuming one-third of public transport users are unskilled workers.

The Model Estimates the Value of Travel Time (VOTT) for passengers and goods in transit in both the *with*- and *without*-project scenarios considering speed and travel time including surface quality, road congestion etc. both for Motorized transport and NMT. Travel time, or journey time, savings are generally considered to be the most important component of transport projects designed to improve transport route and network efficiency. Reduction in congestion and lower travel times therefore represent most road infrastructure benefits. The measurement of time is divided into two distinct streams based on the purpose of the trip. These are either private (non-work) or business-related travel.

12.10.3 Reduction in Accident Cost due to Improvement of Project Road

Road widening, correction of geometrics, speed controls through imposition of traffic calming measures, all lead to reduction in accidents on roads. It is therefore important to quantify the same for inclusion in the analysis, as the project cost includes the investments made towards ensuring safer roads for traffic.

To undertake the benefit assessment, accident data from the police stations was collected for the corridor under study. It is, however, known that the recorded data on accidents are generally underestimated and injuries by even higher order of magnitude. It is expected that the fatalities would be reported to mere correct number in the police stations; hence it would be correct to link the number of serious and minor accidents to number of fatalities, for analysis. Based on the available data, local enquiries, prevailing road condition / infrastructure and best judgement, it is prudent to consider 33% additional to account for Injuries. Further, accident data is rationalized based on the length and conditions of the road, where data is not available. Accordingly, the average data is used to derive accident data where no accident records are available and is validated by respective Road Safety Engineers for the purpose of Road Safety Appraisal. The same has been utilized as input in HDM model to account economic benefits at base case and proposed scenario. The number of accidents is worked out based on data received from the respective Police Stations along the project road corridor as per following **Table** 12-20

Table 12-20: Accidents Data as per Record (in No.)

Year	Accidents as per the Records (in Nos.)		
	Fatal Accidents	Injured Accidents	Total Accidents
2015	00	00	00
2016	00	00	00
2017	00	00	00
2018	00	00	00
2019	00	07	07
Average Annual Accidents	**00**	**07**	**07**

Source: Consultants Estimates and Data Collection from Police Station

For quantification of the above accidents, unit costs per type of accident have been adopted from benchmarking exercise as detailed below. The **Table** 12-21 below provides the costs estimates due to road traffic crashes in India across various studies. Accident costs comparison based on the; 1) IRC SP-30 2019, 2) iRAP Tool Kit, and 3) Socio Economic Costs of Road Accidents in India –A Study undertaken by IIT Delhi and DIMMTS (extract of costs was taken from the presentation made at CSIR-CRRI in Oct 2020).

Table 12-21: Economic Cost for Different Types of Accidents per Victim in INR

Economic Cost for Different Types of Accidents per Victim in INR					
Sr. No.	Category of Accident	Economic Cost of Accidents (As per IRC: SP:30-2019	Economic Cost of Accidents (As per iRAP Equations)	Socio-Economic Cost of Road Accidents in India - DMITS and IIT, presented at CSIR-CRRI -Oct 2020.	Adopted Accident Costs for ECA of Asom Mala Roads
		2019-2020	2019-2020	Oct-2020	At Base Year 2020
1	Fatalities	13,25,049	68,74,230	91,16,363	**91,16,363**
2	Major /Serious Injury	4,32,651	-	3,64,398	**3,64,398**
3	Minor injury	46,680	-	77,938	**77,938**
4	No Injury (Damage of Vehicles only)	-	-	88,463	**88,463**

Source:

1.IRC: SP:30-2019 – Manual on Economic Evaluation of Highway Projects in India

2.http://toolkit.irap.org/default.asp?page=management&id=1 and Assam Statistical Abstract-2019

3. Socio-Economic Cost of Road Accidents in India by IIT Delhi and DIMTS and Training Program at CSIR- CRRI on 31st October 2020

It is noted that the recent study by DIMMTS and IIT Delhi based on the Pan India sampling on the concept of Human Capital Approach*, the following cost are considered.

- Victim related costs (Medical, lost labour, funeral, pain grief and suffering costs)
- Property Damage costs (Vehicle damage, Civil works / Road furniture)
- Administrative costs (Police investigation, legal, Insurance and administrative, court administrative costs)

**The "Human Capital Approach" estimates the loss to society caused by the traffic accident. It considers the Lost productivity of the victim and caregiver.*

Considering the above, Consultant has adopted the average unit cost per victim for Assam Mala Road project as per the recent study and rationalizing the Assam GDP as below **Table** 12-22

Table 12-22: Accidental Cost in INR

Sr. No.	Category	Accident Cost (All Inclusive) (INR)
1	Fatalities	91,16,363
2	Major /Serious Injury	3,64,398
3	Minor injury	77,938
4	No Injury (Damage of Vehicles only)	88,463

Source: Consultant Estimated

The worked-out accidental data and cost is used in HDM-4 for analysis of the accident benefits received in terms of reduction of road accidents due to improvement in the road infrastructure facilities along the project road corridor.

12.10.4 Benefits Due to Increase in Direct and Indirect Employment

The proposed road project will result in the creation of direct jobs and indirect jobs as various inputs will be required from the industrial and services sector for project execution and re-spending of the salaries for different products and services. The economic benefit of the direct and indirect jobs created by proposed road project has been calculated as the product of direct and indirect jobs created and the average daily/ annual emoluments.

The Consultant has extensively researched the different benchmarks used in evaluation of the benefits due to employment generation from the projects in the transportation sector. The below **Table** 12-23 summarizes the benchmarks available from different studies.

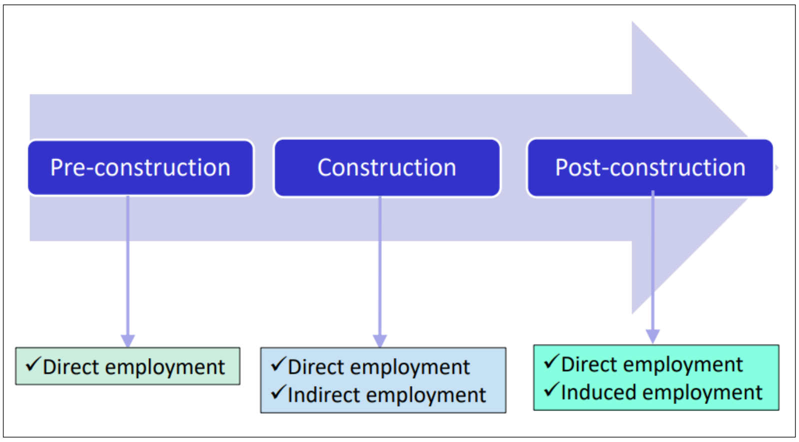
Table 12-23: Number of Jobs Created per US$ 1 Billion of Public Transportation Expenditure

Type of Jobs↓\ Study →	Number of Jobs Created per US$ 1 Billion of Public Transportation Expenditure			
	American Public Transport Association (2009)	American Association of Railroads (2011)	Federal Highway Administration (2011)	Council of Economic Advisors (2015)
Direct Job Created	24,000	20,000	14,975	10,854

Type of Jobs↓\ Study →	Number of Jobs Created per US$ 1 Billion of Public Transportation Expenditure			
	American Public Transport Association (2009)	American Association of Railroads (2011)	Federal Highway Administration (2011)	Council of Economic Advisors (2015)
Indirect Jobs Created	41,000	Not determined	15,094	Not determined

Source: Different Studies

The major employment would be in the construction and maintenance stages. There will be skilled, unskilled, manpower requirement in the project development and execution stage. The local uneducated and educated people will get employment opportunities after development of road facilities.



Direct Employment: to Managers, engineers, surveyors, supervisors, onsite workmen, machinery operators, specialists likewise, etc.

Indirect Employment: to Vendors who supply materials and who carry out small-scale sub-contracting works like repair of existing structures etc.

Induced Employment: Changes in employment due to the availability of highways – These include both direct (access to more jobs), or indirect (local small company hires more people since its products have larger reach) – Local businesses may expand, as the access to customers outside their locality improves due to highway construction, etc.

An estimation of direct and indirect employment is very easy as compared to the induced employment, due to the segregation and availability of accurate data. Therefore, the consultant has considered the direct and indirect employment potential generated in this project road as described in **Table** 12-24 as follows.

Table 12-24: Employment Potential during Construction & Operation Phase

Type	No of Persons	Rate per Day (in Rs.)	No of Days	No of Years	Amount (In Rs. Crores)
Employment Potential during Construction Phase					
Skilled	44	375	300	01	0.495

Type	No of Persons	Rate per Day (in Rs.)	No of Days	No of Years	Amount (In Rs. Crores)
Employment Potential during Construction Phase					
Semi-Skilled	15	300	300	01	0.135
Technical	05	2000	300	01	0.300
Total	**64**		**300**	**01**	**0.93**
Employment Potential during Regular Maintenance Phase					
Skilled	14	375	300	01	0.158
Semi-Skilled	12	300	300	01	0.108
Technical	05	2000	300	01	0.300
Total	**31**		**300**	**01**	**0.57**
Employment Potential during Periodic Maintenance Phase					
Skilled	34	375	300	01	0.383
Semi-Skilled	10	300	300	01	0.090
Technical	05	2000	300	01	0.300
Total	**49**		**300**	**01**	**0.77**

Source: Consultant Estimated

The total employment potential would be around Rs. 14.00 crores during the project development and operational phase. Out of which during 02 years' construction period it would be Rs. 01.86 crores (Rs.0.93*2 years = Rs. 01.86 crores) and during the operation period for regular maintenance phase it would be Rs. 09.05 crores (Rs. 0.57*16 years = Rs. 09.05 crores) and during the operation period for periodical maintenance phase it would be Rs. 03.09 crores (Rs.0.77*04 years = Rs. 03.09 crores). The phase wise details are given in the following **Table** 12-25;

Table 12-25: Employment Benefits during Construction & Operation Phase

Sr. No.	Year	Employment (in Nos.)				Income (in Millions Rs.)			
		Construction	Routine Maintenance	Periodic Maintenance	Total	Construction	Routine Maintenance	Periodic Maintenance	Total
1	2025	64	00	00	**64**	9.30	00	00	**9.30**
2	2026	64	00	00	**64**	9.30	00	00	**9.30**
3	2027	00	31	00	**31**	0.00	5.66	0.00	**5.66**
4	2028	00	31	00	**31**	0.00	5.66	0.00	**5.66**
5	2029	00	31	00	**31**	0.00	5.66	0.00	**5.66**
6	2030	00	31	00	**31**	0.00	5.66	0.00	**5.66**
7	2031	00	00	49	**49**	0.00	0.00	7.73	**7.73**
8	2032	00	31	00	**31**	0.00	5.66	0.00	**5.66**
9	2033	00	31	00	**31**	0.00	5.66	0.00	**5.66**
10	2034	00	31	00	**31**	0.00	5.66	0.00	**5.66**
11	2035	00	31	00	**31**	0.00	5.66	0.00	**5.66**
12	2036	00	00	49	**49**	0.00	0.00	7.73	**7.73**
13	2037	00	00	00	**31**	0.00	5.66	0.00	**5.66**
14	2038	00	00	00	**31**	0.00	5.66	0.00	**5.66**
15	2039	00	00	00	**31**	0.00	5.66	0.00	**5.66**
16	2040	00	00	00	**31**	0.00	5.66	0.00	**5.66**
17	2041	00	00	49	**49**	0.00	0.00	7.73	**7.73**
18	2042	00	31	00	**31**	0.00	5.66	0.00	**5.66**
19	2043	00	31	00	**31**	0.00	5.66	0.00	**5.66**
20	2044	00	31	00	**31**	0.00	5.66	0.00	**5.66**
21	2045	00	31	00	**31**	0.00	5.66	0.00	**5.66**
22	2046	00	00	49	**49**	0.00	0.00	7.73	**7.73**
Total		**128.00**	**496.00**	**196.00**	**820.00**	**18.60**	**90.48**	**30.90**	**140.0**

Source: Consultant Estimated

12.10.5 Exogenous Costs and Benefits

Apart from the VOC, VOT, Accidents, Employment benefits, there are other economic, social, and environmental benefits/effects that can be estimated which include vehicle emissions, energy consumption, traffic noise, agriculture productivity, other welfare benefits to the population served by the roads, leisure, comforts, etc. Although the social and environmental benefits/effects are often difficult to quantify in monetary terms, they can be incorporated within the economic analysis models if quantified exogenously. Alternatively, qualitative social and environmental impact assessments are often carried out in parallel with the economic appraisal.

Other costs or benefits that can be directly associated with a road project may be included in the economic analyses. These usually include independently assessed benefits accruing from socio-economic developments such as increased agricultural productivity, industrial output, accessibility benefits, etc. Exogenous costs could include the costs of providing diversion routes, noise barriers and other impediments during construction. Such costs or benefits are not calculated by road investment models and therefore their inclusion in any economic analyses must be clearly justified as they can easily affect the ranking of alternative projects.

Exogenous costs would include the environmental and social costs that may occur in case due to impact of the proposed construction activities on the surrounding environment, people, and structures. In such cases, proper costs are to be estimated and incurred for undertaking remedial measures. The environmental and social experts associated with the study must estimate costs for such remedial actions.

- In this proposed project road **reduction in pollution** is anticipated due to reduce the fuel consumption in road, reduced travel time. Both these factors are likely to result in the reduction of air pollution due to the introduction of the proposed road project corridor.

- Population along the proposed project road (0.13 Lacs) shall benefit from the project. In addition, the project will **boost the agricultural and Industrial development** of the surrounding area which will eventually boost the economic growth.

- There is also the possibility of an increase in **productivity and economy** in the project influencing areas. The Economic Improvement in the Project Districts (Sonitpur & Lakhimpur) considering enhanced growth in the GDP against normal growth rate due to the project. This benefit will be for 5 years at enhanced rate of 1%, 15 years for enhanced 0.5% rate (Current GDP of the state @ 3.74 Lakhs Crore / annum in 2019-20, Population of Assam is 3.09 Cr and Project Influencing Area is 0.13 Lacs).

- **Agriculture and allied activities** are occupying a very important sector in the (Sonitpur & Lakhimpur) districts and are a source of occupation for the majority contributing to agrarian economy. The forest cover of the district is 40% of the total and 40% is cropped land and the rest 18% is uncultivable and 2% is fallow land. This proposed project road will boost the agricultural and allied activities in the project influence areas as well as entire (Sonitpur & Lakhimpur) districts.

- The resident farmers from the project influence areas are producing Agro based tea, rice (Ahu and Sali), vegetables and sugarcane are the main agricultural crops, among these there are fiber crops (jute and cotton), pulses (black gram, lentil, green gram, gram, tur), oil seeds (linseed, castor, sesame, rape & mustard), plantation crops (banana, papaya, orange, pineapple, areca nut, coconut etc.), spices (chilly, onion, turmeric, ginger etc.), potato, sweet potato, wheat are common among the farmers. By improvising the proposed road facilities farmers will benefit by selling their agricultural produce into the market at right time and right place so that they will get remunerated price for their produces. The net crop area of the (Sonitpur & Lakhimpur) districts is 1,43,790ha. The Kharif area comprises 1,43,790ha and Rabi area of the district comprises 67,790ha.

- The project influencing area is predominated by agriculture and is the greatest asset of an area which plays a vital role in **agricultural development**. Not only farmer's development but the prime objective of proposed infrastructure development is the socio-economic upliftment of the families related to agriculture through implementation of different schemes. This road development project will help to achieve the prime vision of Districts Agriculture (Sonitpur & Lakhimpur) "To achieve productivity growth targets, conservation of natural resources and integration of farming system in holistic approach to bring about sustainable increase in the farmer's income to make the district a hunger free one".

- The proposed project road would support **value addition in the production** and post-harvest segments of selected agriculture value-chains; facilitate agribusiness investments through inclusive business models that provide opportunities to small farmers as well as stimulate the establishment of new small and medium agribusiness enterprises; and support resilience of agriculture production systems in order to better manage increasing production and commercial risks associated with climate change, in the (Sonitpur & Lakhimpur) districts/ project influencing areas.

- The proposed road is designed to be **climate resilient**. The temperatures recorded in project influencing areas/ (Sonitpur & Lakhimpur) districts ranges from 10ºC in January to 38ºC in July. The average annual rainfall recorded in the district is 1720.45 mm and the most important is the intensity and duration of rainfall which is quite variable. There are three climatic seasons-summer, monsoon, and winter. Hydrogeological also the district is proved to be very potential. This climate resilient road will be beneficial to the users to access in all the climatic conditions.

- This project road will help **directly or indirectly to influencing** areas/ (Sonitpur & Lakhimpur) districts for booming agriculture activities, to overcoming hindrances of flood prone areas, Tea Garden areas (covering many parts of the district) and Drought prone areas in way of increase productivity, enhancement of production, Marketing and value addition, Capacity building, etc.

- Teh project road connects to the Alupara, Daimalu, Dholpur, Gohpur, Hawajan, Simaluguri, Narayanpur, Lakhimpur, Sonitpur, Kamrup, Assam, Arunachal, Nagaland, etc. major regions / districts / states and to various village roads, major district roads, state highways and national highways. It connects to NH-15, NH-52A, NH-415, NH-13, SH-43, SH-45, and MDR's. This project road also has inter-state connectivity with Nagaland and Arunachal states. It is important for interstate passengers and freight movements. The project road is also connecting to the new proposed Hollongi Airport. This will also help to reduce the congestion and accidents level on the existing project road. It will also be beneficial to the users for reducing journey travel time and operating cost of the vehicles. It will also help to protect the interest of pedestrian movement and animal crossing by providing the appropriate safeguard measures along the project corridor.

12.11 Economic Viability

The results of economic analysis for the project road are presented in terms of economic internal rate of return (EIRR) and net present value (NPV) at 12% & 9% discount rate. In accordance with the ADB/World Bank guidelines, a project with an EIRR equal to or above 12% or 9% is treated as economically feasible for implementation.

The economic internal rate of return is calculated by the model applying a project discount rate of 12 & 9 percent to the annual undiscounted net differences of the economic elements considered in the analysis. The net cash flow statement showing the economic net present value (NPV) of the project, which is generated and presented, together with the associated EIRR for project road are attached in the **Annexure-12.3**. The cost and benefit stream are presented below in the ***Table* 12-26*.***

Table 12-26: Cost & Benefit Flow Stream for Project Road (in Millions)-Option-1

Sr. No.	Year	Capital Costs	Recurrent Costs	Total Cost	VOC Savings	VOTT Savings	NMT Benefits	Accident Benefits	Exogenous Benefits	Total Benefits	Net Benefits
1	2025	527	(4.18)	**522**	0.0	0.0	0.00	0.00	27.90	**28**	**(495)**
2	2026	744	(4.18)	**740**	(4)	(0)	(7.0)	0.00	27.90	**17**	**(723)**
3	2027	558	(4.18)	**554**	(4)	(0)	(6.9)	0.00	27.90	**17**	**(537)**
4	2028	0.0	1.11	**1.11**	207	206	2.72	0.35	16.97	**434**	**432**
5	2029	0.0	1.11	**1.11**	219	218	2.73	0.38	16.97	**458**	**456**
6	2030	(32)	1.11	**(30)**	233	231	2.78	0.41	16.97	**484**	**514**
7	2031	0.0	1.11	**1.11**	245	245	2.42	0.43	16.97	**509**	**508**
8	2032	52	(4.18)	**47.5**	259	258	2.52	0.46	23.18	**543**	**496**
9	2033	0.0	1.11	**1.11**	274	273	2.86	0.49	16.97	**567**	**566**
10	2034	0.0	1.11	**1.11**	293	288	2.94	0.52	16.97	**602**	**601**
11	2035	(32)	1.11	**(30)**	314	304	3.03	0.55	16.97	**638**	**668**
12	2036	0.0	1.11	**1.11**	328	320	2.51	0.58	16.97	**669**	**668**
13	2037	122	(4.18)	**118**	349	338	2.62	0.62	23.18	**713**	**595**
14	2038	0.0	1.11	**1.11**	377	356	2.89	0.65	16.97	**753**	**752**
15	2039	0.0	1.11	**1.11**	399	376	2.97	0.69	16.97	**795**	**794**
16	2040	(32)	1.11	**(30)**	423	396	3.11	0.73	16.97	**840**	**870**
17	2041	0.0	1.11	**1.11**	445	418	2.44	0.77	16.97	**883**	**882**
18	2042	52	(4.18)	**47.5**	477	440	2.58	0.81	23.18	**943**	**896**
19	2043	0.0	1.11	**1.11**	507	463	2.99	0.86	16.97	**991**	**990**
20	2044	0.0	1.11	**1.11**	540	488	3.14	0.90	16.97	**1050**	**1049**
21	2045	(32)	1.11	**(30)**	605	515	3.32	0.95	16.97	**1140**	**1171**
22	2046	0.0	1.11	**1.11**	610	542	2.53	1.01	16.97	**1173**	**1172**
23	2047	(507)	(4.18)	**(511)**	636	572	2.70	1.06	23.18	**1235**	**1746**
Total		**1422**	**-11.4**	**1411**	**7731**	**7248**	**41.87**	**13**	**448**	**15483**	**14072**
										EIRR	**24.5**
										NPV (Rs. Million) @ 12%	**1965**

Source: HDM-4 Output.

The sum of these discounted values gives the economic net present value (NPV) of the project, which is generated and presented, together with the associated EIRR in the HDM output sheets for project road are attached in the **Annexure-12.4**.

Table 12-27: Results of the Economic Analysis

Road (Discount Rate)	Option-1 (2L+PS)		Option-2 (2L+ES)	
	EIRR (%)	NPV (Rs Million)	EIRR (%)	NPV (Rs Million)
Ghagrabasti to Hawajan Road **(12% Discount Rate)**	**24.5**	**1965**	**25.3**	**2017**
Ghagrabasti to Hawajan Road **(9% Discount Rate)**	**24.5**	**3208**	**25.3**	**3261**

Source: HDM-4 Output Sheets

The project is found to be economically viable. The entire project road is found viable returning an NPV of Rs. (1965) million and an EIRR of (24.5%), EIRR is comfortably above the threshold of 12% at base level. The project is also viable at a 9% discount rate of return.

12.12 Sensitivity Analysis

The robustness of economic feasibility of sample project roads and their aggregation are tested with a sensitivity analysis conducted in the form of risk analysis. These analyses tested the economic feasibility against uncertainties in estimated capital cost and benefits associated with the project road.

A sensitivity analysis has been performed under the following scenarios and found that the project is economically viable even under worse condition at 12% and 9% discount rate when all the factors are supposed to happen simultaneously.

- Base Cost Plus 15% and Base Benefits
- Base Cost and Base Benefits Minus 15%
- Base Cost Plus 15% and Base Benefits Minus 15%

Table 12-28: Sensitivity Analysis

Option	Discount Rate	Base Case		Base Cost Plus 15% and Base Benefits		Base Cost and Base Benefits Minus 15%		Base Cost Plus 15% and Base Benefits Minus 15%	
		EIRR (%)	NPV (In Million)	EIRR (%)	NPV (In Million)	EIRR (%)	NPV (In Million)	EIRR (%)	NPV (In Million)
I 2LPS	12%	24.5	1965	22.1	1750	21.7	1455	19.4	1239
II 2LES		25.3	2017	22.8	1809	22.4	1506	20.1	1298
I 2LPS	9%	24.5	3208	22.1	2984	21.7	2503	19.4	2279
II 2LES		25.3	3261	22.8	3045	22.4	2556	20.1	2340

Source: HDM-4 Output Sheets

The results of sensitivity analysis show that the project road is achieving the economic internal rate of return above 12% and 9% in all the scenarios of increasing cost, decreasing benefits and both cases at 12% and 9% discount rate.

12.13 Conclusions and Recommendations

The project road found economically feasible for the proposed improvement of upgradation to two lane paved/earthen shoulders. Economic Analysis results show an EIRR of 24.5% in base case and 19.4% is worst case, which is above the benchmarked IRR of 12% and 9%. The benchmarked EIRR has been fixed based on social discount rate factor adopted by various multilateral funding agencies.

Therefore, considering their values of feasibility criteria at base case scenario and at worst case scenario, further demand, and better accessibility, it is recommended to construct the proposed upgradation of two lane paved/earthen.

CHAPTER 13

ROAD SAFETY AUDIT

13. Road Safety Audit

Road safety audit (RSA) is a systematic and formal process of inspecting the safety aspects of road schemes before they are built. The simple objective of RSA is to make sure that all new road schemes operate as safely as possible. In other words, RSA is conducted to identify potential safety problems, so that, where possible, the design can be changed to eliminate or reduce them. The audit is carried out by trained and experienced auditors who are independent of the scheme designers.

Important aspects of RSA includes minimization in accident risks or its severity, avoiding the occurrence of accidents elsewhere on the road network, maintaining balance between different categories of road users, reduction in long term cost of project facilities and to increase awareness about safe design practices among various stakeholders of the road such as planners, designers, contractors, etc.

13.1. Approach and Methodology

The approach and methodology adopted for carrying out road safety audit is based on the IRC specification numbered as IRC SP 88 (Manual of Road Safety Audit). The road safety audit approach and methodology are devised considering the detailed scope and stage wise deliverables of the project. The broad level approach and methodology is presented with ***Figure 13-1***.

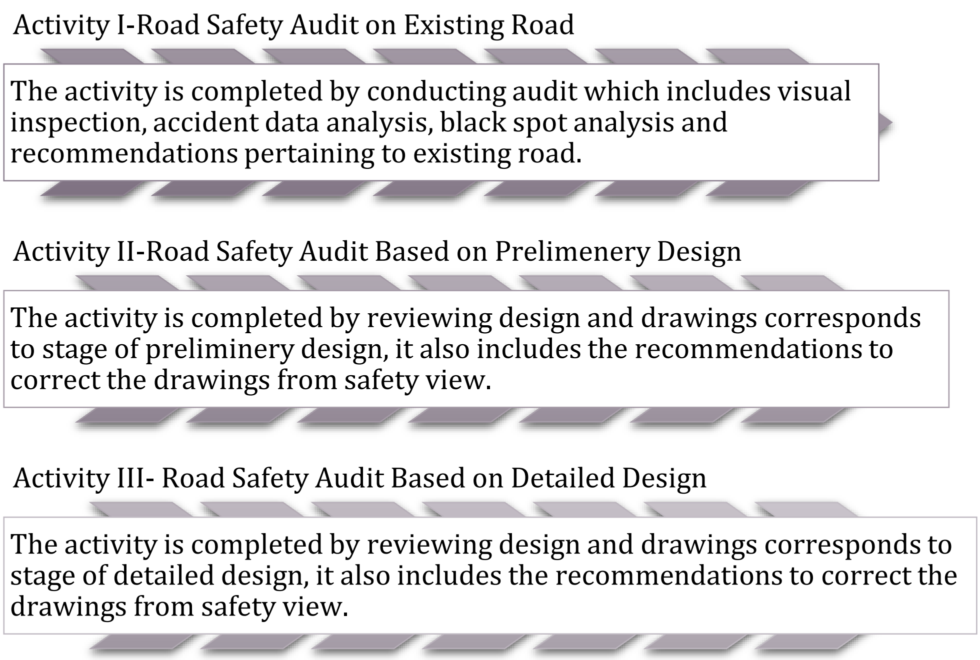


Figure 13-1: (Stage wise Approach)

All activities are carried out in accordance with the checklists issued by Road Safety Manual.

13.2. Standard and specifications

The various codes published by Indian Road Congress are considered for the road safety audit. Specifically, IRC SP 88 (Manual on Road Safety Audit) forms the basis for conduction of road safety audit on road project. Apart from the Manual on road safety audit, various codes published by IRC for geometrics, traffic control devices, pavement, two laning manuals etc. are followed for the project. The section gives an overview of IRC SP 88.

13.3. Team composition

The DPR consultant has deployed the experienced expert team to carry out and complete the assignment. The team composition is elaborated in ***Table 13-1*** as below,

Table 13-1:Team Composition

Sr No	Designation	Team Member-Name
1	Road Safety Specialist	Mr. Lukesh Kantode
2	Highway Design Engineer	Mr. Md Saifee
3	Assistant Road Safety Engineer	Mr. Mandar Joshi

The audit activities at this stage are carried out by the Road Safety Specialist, Highway Engineer and Assistant Road Safety Engineer in close coordination with department person.

13.4. Summary of Existing Road Safety Audit

The road safety audit is carried out at Existing Road Audit stages and submitted separately; That report has the location wise observations and recommendations which have been summarized in following section. In order to achieve the goal, the recommendations have been given for the geometric improvement of inadequate sharp radius curves, Geometric improvement of junctions with inadequate sight vision and geometric deficiency with provision of traffic calming and traffic control devices, Provisions for Vulnerable road users, Special improvement of junctions with railway level crossing, Provisions for Road side furniture and Protection works etc.

The glimpse of curve locations requires geometric are as follows.






The glimpse of junction locations requires improvement are as follows.


The glimpse of other locations requires improvements and Provisions are as follows.

The observation made during the reconnaissance survey for the existing road safety audit is as listed below:

- The project stretch has sharp curves with inadequate radius.
- It is observed that the project stretch has too many blind sharp and S-curves located at structure locations and greenfield area.
- The project stretches passes through urban areas.
- The project stretch has inadequate transition and super elevation.
- It is observed that the sharp curves are also located at high embankment locations.

- It is observed that the road sides are encroached by tree branches.
- There are no provisions for vulnerable road users in urban stretches and at junctions of project corridor.
- There is no lane marking, signages, delineation, arrow marking and traffic control devices along the urban stretches and at junctions.
- It is observed that the junction is found without traffic signages, marking and traffic control devices.
- The junctions located in the urban areas required special provisions.
- It is observed that some junctions are located at sharp curves and built-up areas.
- It is observed that the bus shelter is located just at the edge of junction without object hazard marking.
- The project stretch comprises many locations where vulnerable road users crosses the project road especially at school, hospital, bus bay, narrow bridges locations.
- It is observed that the roadway elements such as, carriageway, paved shoulder, earthen shoulder and side slope etc. are found inadequate as per IRC standards and also in damaged condition.
- The cross fall of the carriageway and shoulders are not as per IRC Specifications.
- The provided side slope is inadequate as per IRC Standards and specifications.
- The project stretch comprises of locations with high embankment and Narrow bridge, without any road side protection work.
- In this project stretch, road components such as structures are being retained, which does not have provisions such as advance warning and traffic control device with all road side protection work and object hazard markers.
- Too many road side properties and development work have their direct access to project Road.
- The project stretch does not have any lighting facility at bus bay, junctions and in built-up/ urban areas.
- The project stretch has railway crossings and this junction need to be improved separately.
- It is observed that from data received from the respective police stations that the project stretch does not have any accident hence project stretch could not be analyzed for accident data and all the recommendations are given on the basis of visual observations.

The recommendations derived from the observations of road safety audit made during the reconnaissance survey is elaborated in the below ***Table 13-2***.

Table 13-2: Summary of Previous Recommendations

Sr No	Recommendations
Road Geometry (Horizontal and vertical Alignment)	
1	The recommendations in regards to road geometry includes the improvement of road alignment by removing sharp and inadequate radius curves and providing adequate sight distance.
2	It includes the improvement of existing alignment by introducing road realignment or bypass to congested project stretches.
3	It includes the improvement of project stretch with provision of adequate radius, transition and super elevation suited to design speed of corridor.

Sr No	Recommendations
4	It includes the provision of chevron sign boards, curve sign boards and road side protection work at sharp curves by providing metal beam crash barriers.
Urban Stretches (Vulnerable Road Users)	
1	It includes the improvement with priority to Vulnerable Road Users.
2	It includes the separate provision in line with IRC guidelines specifically for urban stretches.
3	It includes the improvement of junction elements falls under urban stretch.
4	It includes the provision of footpath and guard rail facilities at urban locations to reduce the conflict points.
5	It includes the provision of traffic control devices as per stipulated standards and specifications.
Junction Improvement	
1	It includes the at grade junction development with adequate provision of pedestrian and vehicular users.
2	It includes the provision of junction elements as per stipulated standards and specifications.
3	It includes the development of junction at the location of sharp curve which falls under the jurisdiction of built-up area.
4	It includes the development of such railway level crossing junctions as per provision given in IRC: 39:1986 and if required special provision such as VUP etc. shall be provided.
Hazardous Location	
1	It includes the preparation and implementation of separate proposal for locations of schools, hospital, bus bay, narrow bridges and any other hazardous location.
2	It includes the provision of traffic calming devices specifically to arrest the speed and avoid the conflict points between the road used and vulnerable road users.
3	It includes the provision of reflective markers on Road side hazards and trimming of tree branches etc.
Roadway Elements (Cross section, Road Damages and Drainage)	
1	It includes the improvement or provision of roadway elements specifically carriage way, paved shoulder, earthen shoulder, embankment base width, utility corridor etc.
2	It includes the provision of adequate cross fall to carriage way or shoulders.
3	It includes the provision of stable slope to high embankments considering material properties and available land width.
4	It includes provision of balancing culverts.
Traffic Control Devices (Road side Protection Work)	
1	It includes the provision traffic furniture's/devices along the project stretch with respect to location, facility, hazard or any other project stretch element.
2	It includes the provision of alerting devices at the location where improvement is not possible because of site or any other constraints.
Signs, Pavement Marking and delineations	
1	It includes the provision of Pavement marking, channelization marking and marking at hazard locations and provision of signages and delineation at requisite locations.

Sr No	Recommendations
Access to property and Development	
1	It includes restriction of such illegal direct access to main road by providing one common access to project road by connecting of numbers of access along project stretch.
Lighting and Night time issues	
1	It includes the provision of lighting facility at bus bay, junctions and built-up/ urban area locations.
Accident Prone Locations	
1	It includes the improvement of locations found based on analysis of accident data of last five years pertaining to project stretch.

As per the site observations during Existing Road Safety Audit stage, certain remedial measures were proposed for the improvement and upgradation of the project road. Accordingly, various recommendations were incorporated at PPR and Design Road Safety Audit stage. The summary of the recommendations for the Final Design Road Safety Audit have been mentioned in Section below 13.6.2.

13.5. Audit and compliance to Black spot

The audit of existing road includes the critical evaluation and remedial plan to convert the black spot in non-accident zone. The assignment to identify the black spot from police station data is also carried out. As the project stretch is located on green field area and no existing road prevails along the proposed alignment of the road, there is no such an established black spot prevails on the project corridor.

And also, the investigation shows that the project stretch does not have any accident from last five years hence the analysis could not be performed to identify the accident-prone locations.

13.6. Safety Audit (Design stage aspect)

The components reviewed at the stage of detailed stage along with its risk magnitude and priority index are elaborated in below table:

Table 13-3: Safety Audit Components

Sr. No.	Particulars	Risk (Considered)	Priority
A	**Horizontal & Vertical Alignment**		
1	Horizontal Alignment	Very High	Essential
2	Vertical Alignment	Very High	Essential
B	**Typical Cross Section**		
	Ghagrabasti to Mazgaon (PKG-1)		

Sr. No.	Particulars	Risk (Considered)	Priority
1	TCS TYPE - I TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)	Very High	Essential
2	TCS TYPE – II TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (NEW CONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)	Very High	Essential
	Sonapur to Holongi Chariali Airport Road		
3	TCS TYPE – III TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY (RECONSTRUCTION OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)	Very High	Essential
	Mazgaon to Hawajan (PKG-2)		
4	TCS TYPE - I TYPICAL CROSS SECTION FOR 4 LANE DIVIDED HIGHWAY WITH RAISED MEDIAN AND BOTH SIDES FOOTPATH OVER DRAIN (BUILT-UP AREA)	Very High	Essential
5	TCS TYPE - II TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, (OPEN COUNTRY)	Very High	Essential
6	TCS TYPE – III TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)	Very High	Essential
7	TCS TYPE – IV TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)	Very High	Essential
8	TCS TYPE – V TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS RETAINING WALL, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)	Very High	Essential
9	TCS TYPE – VI TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, LHS GEOBAGS WALL, RHS GABION WALL (OPEN COUNTRY PLAIN/ROLLING TERRAIN)	Very High	Essential
10	TCS TYPE – VII TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, GEOBAGS (OPEN COUNTRY PLAIN/ROLLING TERRAIN)	Very High	Essential
11	TCS TYPE – VIII TYPICAL CROSS SECTION FOR 2-LANE HIGHWAY, GEOBAGS (HIGH EMBANKMENT NEW CONSTRUCTION OPEN COUNTRY PLAIN/ROLLING TERRAIN)	Very High	Essential
12	TCS TYPE – IX TYPICAL CROSS SECTION FOR 4 LANE DIVIDED HIGHWAY (OPEN COUNTRY/PLAIN AND ROLLING TERRAIN)	Very High	Essential
D	**Intersection**		
1	Major Intersection	Very High	Essential
2	Minor Intersection	Very High	Essential
E	**Standard Drawings**		
1	Road Safety Measures	-	-

Sr. No.	Particulars	Risk (Considered)	Priority
F	**Adjacent Land**	Very High	Essential
G	**Vulnerable Road Users**	Very High	Essential
H	**Road Signs and Pavement Marking**	Very High	Essential
I	**Lighting and Night Time Issues**	Very High	Essential
J	**Drainage**	-	-

13.6.1. Road Safety Measures

The road safety measures are proposed along the whole corridor including at project facilities, amenities, junctions, built-up areas and sensitive locations such as hospital and schools. The broad road safety features are elaborated as below,

- Road Markings
- Road Signages
- Guard Rail
- Traffic Diversion Plans
- Traffic Calming Devices
- Road side safety Barrier
- Solar Light
- Speed reduction measures

➢ **Road Markings**

Road markings of hot applied thermoplastic material with glass reflectorizing beads are proposed at serval locations of project stretch. Road markings perform the important function of guiding and controlling e.g. traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety.

➢ **Road Signages**

Cautionary, Mandatory and Informatory signs are provided depending on the situation and function they perform in accordance with the IRC: 67-2012 guidelines for Road Signs.

Chainage wise bifurcations of the road signages is elaborated as below,

Figure 13-2: Road Sign

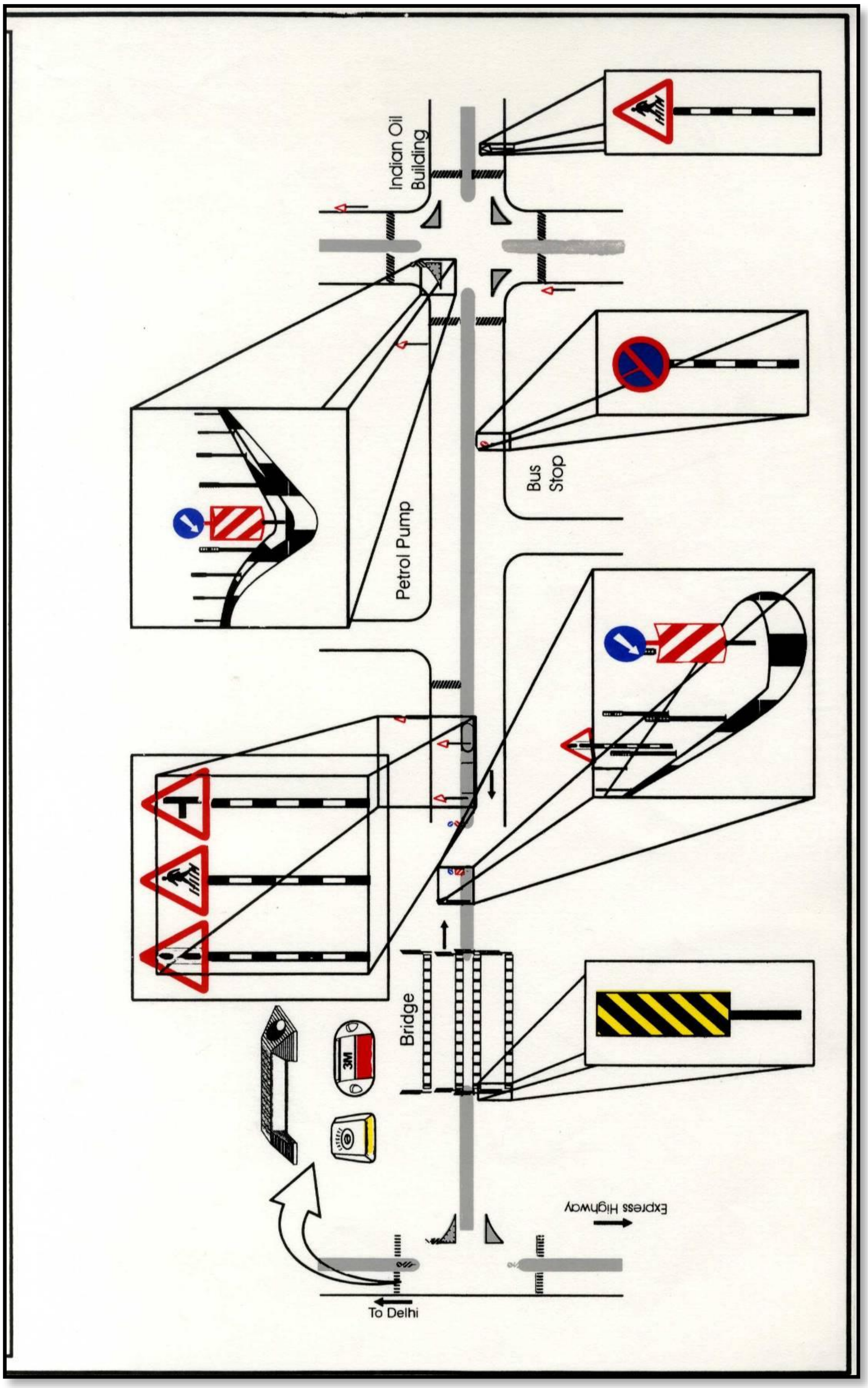


Figure 13-3: Road Furniture and Appurtenances

- **Guard Rail**

The guard rail is proposed at the built-up section where the pedestrian movement is predominant and need to bifurcate the road users among pedestrian and vehicular.

Figure 13-4: Guard Railing

- **Traffic Diversion Plans**

A work zone is an area of a highway where road user operating conditions are changed because of construction and maintenance activities. The construction and maintenance activities would involve movement of workers and construction equipment requiring dedicated space for performing the activities and moving materials for the activities. The presence of regular traffic and works traffic makes the work zone a potential zone of conflict resulting in disruption to normal traffic and hazards. A work zone is typically distinguished by the presence of signs, channelizing devices, barriers, pavement markings, and/or work vehicles. It extends from the first warning sign or high-intensity rotating flashing or oscillating or strobe lights installed on roadside or a vehicle-mounted sign posted to indicate the work zone, and continues to delineate the channelized vehicle paths till up to the end road work sign.

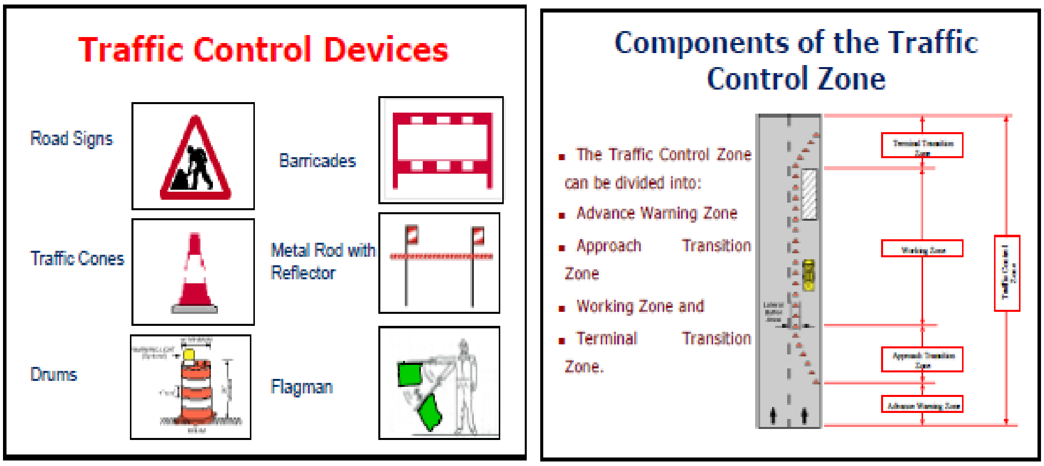


Figure 13-5: Traffic signages at traffic diversion locations

- **Traffic Calming Devices**

Speed reductions measure plays an important role in reducing the conflicts between motorist and non-motorists. The locations where traffic movement involves vulnerable road users such locations shall be provided with the speed reduction measures at prime instance, secondly all the locations which are prone to accident because of deficient geometry are proposed with the speed reductions.

- **Road Side Safety Barrier**

Road side safety barrier is proposed along the project corridor with the objectives to shield the two types of road hazards i.e. embankments and road side obstacles and also for preventing the vehicles veering off the sharp curves. All the embankments with height 3m or more are proposed with safety barriers at the edge of formation with delineating reflectors. W beam crash barrier are proposed along the curves upto 450m for the entire length of curve including transitions.

Typical arrangement of w-beam crash barrier is shown below

Figure 13-6: Crash Barriers

13.6.2. Recommendations

Taking into consideration the observations of the Safety Audit, the following recommendations have been proposed:

- The recommendations include the provision of Rambler Marking, Cat Eyes, Road Studs
- Provision of Metal Beam Crash Barrier for total curve length and Chevron Sign Board facing both side
- Installation of cautionary sign (Both Ways at start of the curve)
- It is recommended to revise the designed gradient by considering the minimum drainage criteria and grade brake aspect and to provide the width of earthen shoulder as per IRC SP 73.
- It is directed to show the suitable cross section equipped with pedestrian facilities.
- Provision for ramps, up and down kerbs, where there is regular pedestrian traffic from the footpath over drain.

- It is recommended to improve the Y type junction to T type as safety concern, suitable project facilities and traffic signages, pedestrian marking for full width of road.
- Incorporation of Splitter Island in order to provide the divided carriageway and conflict free traffic flow.
- Provisions for junction at curve locations, adequate turning radius at junction i.e. minimum 15m or absolute minimum 12.8m and adequate detailing of Island.
- It is recommended to provide the paved area from paved shoulder to entry of public amenities (School/ Hospital) and provide marking as well as Keep Clear Marking (IRC: 35:2015).
- It is also recommended to provide the separation to avoid the conflict point between road user and pedestrians along with provision of bus shelter with lighting of requisite standards
- Separation between paved shoulder and paver block portion by incorporating guard rail or by providing different texture.

The detailed analysis of each component and respective recommendations for this project road has been presented in Detailed in **Volume XIII**: Road Safety Audit.

13.7. Conclusion

The project stretch consists of green field alignment with geometrical part as horizontal alignment and curves, major bridges, minor bridges and at grade intersections. It can be concluded that the safety concerns of the project are resolved with satisfactory design provisions as per Indian Road Congress standards. The key conclusions are mentioned as below:

- The project stretch does not contain any black spot location as no accident data received, whereas the project stretch has sharp blind curves, which could be result in black spot locations.
- Geometry of the road is designed with the standard design speed.
- The arrangement requisites at the hazardous reach is being made through requisite design and drawings.
- All the intersections are designed with stop control provision.
- The project stretch is provisioned with adequate pedestrian facilities.
- The junctions with railway crossing improved with special provision and recommendations.

CHAPTER 14

IMPLEMENTATION SCHEDULE

14 Implementation Schedule

14.1 General

The project work for the proposed road consists of improvement of **Ghagrabasti to Hawajan via Holongi Airport.** The Project Road **Ghagrabasti to Hawajan via Holongi Airport [A28]** falls in the district of Sonitpur and Lakhimpur. The project road consists of two alignments wherein the first alignment originates from Ghagrabasti on NH-415 at Y-Junction where left side of the NH-415 goes to Itanagar and the right side to Gohpur. The project road ends at Hawajan on NH-15 making a T-junction. The second alignment initiates near Sonapur on Ghagrabasti to Hawajan section and traverses in the north direction to end at Proposed Holongi Airport. As per the topographic survey and designed alignment plan, the total length of the road comes out to be 28.136 km.

Table 14-1 shows the details of the project road stretch considered for the Detailed Project Report.

Table 14-1: Details of Project Road

Sr. No.	Group	Corridor No.	Project Road Stretch	Design Length (km)
1	III	A28 (Part I)	Ghagrabasti to Hawajan	26.006
2	III	A28 (Part II)	Sonapur to Holongi Airport	2.130

The project alignment and the settlements along the project road are presented in ***Figure*** 14-1***.***

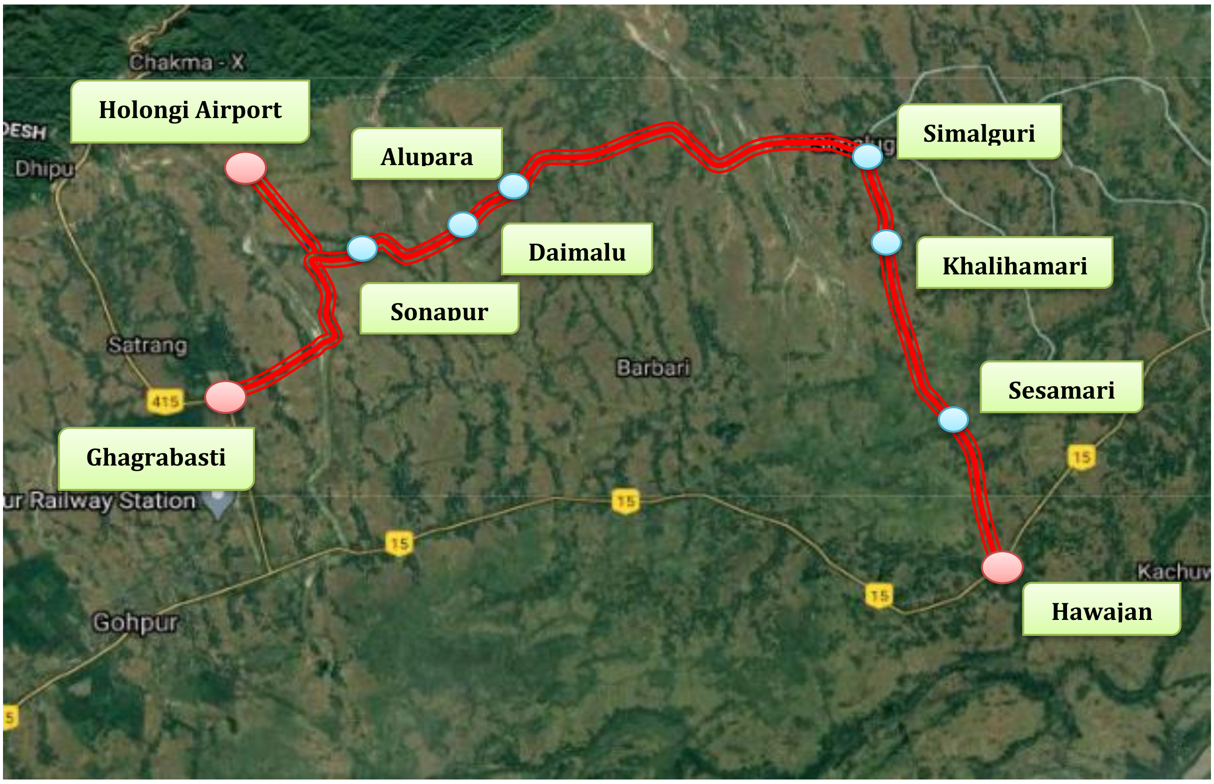


Figure 14-1: Settlement along Ghagrabasti to Hawajan road & Sonapur to Holongi Airport

14.2 Phases in Construction Schedule

The following key activities typically occur during the Construction of a Road infrastructure project and could be considered under separate heads such as:

- Establishment of contractor on project site and obtaining of the necessary permits and clearances to carry out the construction works.
- Finalization of the designs and approvals of material samples, rates and agencies.
- The construction work of Road and other Structures; and
- Commissioning and handing over to the PWRD.

14.2.1 Project Site Set Up and Permits Clearance

Many a times in construction of infrastructure road projects, the government will make land available after acquiring it, to the contractors. During the project term, the contractor will manage the operation and maintenance of the land and infrastructure.

Before acquiring, the government commissioned a thorough investigation by appropriately qualified experts of all property rights in, and all title and land use restrictions attaching to the land. This is done to ensure that the project will not be jeopardized due to a late discovery of a third-party claim to the land or a land-use restriction that could delay or prevent the construction of the project or interfere with the private party's possession of the land. The government will have also undertaken the necessary land acquisition from legitimate residents and managed the relocation of any other occupants. Depending on the location of the site and the nature of the project, the government may also have had to provide access and ensure the availabilities of utilities at the site.

These actions of the government prior to contract award will have ensured that both parties are well aware of land-related issues and risks.

Problems with regard to the chosen sites and the conditions can and do emerge during the Construction Phase. One of the more common issues is the timely hand-over of the site to the contractor and sub-contractor. It is recommended that the government ensure the site is available and handed over immediately after the contract is signed. This will ensure that at least land hand-over related disputes are avoided.

Permissions, Clearances and LA gets more complex in projects with extensive land requirements over a large number of distinct properties. These include projects involving roads, rail, pipelines, and transmission lines. Although hand-over of a single continuous stretch of land is ideal, it is not always possible. In cases where it is not possible, the government must ensure that it does not subject itself to disputes and claims from the private partner.

This phase of the construction includes:

- Mobilization of the construction team to site.
- Acquiring all the statutory requirements and permissions.
- Preparation of the Project execution plan, Health safety & environment plan and Quality assurance plan.
- Issuance of GFC drawing and re-evaluating surveying such as Road works, Structure/Bridges and other miscellaneous items.
- Approval of material samples, material rates and material acquiring agencies.

The Draft baseline schedule of A28 – Ghagrabasti to Hawajan via Holongi Airport (L: 28.136 Km) showing the schedule required for project site setup and other permit clearances is Submitted in **Volume XII- Proposed Work Programme & Construction Schedule of DPR.**

14.2.2 Project Construction

Construction, in general, can take many forms of delivering the final product. It is not uncommon for the construction contractor to split the work into phases or smaller packages in order to achieve its milestones. In this case, the construction contractor will often tender individual work packages out to sub-contractors. However, the main contractor will retain responsibility for the quality of all work and for coordination of sub-contractor activities.

During the construction works, there are many issues to consider but the most important points are as follows.

- Have appropriate quality requirements and a duty of care been imposed on the contractor?
- Is there any assurance that defects identified in the inspected works will be remedied?
- Is there a defects liability period and, if so, for what period?
- Has the design been addressed appropriately?
- Is the project schedule optimistic or realistic?
- In the case of a dispute, what are the procedures that would be implemented?

The activities during the construction works are numerous, but the most work intensive period is in the middle of the phase where all of the work packages are delivered. It is in this stage of the project that many sub-contractors would be involved. As a result, it is particularly important to pay attention to sequencing, lead times for the material delivery, and any time-sensitive legislative compliance matters which can disrupt the program.

This phase of the construction includes:
- Site clearance, earthwork and grading/leveling
- Procurement scheduling.
- Construction of the road & structures.

Safety:
The execution of any civil project involves various health and safety hazards which if not given proper considerations may lead to accidents on the project site. The construction workers are exposed to several risks on the construction site due to operations involving heavy machineries and tough working conditions. Project planning and scheduling plays a very critical role in construction of road projects to attain objective and goals of the project in estimated time. A project cannot be completed at correct time if accidents occur due to hazards creating loss of lives, time and money eventually. To avoid such hazardous incidents, it becomes imperative to give due importance to safety measures from the planning and scheduling stage.

There is lack of training and awareness about the safety measures to be implemented on the project site. A safety culture must be developed to ensure that proper awareness is instilled in the workers and onsite stakeholders in educating them with respect to the importance of safety to avoid accidents and bad happenings. Certain workplace safety measures should be considered while deriving the implementation schedule such as deriving roles and responsibilities of safety manager, periodic training of onsite stakeholders, workplace safety programs and time to time monitoring of safety protocols.

The Draft baseline schedule of A28 – Ghagrabasti to Hawajan via Holongi Airport (L: 28.136 Km) showing the schedule required for construction is submitted in **Volume XII- Proposed Work Programme & Construction Schedule of DPR.**

14.2.3 Commissioning and Hand-Over to the PWRD

Before the asset is formally handed over to the PWRD, there are certain steps that need to be carried out by the independent certifier/consultant on behalf of the government. These activities include the testing of an asset and issuing the completion certificate.

If the performance tests for the readiness of an asset fail, the contractor must remedy such defects in order to obtain the completion certificate.

The completion certificate is issued by consultant or by the PWRD and is contractual evidence that the Construction Phase is complete. Once it is issued, the infrastructure is available and commencement of services begins. This is called in many jurisdictions as the "service commencement date" or the "operating commencement date".

The commissioning process may also be drafted as the completion certificate and availability or service commencement authorization may respond to a two-stage approach with a provisional acceptance of works that allows for entering into operations provided that:

- the project has been substantially completed;
- Operations can commence under appropriate safety standards; and
- Only a list of minor defects or non-compliances of minor relevance have been detected (usually referred to as the "punch list") and these don't prevent service commencement.

The "punch list" items are allowed to be resolved within a certain time.

It may be appropriate to have service commencement despite incomplete construction. The government must ensure that the private partner always remains incentivized (through the payment mechanism) to complete the outstanding works. It may be feasible to have phased-in service commencement. In these situations, an appropriate phasing-in of the revenue stream or the use of penalties for late completion may be justified. In such cases, the government may either stipulate that full-service commencement will only be achieved when all phases in the project reach the required output specification level, which would incentivize the private partner to bring them all up to the required output specification levels as quickly as possible or stipulate that partial service commencement will be achieved as each phase reaches the output specification level for the services provided.

This phase of the construction includes:

- Final testing and commissioning of Road work and Structures.
- Preparation and submission of As-Built drawing.
- Demobilization.

14.3 Software (MS Project)

Microsoft Project is a tool that helps manage portfolios and implementing projects in different fields by scheduling, budgeting, and allocating human and material resources. It suggests several templates depending on the field and the purpose of the project, as it can be personalized depending on the users' needs. The success of any construction project is largely dependent on the selection of the planning, scheduling, and controlling system adopted for the project. For many linear projects, taking the example of the highways and railroads, time and space are taken into consideration. Introducing Microsoft Project in linear project scheduling is a need especially when it comes to the construction part of the project.

There are several applications of Microsoft Project which helps in smooth execution of linear projects like State and National Highways. These projects require schedules that maintain resource continuity for an activity from one unit to the next one and achieve logic constraints at the same time. Microsoft Project provides the flexibility to help manage a project, provides assistance in every phase of the project, and calculates schedules and other project information. Microsoft project supports calendar controls, allocation of resources, production of PERT, GANTT charts, resource charts, calendar charts and dozens of reports. These applications play a vital role in scheduling, executing and monitoring various linear projects and immensely save time if followed religiously.

The Final baseline schedule of A28 – Ghagrabasti to Hawajan via Holongi Airport (L: 28.136 Km) is submitted in **Volume XII- Proposed Work Programme & Construction Schedule of DPR.**

CHAPTER 15

LONG TERM ASSET MANAGEMENT

15 Long Term Road Asset Management

15.1 Executive Summary

The road sector is highly complex sector and one of the most important sectors for the development of country/society. In case of deterioration of these roads, the effect would be immense and would directly impact country's economic growth. Most of the investment in India is on infrastructure which majorly includes construction of roads along with its maintenance and rehabilitation. Development/Upgradation of an asset management system for road administrations is a logical evolutionary step from managing individual assets from a broader perspective in the mostly efficient way. As such, asset management system is generally integrated systems in which existing management systems for individual assets can be combined to produce new and often more conceptual information. The use of Road Asset Management System (RAMS) would assist in planning and prioritization of assets with its storage, transformation, analysis, modeling and reporting capabilities.

Considering the fact that construction of new roads is much more costly than maintenance, the best approach is always to give high priority to protect existing Road infrastructure.

15.2 Objective of Maintenance

The objective of maintenance function is to maintain and operate the highway system in a manner such that:

- Comfort, convenience and safety are ensured to the commuters.
- Investment in roads, bridges and other road assets should be preserved and kept in the original condition to ensure the investment of public funds is preserved.
- Consistency of maintenance service.
- Economy of operation and performance improvement.

15.3 Concept of Road Asset Management Process

A Road Asset management could be broadly defined as a systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organized and flexible approach in making the decisions necessary to achieve the public's expectations.

The Asset Management system focuses on providing a structured approach to road management and development to enable authorities to operate, maintain and restore their 'Road assets' to meet key performance requirements. A Road Asset Management Action Plan will provide the framework to make the best-informed decisions about the use of available resources in managing its operating programme by considering all the engineering, business and economic factors affecting the asset.

The asset management system allows enough scope for adoption of the simple methodologies and addresses the issues of timely removal of deficiencies even from project preparation/designing stage to make the road assets so created more sustainable.

15.4 Process of Asset Management

The proposed process of asset management system begins with site condition survey for all the road asset. The condition survey would be recorded in the prescribed format attached in ***Annexure 15-1 to 9***. All the recorded road asset condition data are processed and converted into the predefined RAMS format. The process of asset management system is also proposed with public issues interface system. The public issues received shall be sent for investigation and validation. If authentic, then it would be considered into the RAMS format but if found false, would be discarded. This data then goes as an input to the Road asset management system. The road asset management system then serves as a data base for all the recorded road assets and shall locate every individual road asset when and where required via its GIS interface. The output obtained from RAMS then goes as an input into HDM4 (an analytical software) and HDM4 gives the maintenance plan (Output) which also includes the cost of maintenance for the road asset. The maintenance plan obtained clearly defines the type of work which is to be executed along with their chainage and cost. A sample of the draft maintenance and improvement plan of is attached in ***Annexure 15-10*** for understanding the output details obtained.

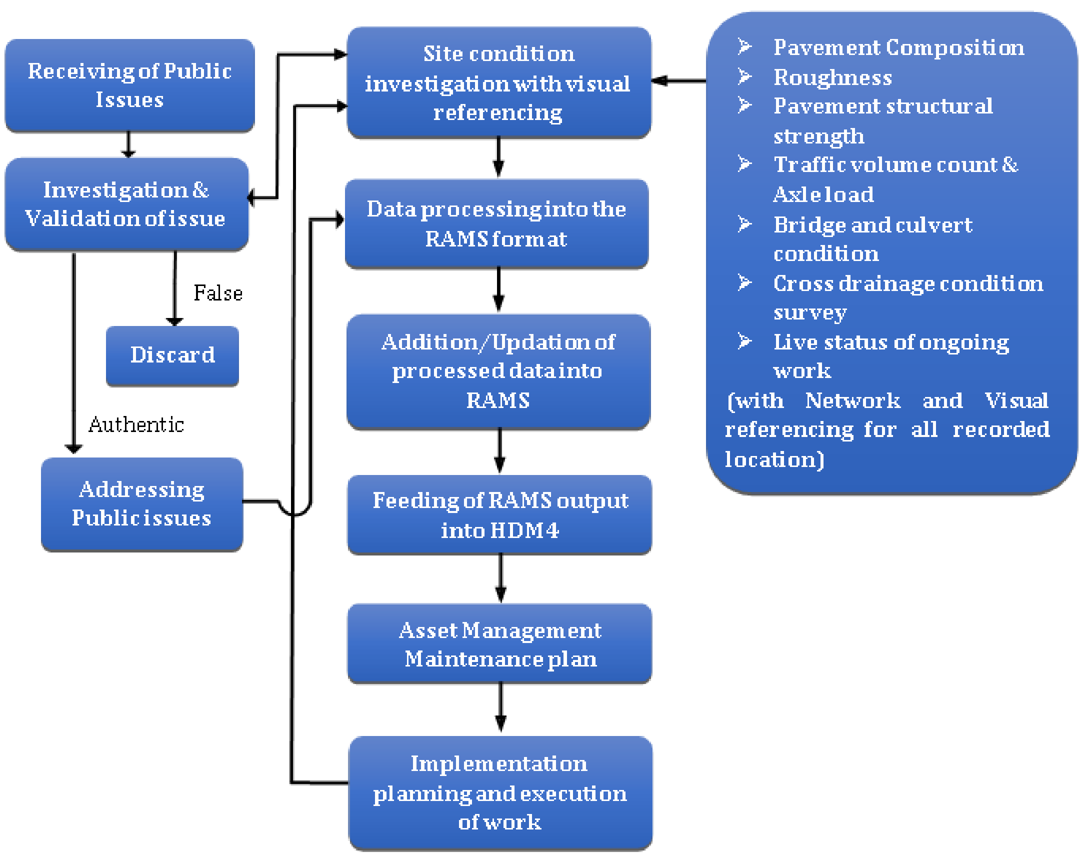


Figure 15-1: Asset Management Process

15.5 Asset Management Tools and Techniques

The tools and techniques help the road asset management process to achieve its objectives of maintaining the Road Asset. Following mentioned tools and techniques are used in the process based on their order of occurrence:

15.5.1 Manual Data Collection

In site condition investigation, all the site data shall be recorded manually based on the survey sheets. The data recorded shall be for following components:

- Road Inventory (including side drains)
- Culvert Condition Inventory
- Bridge Condition Inventory
- Pavement Roughness
- Pavement Composition
- Pavement Condition (including side drains)
- Traffic Volume during AXLE Loading
- Axle-Loading
- Traffic Volume Count

Investigation and survey sheets shall be provided to all the site team for all the component of road asset as attached in ***Annexure 15-1 to 9***. Based on the mentioned criteria, the surveyor shall evaluate and record the particular road asset. The survey sheet would be formulated in a way where maximum data could be collected on the particular asset.

15.5.2 Road Asset Management System

Road Asset Management System (RAMS) is strategic and systematic tool for maintaining, upgrading, and operating road assets effectively. Information collected in this tool will be useful for development and maintenance of existing road asset. The road asset management system includes following modules:

i. WEB GIS
(includes the entire map with marked road alignment and other road assets as per their actual location)

ii. Traffic Information System (TIS)

iii. Bridge Information System (BIS)

iv. Pavement Management System (PMS)

v. Right of Way Feature Information System (RWFIS)
(the ROW features available along the road stretch for each chainage right and left which included offset, latitude longitude etc.)

vi. Road Safety Information System (RSIS)

(included types, locations, fatalities, reason for the accident and also the safety measures which could be incorporated)

vii. Report
(includes all the recorded data from the above modules for view/download)

15.5.3 HDM4

HDM-4 is a computer tool for Highway Development and Maintenance Management System. It is a decision-making tool for checking the Engineering and Economic viability of the investments in road projects. This tool is incorporated with features so that it can be used in any locality of the world with any environment and engineering situation. HDM-4 has four main areas of application:

- Strategic planning
- Roadwork programming
- Project analysis
- Research and policy studies

The output obtained from HDM-4 is attached as ***Annexure 15-10***

Other data collecting tools which could be used for Asset Management are:

Table 15-1: List of Data collecting tools for Asset Management

Data Collecting Tools	Data Analyzing Tools
Visual inspection	Microsoft Excel 7
Contractor records	Microsoft Access 6
Capture at installation	Oracle database System
Field Laptops	ESRI ArcGIS
Photo/video log	GIS Geodatabase
	Pontis
	SQL server/database system

15.6 Asset Management Planned Framework

As per the Asset management plan mentioned in the RFP and the discussion with the PWRD, the approach of the entire road asset management plan would be in distinct two direction which would be:

- Physical maintenance of the entire road asset
- Recording site data as per RAMS requirement

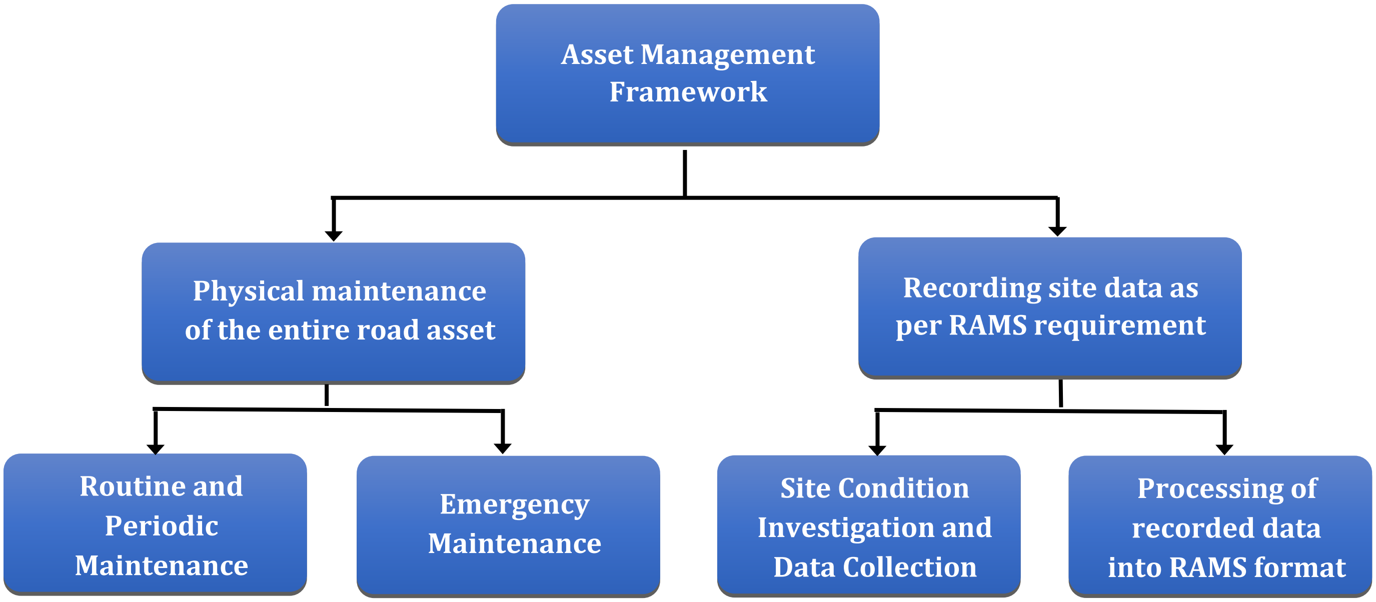


Figure 15-2: Asset Management Planned Framework

15.6.1 Physical Maintenance of the Road Asset

The physical maintenance shall deal with the approach in standardization of the frequency required for monitoring/investigation the road assets. As there are assets categories which required investigation annually whereas some requires only once in its life. Road assets which are very crucial especially related to road safety need to be monitored more frequently in comparison to other. Hence, the maintenance of state highways and major district roads includes routine maintenance, periodic maintenance and emergent maintenance for a long-term asset management and could further be explained below:

15.6.1.1 Routine Maintenance

Routine maintenance activities are usually performed on a regular basis throughout the year. It consists of both off-carriageway and on-carriageway activities and often performed using manual Labors. The need for routine maintenance can to a large degree be forecasted.

Routine maintenance activities are further defined as either cyclic or reactive, although the distinction between these terms is not always very clear.

Cyclic activities are performed at predetermined intervals throughout the year purely as a preventive measure because of events we know will occur (e.g. cleaning drains before and during seasonal rainfall), and are scheduled at fixed times during the year.

Reactive activities are performed in response to a triggering condition that requires action before the problem gets out of hand (e.g. blocked culvert, crack sealing and pothole patching).

The routine maintenance activity commonly includes:

- Remove debris from roadway and drains
- Clear drains, allowing free passage of water
- Clear culverts and other water crossings

- Repair shoulders and side slopes
- Patch potholes, seal cracks and repair edges of pavement
- Cut grass and bush
- Maintain road signage and pavement markings

Table 15-2:Routine Maintenance Chart

SR.NO.	TASK DESCRIPTION	PERIODICITY
1	Cleaning of Road Surface	Once in two Months
2	Cleaning of Signs	Before Monsoon
3	Cleaning of Gantry Signs	Before Monsoon
4	Cleaning of Metallic Crash Barrier	Before Monsoon
5	Alignment of Traffic Signs	Before Monsoon
6	Cleaning of Drains	Before Monsoon
7	Cleaning of Crossing	Before Monsoon
8	Cleaning of structures	Before Monsoon
9	Garbage Collection	Daily
10	Removal of Weeds	Twice a year
11	Pruning of Bushes	Twice a year
12	Trimming of Trees	Once a Year
13	Watering of plantation	As required
14	Cleaning of Medians	As required
15	Cleaning of CD Works	Before Monsoon
16	Cleaning of Bridges and Viaducts	Before Monsoon
17	Minor Maintenance of Soft Shoulders	Once in a year

15.6.1.2 Periodic Maintenance

Periodic maintenance covers renewal of road surface, typically carried out after a period of 5 to 10 years, depending on initial construction standards & quality, traffic levels, pavement type and weather conditions. The work involved is normally larger and require more equipment and specialist skills. Carrying out periodic maintenance involves more work and higher costs, and includes such things as re-gravelling, surface overlay, major repairs to bridges and culverts, or improving of longer stretches of bad areas on the road. As a result, this work is considerably more costly than routine works. The most common periodic maintenance activities include renewal of road surface and major repairs of structures. Periodic maintenance is planned in cycles covering several years, thereby describing when individual roads in the network are due for such a treatment.

The project road Ghagrabasti to Hawajan via Holongi Airport (A28) has a total design length of 28.136 km. There are 2 major bridges that are under construction and 13 minor bridges out of which two are under construction, 2 are timber bridges, 6 have been abandoned due to realignment in place of which 6 new minor bridge has been proposed on the improved alignment whereas 3 bridges are proposed to be retained with minor repairs. There are existing 22 Pipe culverts, 10 Slab culverts and 8 Box culverts in the project stretch. One LUVP has also been proposed to facilitate the better movement of vehicles. Details of Road and structures are mentioned in ***Table 15-5*** and ***Table 15-6***.

It needs to be borne in mind that if routine maintenance is regularly carried out, particularly attending to timely patchwork on the pavement, maintenance of camber/super elevation and side drains, the requirement of periodic maintenance can be postponed. Format periodic maintenance is given in ***Annexure:15-11.***

15.6.1.3 Emergency Maintenance

Emergency maintenance responds to occasional, unforeseen events that occurs and which affects the serviceability of the road asset such as landslides, washouts, large trees or debris on the road and broken drainage structures etc. Emergency maintenance is the response maintenance plan in such situation as Emergent condition may develop from time to time adversely affecting sage and convenient travel.

Emergency maintenance can be categorized into (i) temporary restoration works, re-opening safe passage on the road, and (ii) permanent restoration, securing the stability of the road and reinstating all its components to its former (or a better) condition.

The personnel appointed for the maintenance of traffic should be available on calls all the time and should be ready to be at service in case of emergency condition.

It is important to identify and locate all defects of surface, shoulders, side drains, cross drainages etc., during the inspection of the road. During inspection each road should be divide in section of 5 KM and each KM should be further subdivided into 200 meters stretches for inspection purposes. All roads must be inspected immediately before and after rains in addition to routine maintenance.

Also, the extent of the defects should be recorded over which they occur and the severity of the defect may be also be indicated as mentioned below:

- Severe — Requiring urgent action
- Less Severe — Requiring special attention
- Defect — Requiring recurrent action
- Ordinary — Highlighting

Format of Emergency maintenance is given in ***Annexure 15-11.***

15.6.2 Recording Site Data as per RAMS Requirement

The RAM system is a tool used for decision making for an asset which in returns encourages continuous improvement of the asset throughout its asset life. The RAM is also a medium of communication with all its internal and external stakeholders. So, the outcome from a RAM system would be an improved management of infrastructure asset and improved decision making which would be based on quality information received.

For the recording of site data into road asset management system, mentioned are the 2 stages through which it could be achieved.

15.6.2.1 Site condition investigation and data collection.

To begin with Road Asset Management, site condition investigation is the foremost activity to proceed with. In site condition investigation, all the road asset details are been inspected which includes pavement roughness, pavement composition, pavement condition, condition for bridge, culverts & other structures, traffic etc. and the entire road asset inspection is been recorded Automatically/manually.

15.6.2.2 Processing of the recorded data into RAMS format

All the recorded asset data from the site investigation would be processed and converted into the predefined CSV format which is used by RAMS. The sample of the formats are attached at the end for all the site investigation activities from ***Annexure- 15-1 to 15-19***.

15.7 Level of Service for RAMS

Level of service is a parameter or combination of parameters which reflects a desired outcome to be delivered. A level of service is a means for capturing and realizing value from the assets through the delivery of services like road, bridges, bus stops etc. to the stakeholders. Some of the Level of Service parameter could include:

a. Safety
b. Reliability
c. Quality
d. Transparency
e. Availability/Accessibility
f. Responsiveness

In order to improve the present level of service of Road Asset management system in Assam, bellowed mentioned is the status comparing the current and desired level of services.

Table 15-3: Level of Service

Sr. No.	Level of Service	Current level of Service	Desired Level of Service
1	Safety	No details are present in RSIS (Road safety information system) of RAMS	RSIS (Road safety information system) needs to be updated with the actual data of location, types, fatalities, reason for the accident by collecting information for the police department or from other legit source for A28 Road.
2	Information of ROW	The ROW information is	The Row of road A28 need to

Sr. No.	Level of Service	Current level of Service	Desired Level of Service
		not provided in RWFIS (Right of way feature information system)	incorporated into the RWFIS (Right of way feature information system). The ROW of A28 could be collected for the ROW sheet submitted by the DPR consultant.
3	Traffic, Bridge & Pavement information	Is as per the old data	Traffic, Bridge & Pavement information need to be added/updated as per the data received from the DPR consultant of A28 road into the RAMs under TIS (Traffic Information System), BIS (Bridge Information System), PMS (Pavement Information System)
4	Environmental & Social Information System [EIS]	No provision	EIS provides necessary data and a platform to undertake specialized analysis for Environment Impact Assessment or Social Impact Assessment. EIS provides a comprehensive database of environmentally sensitive areas.
5	WEB GIS	Is as per the old data	The WEB GIS need to be updated as the Construction of A28 begins along with the addition of proposed road assets with their locations.
6	Transparency/ Responsiveness	No provision to address public issues	A provision to address an issue/problem for the regular commuters of the road is to be provides. Detailed explanation is provided in **15.13.7 Public Issues.**
7	Complete Information on RAMS	Limited details are present in the RAMS	Complete information with respect to the Road, culverts, pavement, bridge, traffic etc. to be incorporated into the RAMS
8	Photographs of road asset	Complete photographs are not present	Photographs of all structures, critical defects etc. found along with the existing condition of the asset needs to be uploaded into

Sr. No.	Level of Service	Current level of Service	Desired Level of Service
			the RAMS.
9	Road notations	Not well defined	For road stretches, naming must be proper having definite start and end points marked along with chainages in the GIS Web viewer
10.	Transparency (Publishing of annual performance statistics)	Currently not practiced	Publishing of annual performance statistics would encourage the collection and management of data for RAMS and ensures the use of collected data. These could be published in statistical yearbooks or in annual reports. (as per compendium of best practices in RAM by ADB January'2018)

The details analysis of Level of Service is incorporated in Chapter-4 (Traffic studies and Demand forecast) of the main report.

15.8 Detailed Proposal for Long-Term Asset Maintenance Management Action Plan (Multiyear plan)

The considerations for maintenance provisions for road corridors under Asom Mala post construction and opening of road to traffic shall be as follows

Table 15-4: Consideration for Maintenance Provision

Sr. No.	Years	Type of Maintenance
1.	First 4 years (from opening of road to traffic)	Routine Maintenance
2.	5th Year (from opening of road to traffic)	**Mix Seal Surfacing (MS)** shall be provided on the carriageway & paved shoulder as **Periodic Renewal Layer/Coat**
3.	6th to 9th Year (from opening of road to traffic)	Routine Maintenance
4.	10th Year (from opening of road to traffic)	• As per calculated MSA for next 10 years (20th Year MSA minus 10th Year MSA) the strengthening layer (i.e. overlay) in the form of BC **or** BC+DBM as required shall be provided on the carriageway & paved shoulder as **Periodic**

Sr. No.	Years	Type of Maintenance
		Strengthening Layer. • If 20th year MSA is less than or equal to 10 MSA, then provide 40mm BC.
5.	11th year to 14th year (from opening of road to traffic)	Routine Maintenance
6.	15th Year (from opening of road to traffic)	**Mix Seal Surfacing (MS)** shall be provided on the carriageway & paved shoulder as **Periodic Renewal Layer/Coat**
7.	16th to 19th (from opening of road to traffic)	Routine Maintenance
8.	20th Year (from opening of road to traffic)	**Mix Seal Surfacing (MS)** shall be provided on the carriageway & paved shoulder as **Periodic Renewal Layer/Coat**

The details of Road assets of **Ghagrabasti to Hawajan via Holongi Airport [A28]** after the completion of the road improvement which need to be managed and maintained are described below:

15.8.1 Road Asset

The entire project road of **Ghagrabasti to Hawajan** (Chainage km. 0+000 to km. 26+006) and **Sonapur to Holongi Airport** (Chainage km. 0+000 to km. 2+130)**.**

Table 15-5: Details of Project Road

Sr. No.	Group	Corridor No.	Project Road Stretch	Design Length (km)
1	**III**	A28 (Part I)	**Ghagrabasti to Hawajan**	26.006
2	**III**	A28 (Part II)	**Sonapur to Holongi Airport**	1.230

15.8.2 Structure Assets

There are 2 major bridges that are under construction and 13 minor bridges out of which two are under construction, 2 are timber bridges, 6 have been abandoned due to realignment in place of which 6 new minor bridge has been proposed on the improved alignment whereas 3 bridges are proposed to be retained with minor repairs. One LUVP has also been proposed to facilitate the better movement of vehicles. There are existing 22 Pipe culverts, 10 Slab culverts and 8 Box culverts in the project stretch. The further breakup of bridges and culverts is mentioned below:

Table 15-6: Structure Summary of A28 (Ghagrabasti to Hawajan via Holongi Airport)

Structure Details	Existing no. of Structures	Retained with Minor repairs	Reconstruction				Newly Proposed	Total no. of Structures
			Box Culvert	Minor Bridge	Pipe Culvert			
					Single Vent	Two Vent		
Major Bridge	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Minor Bridge	**13**	**3**	**-**	**2**	**-**	**-**	**6**	**11**
Slab Culvert	**10**	**-**	**10**	**-**	**-**	**-**	**-**	**10**
Pipe Culvert	**22**	**-**	**22**	**-**	**-**	**-**	**-**	**22**
Box Culvert	**8**	**-**	**6**	**2**	**-**	**-**	**-**	**8**
LUVP	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**
Total	**55**	**3**	**38**	**4**	**-**	**-**	**7**	**52**

15.8.3 Other Assets

All the Assets along with its quantities which would be a part of corridor A28 after the completion of its construction is as follows:

Table 15-7: List of all Road Assets of A28 (Ghagrabasti to Hawajan via Holongi Airport)

Sr. No.	Description of Assets	Unit	Quantities
1	**Bitumen Pavement**	Cum.	12052.6
2	**Paver Block Pavement**	Sqm.	0
3	**Earthen Shoulder**	Cum.	23725.01
4	**Surface Drains**	Rmt.	0
5	**RCC Covered Drain with Footpath**	Cum.	3226
6	**Footpath Paver Block**	Sqm.	0
7	**Major Bridge**	Nos.	0
8	**Minor Bridge (Box Culvert)**	Nos.	11
9	**Box Culvert**	Nos.	43
10	**RCC Crash Barriers**	Rmt.	1772.5
11	**Metal Beam Crash Barrier**	Rmt.	8495
12	**Railing**	Rmt.	4206
13	Flexible Crash Barrier, Wire Rope Safety Barrier		882
14	**Street Light**	Nos.	34

Sr. No.	Description of Assets	Unit	Quantities
15	**Road Markings**	Sqm.	12954.65
	i. Arrow Marking	Nos.	0
	ii. Chevron Marking	Nos.	0
	iii. Stop Marking	Nos.	0
16	**Traffic Sign Board:**		
	i. 90cm equilateral triangle	Nos.	189
	ii. 60cm equilateral triangle	Nos.	187
	iii. 60cm circular	Nos.	112
	iv. 80cm x 60 cm rectangular	Nos.	24
	v. 60cm x 45 cm rectangular	Nos.	24
	vi. 60cm x 60 cm square	Nos.	24
	vii. 90cm high octagon each	Nos.	10
	viii. Hazard Object Marker	Nos.	333
	ix. Chevron Sign	Nos.	219
	x. Informatory Sign area less than 0.9 Sqm.	Sqm.	167.54
	x. Informatory Sign area greater than 0.9 Sqm.	Sqm.	18.75
17	**Road Studs/Cat eye's**	Nos.	15010
18	**Boundary pillar**	Nos.	260
19	**200th meter stone**	Nos.	110
20	**5th kilometer stone**	Nos.	7
21	**Ordinary Kilometer stone**	Nos.	20
22	**Cable Duct Across the Road**	Rmt.	120
23	**Bus Stop with Shelter/Structure**	Nos.	12

The detail showing the long-term asset maintenance management action plan (Multi-Year Plan) is attached as ***Annexure 15-12.***

15.9 Maintenance Plan for existing road during construction period

Every road construction site is unique and will provide its own challenges. In any road construction it is very important to ensuring that the work site is free from risks to health and safety. Vehicles including powered mobile plant moving in and around a workplace, reversing, loading and unloading are often linked with death and injuries to workers and members of the public. To maintain traffic and pedestrian movements it is necessary to identify and markup relevant temporary works and arrangements along with their location on site plans such as:

- Site entrance(s) (pedestrian and vehicle)
- Site accommodation
- Overhead lines
- Minimize vehicle movement
- Traffic routes and vehicle only areas

- Storage / loading and unloading areas
- Using of signages
- Parking arrangements
- Pedestrian walkways
- On site hazards – excavations, shifting etc.

Based on the actual site condition, the maintenance plan during construction needs to be updated on a regular basis as work progresses and then communicated to relevant onsite contractors and delivery drivers. Typical plan of maintenance during construction period is attached in ***Annexure 15-13.***

15.10 Risk Management Plan

Risk Management Risk management is a systematic approach to identify and deal with the risks that threaten our plans and projects and impact upon the continuation of service delivery. To end this, risk management framework is developed and the purpose of which is to define in a controlled way how risks and opportunities will be handled within the PWRD roads.

The framework provides information on roles and responsibilities with respect to the processes and procedures to be followed. It sets the context in which risks are managed, in terms of how they will be identified, assessed, managed and reviewed.

The proposal is for a four-step framework for identifying, assessing, managing and controlling and reviewing risk. This would be a continuous process and can easily be integrated.

Figure 15-3: Risk Management Plan Framework

15.10.1 Risk identification

Risk Identification is undertaken by all officers as part of their daily activities, these are then brought together as part of a group brainstorming exercise the thoughts and ideas from that brainstorming are then grouped into common themes and developed into a risk that expresses how the issue will impact upon achievement of the strategic objectives.

15.10.2 Risk Evaluation

The next step is to assess those risks in terms of the likelihood that they will occur and the impact if they do. The criteria for the levels of likelihood and impact for risks are shown in table below.

Table 15-8: Likelihood of risk occurrences with description and definition

Descriptor	Description
Almost Certain	I would not be at all surprised if this happened within the next few months
Likely	I think this could occur sometime in the coming year or so
Possible	I think this could maybe occur at some point, but not necessarily in the immediate future
Unlikely	I would be mildly surprised if this occurred, but cannot entirely rule out the possibility
Rare	I would be very surprised to see this happen, but cannot entirely rule out the possibility

(*Note*:

- *Threat 0% probability will never happen = no threat*
- *Threat 100% probability is certain = not a risk – issue that needs to be addressed*
- *Risk management deals with threats whose probability lies within those extremes 1% to 99%)*

Table 15-9: Risk Rating Matrix

SEVERITY

	Rare	Unlikely	Possible	Likely	Almost Certain
Insignificant	1	2	3	4	5
Minor	2	4	6	8	10
Significant	3	6	9	12	15
Major	4	8	12	16	20
Catastrophic	5	10	15	20	25

FREQUENCY

15.10.3 Risk Control

Now that the assessment has been identified for likelihood and impact, it needs to be agreement on who will own the risk (and/or manage it) and how the risk will be managed, controlled or exploited.

When the existing controls and action plans have been identified, the risks are re-assessed for likelihood and impact. This gives a forecasted controlled score of the Risk Profile as a result of the mitigation action plans. That information is then recorded in the risk register.

15.10.4 Reviewing and Reporting

A risk register shall be brought into use to record all possible risk, its impact and its likelihood of occurrences. Based on the mentioned criteria, for which the risk is maximum would be prioritized from maximum to minimum and accordingly reviewing of the risk shall be carried out.

15.11 Special Repairs Works Plan

Special Repair is required when road structures such as culverts and bridges have suffered serious distress and damage requiring major repairs or even replacement. Major repairs of protective works such as breast walls, retaining walls, bearing expansion joints may also be treated as special repairs. The necessity or requirement of special repairs would be known only after the routine/periodic maintenance of the road.

15.12 Upgrade Plan

Upgrade plan is about the services to provide and install periodic updates, patches, undertaking minor enhancement and refinements required in the interface, menu, additional attribute, reports to improve its effectiveness based on the feedback information collected from its use. A technical document mentioning the details of the requested enhancement of software updates/patches and the type and extent of changes conducted on the software must be clearly mentioned after the successful implementation of the upgrade. The operating consultant will be responsible for testing the patches and its upgradation, and successfully deploy the same on to the servers. Considering the present level of RAMS required upgradation parameters and desired level is mentioned in **Section 15.7**.

15.13 Asset Management Methodology and Practices

The road asset management methodology would give a complete sequential flow of stages which would be undertaken to achieve the objective of maintenance of road asset. The methodology is as follows:

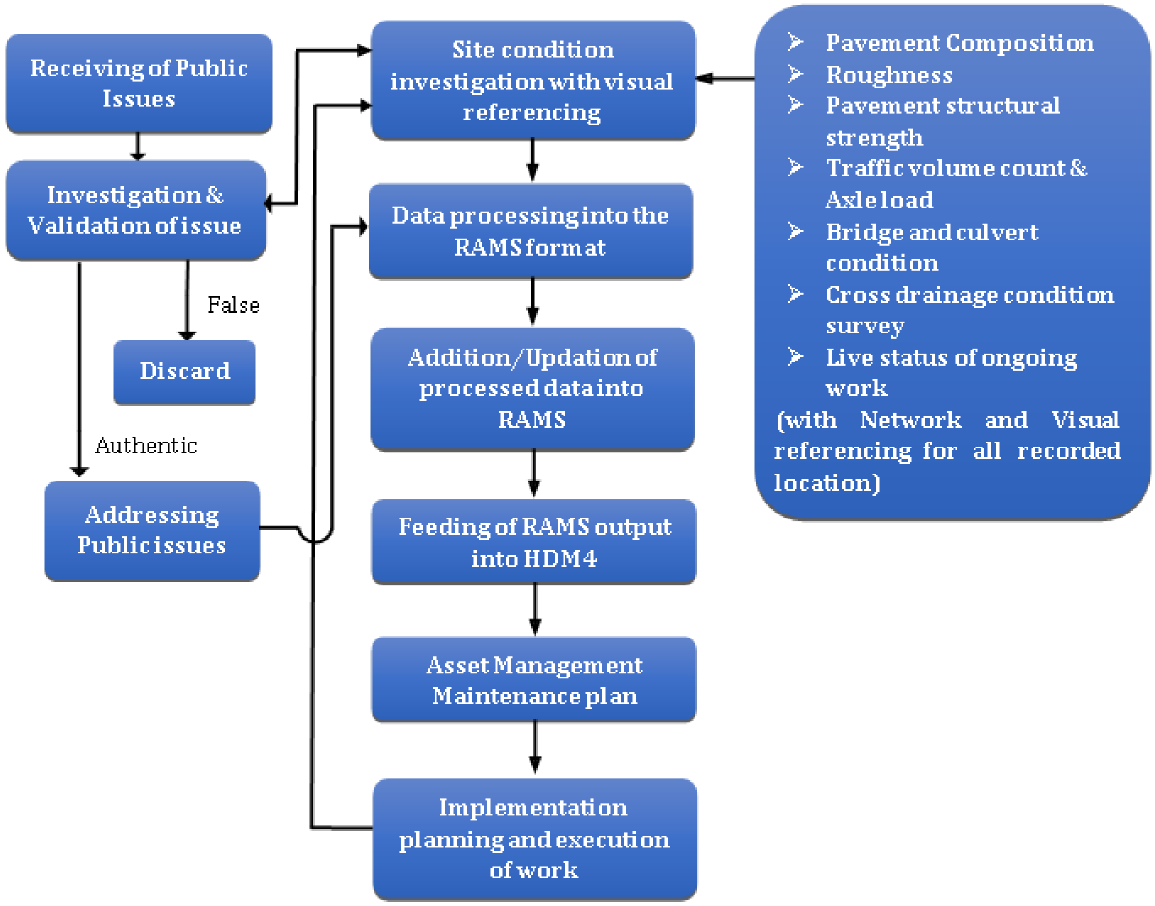


Figure 15-4: Asset Management Methodology

15.13.1 Site Condition Investigation with Visual Referencing

Data collection constitutes the most time consuming and resource requiring component for asset management system. It is also subjected to budgetary scrutiny and risk due to financial constraints. In Assam road asset management, most of the data would be collected through automated means using electronic and mechanical equipment to obtain most accurate data.

The process of Road asset management begins with site survey and inspection of the present road assets. Frequency of the inspection is given in ***Annexure 15-14*** In site condition investigation following are the categories of investigations carried out:

15.13.1.1 Pavement Condition

Monitoring the ability of the road surface to retain it in its present good condition is very important. It is also important to realize that sometimes it becomes very difficult to locate and identify cracking or any other defects on the surfacing. The Pavement Condition Index is a simple, convenient and inexpensive way to monitor the condition of the surface of roads, identify maintenance and rehabilitation needs and ensure that road maintenance budgets are spent wisely.

The Pavement Condition Index rates the condition of the surface of a road network. The PCI provides a numerical rating for the condition of road segments within the road network. The PCI measures two conditions:

- The type, extent and severity of pavement surface distresses
- The smoothness and ride comfort of the road.

The PCI is a subjective method of evaluation based on inspection and observation. It is neither a complex nor time-consuming exercise. Knowledgeable and experienced public works officials drive the road network and evaluate its condition in a systematic way. The observations are entered into the RAMS database for evaluation and use. **The PCI should be conducted annually so that changes inroad condition can be evaluated.**

15.13.1.2 Roughness

Roughness is an overall indicator of the quality of a pavement at a particular point of time and it adversely affects not only the vehicle riding quality but also the road user costs. The roughness survey will be carried out using Bump Indicator to know the condition of existing pavement and to identify the maintenance requirements. Roughness surveys will be conducted for the entire road stretches.

15.13.1.3 Pavement Structural Strength

The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade.

A pavement is regarded as having insufficient strength if the deflection measured under a test load exceeds a pre-determined value related to the traffic expected. In case where the structure has to be strengthened, the observed deflection serves as the basis for determining the thickness of the overlay to be applied.

15.13.1.4 Traffic Volume Count

The survey data will be analyzed to arrive at peak hour traffic, mode-wise traffic composition, hourly and daily variations, directional split of traffic at the survey locations. The daily traffic volume counts will be averaged and mode-wise (vehicle type) Average Daily Traffic (ADT) will be presented in tabular and graphical forms. Classified vehicle counts will be converted into Passenger Car Units (PCUs) based on guidelines for capacity analysis for rural areas.

15.13.1.5 Axle-Load

Axle load survey is to be carried out for obtaining the loading pattern and to estimate Vehicle Damage Factor (VDF). The Axle load survey is to be carried out using portable weigh pads. Axle loads of LCVs, Bus, two & three axle trucks and Multi axle vehicles are to be recorded on random sampling basis. The vehicles would be stopped with the help of police and the drivers would be directed to stop their vehicles in such a way that wheel of each axle can be weighed using the weighing pad. The readings are to be recorded by trained enumerators for each axle separately.

15.13.1.6 Bridge, culvert and cross drain works Condition survey

To monitor asset condition, a systematic program of bridge, culvert and for the cross drain works inspections is to be formulated based on three levels of inspection. The three levels of inspection are:

- Routine Maintenance Inspections (Level 1) has to be carried out in conjunction with routine pavement inspections to check the general serviceability of the structure for road users.
- Condition Inspections (Level 2) has to be carried out on a territory basis to assess the condition of each structure and its components.
- Detailed Engineering Inspections (Level 3) would be carried out only if there's a necessity to assess the structural condition and capacity of structures which have been identified as critical and needs to be considered for rehabilitation, strengthening, widening or replacement.

15.13.1.7 Live Status and History of Ongoing works

All the work along with its updated status of the Road assets need to be collected by the site survey team. The work may include:

- New Construction
- Improvement Work
- Maintenance Work

The Data collection team also need to collect the complete background information of the project in order to identify the status of work. Major part of the data collection would be through the respected PWRD office.

The work status may range from:

- In progress
- Delayed
- Suspended
- Proposal
- Expected to commence (commencement Date)

Visualization of any road network is important to understand its complexity. Having a tool for visualization makes it effortless for the users to understand and thus could proceed with the plan. In order to visualize the road network, certain inputs are to be added into the tool and the data obtained would be through visual referencing. In site visual referencing following are the categories of referencing carried out:

- **Network Referencing**

  Network referencing is carried to locate the exact location if all the road asset component which includes but not limited to bridges, culverts, accident prone areas, traffic stations, major district roads, state highways, ongoing projects, any famous landmarks, urban and rural roads etc. The network referencing could be achieved using DGPS device or an Hand held GPS device. The network referencing could also be obtained using smart phones.

- **Visual Referencing**

  Along with network referencing, visual reference is also of equal importance as here the user gets photographic view of the road asset components which he/she wants to locate. Here the site team is expected to take updated pictures of the asset component. HDR Camera or Smart phones could be used to take pictures.

15.13.2 Data Processing into RAMS Format

All the recorded asset data from the site investigation would be processed and converted into the predefined CSV format which is used by RAMS. The sample of the formats are attached at the end for all the site investigation activities from ***Annexure- 15-1 to 15-9***.

15.13.3 Addition/Updating of Processed Data in RAM

All the collected data from the site condition investigation and visual referencing would be processed and converted int the CSV format. Further with the help of PWRD staff/RAM operator processed information shall be added/updated in the Assam Road Asset Management tool. Periodic training shall be provided to the PWRD staffs/agency who would be adding/updating and operating the RAM tool for any new additions in the RAMS tools.

15.13.4 RAMS to HDM4

The output obtained for the RAMS tools would be further feed as an input into the analysis tool HDM-4. HDM-4 is a computer tool for Highway Development and Maintenance Management System. It is a decision-making tool for checking the Engineering and Economic viability of the investments in road projects.

15.13.5 Asset Management Maintenance and Improvement Plan

The output obtained form HDM-4 is a maintenance and improvement plan formulated based on the site condition survey. The plan obtained consist of detail of work to be executed with start and end chainages, cost of the action and Economic Internal Rate of Return. A sample output of Draft Maintenance plan & Improvement Plan (Analysis base year: 2017) is attached as ***Annexure 15-10*** in order to understand the details obtained at the output stage.

15.13.6 Implementation Planning and Execution of Work

Based on the present condition and obtained maintenance plan from HDM-4, decisions are been given with regards to maintenance/reconstruction of the road asset. After obtaining all the decision, grouping and scheduling of activities would take place by the PWRD officials and based on the type and quantity of work, tenders would be floated for the selection of vendors.

15.13.7 Public Issues

This process is brough into implementation keeping in mind to increase transparency with the citizen of Assam. This would cater the issues of all the citizens especially the daily commuters of the specific road stretch as now they could directly put forward their issue to the PWRD which would be added to the RAMS if found authentic for its resolution.

Following are the step through which a citizen can raise their issues to the PWRD:

Considering the present issue of an individual is a pothole repair

- Step-1: Open the PWRD complain registration portal
- Step-2: Stand as close as possible to the pothole
- Step-3: Add location by detect my location option/pin the flag at the pothole location
- Step-4: Clicking a picture of the pothole and upload it in the portal
- Step-5: Description of the issue (Optional)
- Step-6: Click on Submit. A "Received" status will appear on successfully submission of the issue.

The issues received by the portal are further filtered out based on its authenticity and number of repetition and then it would be investigated by the same site investigation team during their investigation and then would be added to the Data processing stage of RAMS.

15.14 Standards and Guidelines

Based on the compendium of Best Practices in Road Asset Management by Asian Development Bank (January;2018), following are considered as best practices in introducing and developing road asset management:

15.14.1 Collect only what is required

A RAMS requires a said amount of data for the entire network. This should not be confused with the data needs for project preparation, where more detailed data is required, but only for the few roads where interventions are planned. The types of data to be collected for the RAMS should be kept to a minimum, especially for data collected annually. Additional types of data can be gradually added as the RAMS evolves, other data needs are identified, and new data collection methods are introduced.

15.14.2 Use an appropriate level of accuracy.

Collection of very accurate data seems like a good idea, this generally increases the cost, while not necessarily improving the outcomes of the RAMS. Especially during the introduction of a RAMS, less expensive data collection methods may be preferable, even where these reduce the accuracy of the data and gradually the level of accuracy in the data collection could be increased.

15.14.3 Ensure data is reliable.

Lower level of accuracy is acceptable, but the data should be reliable. Only if data is reliable can the level of accuracy be kept within acceptable margins. Unreliable data leads to unreliable results, with errors in the data itself compounding the level of inaccuracy. It is preferable to use proven data collection methods for which there is some experience in the country, ensuring proper calibration and use of equipment. Over time, new technologies can be introduced to improve data reliability or reduce costs.

15.14.4 Ensure data has the correct format.

Data must have the correct format to be entered into the RAMS, or should be easily transformed into that format. For instance, qualitative condition measurements of good or bad are not always easily translated into quantitative measurements related to affected surface area.

15.14.5 Introduce proper quality control procedures.

Before collected data is entered into the database, it should be checked for inconsistencies and processed to fit the database’s parameters. This is generally done in a separate database where data is entered and checked before being transferred to the main database.

15.14.6 Make the Database Easy to Use

Apart from providing a system to manage the data for the RAMS, the road database also performs other functions such as providing data on specific roads and providing statistics on the road network as a whole. It contains a wealth of information for planning interventions and monitoring the road network’s performance. 28. To allow the database to provide these functions, it must be made easily accessible. This requires the database to be remotely accessible so that the data can be accessed (and checked) from different offices. This is preferable to sharing several copies of the database, where different copies may contain different data.

It also means that the database should be easy to use. This requires an easy web-based interface to search for data, but also a function to export data to commonly used software formats such as Excel or Access, allowing users to further process and analyze the data. Parallel systems may exist for the general public (with a more limited set of data) and for use by authorized government staff (with a more complete set of data).

15.14.7 Publish Annual Performance Statistics

To encourage the annual collection and management of data, even where a RAMS may not yet be fully operational, some countries have started publishing annual performance statistics. These are published in statistical yearbooks or in annual reports. Apart from providing information about the performance of the road sector over time, this ensures the collected data is used. Where such results are made available publicly, these can also introduce greater transparency. The regular collection and publication of such data institutionalizes the concept of data collection and data management, and introduces data analysis as a road management tool. From there, it is a small step to introduce a full-fledged RAMS.

15.14.8 Integrate into Decision-Making Processes

A RAMS can be a very powerful tool for determining the optimal use of available maintenance funding in a transparent manner, as well as for determining optimal budget levels for the repair and maintenance of the existing road network. A RAMS can indicate what types of interventions give the best value for money, and can show which roads should be prioritized to get the maximum economic benefit out of the available maintenance budget. In addition, a RAMS can help determine the budget levels required to improve the road network to a minimum condition and keep it there, and indicate what the future effects of different budget levels will be on road network conditions. This makes it a powerful tool for decision making and negotiations on the amount of funding to be allocated to road maintenance

15.14.9 Develop the Works Implementation Capacity

A RAMS analysis generally recommends more periodic maintenance, especially for roads in fair condition. The idea is that timely periodic maintenance of roads in fair condition will reduce the need for investment in routine patching, and will avoid the need for costly rehabilitation in the future.

Other standards and guidelines include Manual for maintenance of roads from Ministry of shipping and transport (Roads Wing).

15.15 Future Demand

As per the traffic conditions the future demand has been proposed, based on the required traffic surveys (As per IRC: 09-1972 and IRC: 102-1988). Their detailed analysis is discussed in **Chapter 4 (Traffic Studies and Demand Forecast).**

15.16 Implementation Plan for Asset Management

The Implementation plan for the long-term road asset management is disused in detail in ***section 15.13*** of this chapter. A summary of implementation of the Asset management plan would be as follows:

- Collection of road asset data in the said format as mentioned in ***section 15.13.1*** of this chapter
- Process field data and upload in ARAMS database to diagnose the pavement performance;
- Develop asset management policies, strategies and implementation plan for PWRD to effectively manage their assets;
- Develop annual maintenance plans for periodic, routine, special, and emergency repairs;
- Prioritize sections and allocate funds from various funding sources to the road sections

- Prepare network level reports on asset value, road condition, road capacity, safety ratings, safety hazards, traffic levels, historical trends etc.

15.17 Critical aspects to RAMS

This act as a baseline for the road asset management outcome. This is the most important part, through which the RAM could be brought into working with the required depth/accuracy.

The principal objective of RAM plan is to draw a long-term asset management plan for the road network including the maintenance of cross drainage which would be followed by the PWRD officials for their Infrastructure Road Assets. Following would be the envisaged aspects which needs to be considered in the Road asset management system:

- Selection of site team for road investigations and visual inspections of road assets on periodic basis.
- Data validation in all site condition survey.
- Operation and maintenance of RAMS database and addressing issues when and where required.
- Precisely processing of all the site data obtained from the survey & inspection into the RAMS by means of adding/updating it as an input.
- Training to be provided on data collection to site team and to the PWRD officials/staff who would be operating on the RAM tool, periodically.
- Reviewing the obtained maintenance plans for the improvements on the road assets and wisely planning its execution.

15.17.1 Enhancing Safety through Maintenance:

High priority needs to be accorded to ensuring maintenance of all safety features provided on the road. Particular attention needs to be paid to the following:

- Maintaining functionality of road signs, pavement markings and other traffic control devices so that they are clearly visible from a distance. This would involve pruning/trimming of tree branches, repairs/replacement of damaged signs, worn out markings and traffic control devices.
- Ensuring visibility of cautionary signs particularly near speed breakers, road junctions and pedestrian crossings.
- Taking corrective measures at locations where sight distance is seen to be compromised.
- Ensuring that the road remains open to movement of traffic at all times as far as possible.

CHAPTER 16

CONCLUSIONS AND RECOMMENDATIONS

16 Conclusions and Recommendations

Due to growing population and increasing inter-dependency with residents in other parts of the state, improvement of present roads and better connectivity demands are increasing regularly. The present roads in terms of riding quality and level of service are not meeting the requirement and expectations of road users. Pavement condition in view of present and future requirements has been analyzed on anvil of different criteria mentioned below, which helped to conclude regarding taking up this project.

(i) Geometric improvement for some stretches has been proposed to increase the safety of the road user and reduce the travel time with increased design speed, level of service etc.

(ii) Based on the site conditions, existing RoW and need for geometric improvements major realignments are required at Sonapur – Realignment 1 (Existing Ch. Ch. 4+950 to Ch. 6+500), Salbari – Realignment 2 (Existing Ch. 9+500 to Ch. 10+575), Alupara – Realignment 3 (Existing Ch. 12+875 to Ch. 14+575), Niran Chuba – Realignment 4 (Existing Ch. 23+850 to Ch. 24+625). Some minor realignment to improve the geometry of existing road has been done wherever required.

(iii) Based on visual pavement condition survey and analysis of the pavement distress data as per guidelines given in IRC:82-2015 approximately 18%, 38% and 44% existing road corridor is in good, poor and very poor condition.

(iv) Based on Roughness Survey data (IRI value) approximately 14.62% and 85.38% existing road corridor is in poor and very poor condition.

(v) Pavement condition of existing road has not been surveyed by FWD Test as the existing condition of the pavement was found to be poor through visual pavement condition survey.

(vi) Various traffic surveys like Classified Traffic volume count (TVC), Average daily traffic (ADT), Origin -Destination Survey, Turning Movement Survey, Speed - Delay survey, Pedestrian and Animal Count survey, Parking survey (in urban areas), Bus shelter and Truck Lay bye survey were conducted as per IRC and other available guidelines to conclude about capacity augmentation existing road corridor, improvement proposals and highway facilities.

(vii) Based on traffic dispersal, traffic movements and road condition the project road has three traffic homogenous section as follows:

Section-1: Ghagrabasti to Sonarijan (Ch. 0+000 to Ch. 07+100)
Section-2: Sonarijan to Alupara (Ch. 0+000 to Ch. 14+800)
Section-3: Alupara to Hawajan (Ch. 14+800 to Ch. 26+006 and Ch. 0+000 to Ch. 2+130)

(viii) Based on past data of traffic growth and economic parameters, the average projected traffic growth has been arrived as 6.5%. The projected traffic in terms of AADT in 20 years is 3357 vehicles (2474 PCUs) for Sonarijan section, 3140 vehicles (2168 PCUs) for Alupara section and 6183 vehicles (3962 PCUs) for Sesamiri section.

(ix) Based on traffic volume count survey and traffic capacity analysis following improvement measures are required in terms of capacity augmentation of road.

- Ghagrabasti to Hawajan with its current intermediate lane configuration will require considering the policy of PWRD Assam to construct high speed corridor 2-lane road with paved shoulders shall be constructed for safety of road users and future socio-economic development planning the area and international connectivity.

(x) The design MSA in 10th year and 20th year from the year of opening of road to the traffic are 10 MSA and 10 MSA respectively.

(xi) Due to very high VDF value caused by highly overloaded 2 Axle Vehicles (mainly carrying food grains & food products and quarry materials) the section of the road from Ch. 0+000 to Ch. 26+006 and Ch. 0+000 to Ch. 2+130 is recommended to be constructed as Flexible Pavement.

(xii) The project road does not require environmental clearance from the MOEFFCC as per EIA Notification 2006 and NOC from the Standing Committee of National Board for Wildlife (NBWL). The project road also does not require NOC from the Archaeological Survey of India/ State Directorate of Archaeology. During pre-construction and construction stage it is expected to cause some environmental impacts which are not significant, these are mostly site-specific and short term (temporal). Effective implementation of the proposed Environmental Management Plan (EMP) will minimize, mitigate and eliminate the adverse impacts; moreover, it will also bring positive impacts. Overall, the project anticipates positive impacts; hence the project shall be taken up for development of the project area and surrounding.

(xiii) This social assessment along the project road has been carried out by keeping a consideration for minimum resettlement impact through feasible engineering designs. However, there will be some adverse social impact which will be properly mitigated through resettlement provisions.

(xiv) The Social Impact Management Plan (SIMP) will include Resettlement Plan (RP) and will be prepared on findings of SIA and mitigation of adverse impacts through Entitlement Matrix along with Implementation, Monitoring and Grievance Redress Mechanism on the provisions of approved Resettlement Framework (RF) for Assam Rural Network Improvement Project (ARNIP) under Asom Mala program.

(xv) Total Project Cost (including all taxes, cess and cost of pre-construction activities) for **Package I** and **Package II** shall be 122.26 Crores and 139.47 Crores respectively. The Civil cost (without taxes, cess and cost of pre-construction activities) for **Package I** and **Package II** shall be 63.80 Crores and 85.29 Crores respectively.

(xvi) All the project road sections are economically viable individually, and the project road as a whole is also found to be economically viable for both the cases, as the EIRRs are above the minimum 12% in base case scenario and above 9% in the worst-case scenario.