GOVERNMENT OF GOA

PUBLIC WORKS DEPARTMENT

WORK DIVISION XV (NH), P.W.D., PANAJI, GOA

Consultancy Services for the Preparation of Detailed Project Report and Bidding Documents for the "Proposed Construction of High Level New Bridge along with its approaches across River Zuari at Borim on NH – 17B (NH-566) in the State of Goa".

FEASIBILITY REPORT

SEPTEMBER - 2018

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Chapter – 1

INTRODUCTION

1.0 INTRODUCTION

1.1 General:

i) The Ministry of Road Transport & Highways (MORT&H) is responsible for the development, maintenance and management of National Highway and for matters connected or incidental thereto. Ministry of Road Transport & Highways intends to construct new bridges on National Highways as per new specification, in place of old, weak and narrow bridges in a phased and in a time bound manner. Accordingly, proposals are invited from eligible consultants for prioritization and preparation of project report for construction of bridge for which state PWD will be the implementing agency.

ii) NH-17B starts at Farmagudi from the junction with NH-4A at Km. 127/400 and proceeding via Borim Village, Verna and terminating at Marmagoa Port. This stretch was declared as National Highway in July 1999. On this National Highway, there is a High level Bridge across River Zuari at Borim having a length of around 431 m. The Bridge is a prestressed balance cantilever concrete bridge with a central navigable span of 122 m. The Bridge was built by M/s Gammon India and was opened to traffic in 1986. There is major commercial traffic along this corridor crossing this bridge. Over the years the traffic on the NH-17B has increased substantially and the existing two lane Bridge is burdened carrying this manifold traffic. Typical problems manifested in the long span cantilever prestressed bridges have plagued the existing Bridge also and inherent corrosion in saline atmospheric conditions have only aggravated the deterioration of the bridge.

iii) The work of preparation of Detailed Project Report and bidding documents for the "Proposed Construction of High Level New Bridge along with its Approaches across River Zuari at Borim on NH-17B (NH-566) in the state of Goa." is entrusted to M/s. Technogem Consultants Pvt. Ltd.

iii) The Letter of Award (LOA) bearing No. PWDD/WDXV(NH)/Accts/8109/2016-17/423 was issued on 29th August, 2016.

iv) Thus, the date of commencement of Consultancy Services is 8th November 2016 and time period for completion of the assignment is 12 months.

1.2 Site Office:

The consultants have established site office for field work at Madgaon. The distance between Site and Madgaon is about 15 km. Hence, this location is better for accessibility to the project corridor, to monitor field investigation/ survey activities etc.

The address of site office is as given below:

M/s. Technogem Consultants Pvt. Ltd.,
C/o. Rama Naik,
Shop No. G9, Ciedade Apartment,
Vidyanagar, Gogol,
Margao, Goa – 403601.

1.3 Mobilization:

We had mobilized a team of key personnel's as well as support staff at site and started the work on 8th November 2016. Initially, Reconnaissance survey had been carried out by the team of engineers.

1.4 Objectives of the Assignment:

- The main objective of the Consultancy Services is to establish an economically and strategically significant link from Ponda to Verna, Vasco and Madgaon by constructing a new bridge across River Zuari at Borim. The link will be useful for the town/ villages along the project corridor.
- To study present traffic pattern & prepare proposal for smooth flow of traffic.
- To establish technical, environmental, social, economical and financial viability of the project and prepare Detailed Project Report and bidding documents for the "Proposed Construction of High Level New Bridge along with its Approaches across River Zuari at Borim on NH-17B (NH-566) in the state of Goa".
- To ensure Detailed Project Preparation incorporating aspects of value engineering, quality audit and safety audit requirements in design and implementation and submit the reports in given time frame.

1.5 Scope of the Services:

The scope of the services involved in Project Report preparation for construction of new bridge, and its long approaches on either side will cover the followings;

- prioritization based on traffic and its financial viability,
- review of all available reports and published information about the project and the project influence area,
- detailed reconnaissance survey

- Identification of possible alignments for the new bridge, selection of best suited alignment/ geometrics for the proposed Bridge, the realignment up to minimum 2 km length or greater if the situation demands to create effective traffic movement,
- Inventory and condition survey of existing Bridge/ Culverts and approach roads along the new alignment and connectivity/ accessibility to village traffic,
- topographic surveys using total station as per guidelines of latest IRC SP-19. Fixing of TBM and all reference point in ground during survey and should be clearly shown on detailed survey drawings,
- carrying out detail hydrological study required for completion of Bridge design and project report preparation,
- geotechnical investigation work for proposed Bridges as per guidelines of IRC SP-19 and IRC-78,
- preparation of alignment option study report and GAD for approval of concerned authorities,
- Finalization of GAD of the proposed bridge and submission to the Employer for approval of GAD by concerned authorities,
- to interact with authorities on technical issue during approval of GAD by authority.
- to prepare LA (Land Acquisition) plan and to assist in LA process till completion,
- to obtain the required clearances (if required) such as forest clearance, environmental clearance, CRZ clearance etc.,
- to prepare GAD for construction of proposed bridge, plan & profile of approach road as per guidelines of related latest IRC and IS codes,
- to submit bidding documents as per MORT&H planning commission, to provide required schedules as per EPC/BOT documents,
- to prepare the firm cost estimate as per Ministry's Data Book, based on detailed design and to carry out rate analysis with supported market quotations to calculate Fair Market Rate wherever new or innovative items are included,
- to obtain approval from MORT&H and State Government,
- to provide update Cost Estimate based on current rates and tender document at the time of Bidding if required.

1.6 Reports to be submitted:

The preparation of Detailed Project Report has been split into 4 stages & accordingly following reports are to be submitted to the Employer;

Table 1.1 Schedule of submission of Reports

Stage No.	Activity	Cumulative Time period in days	No. of copies to be submitted
1	Alignment option and Inception Report.	60	3
2	Selection of the best alignment & geometrics with comparative economics of cost and finances.	90	3
3	Survey/Investigation and preparation of GAD of proposed Bridge approval by concern Authorities. Prepare the LA plan and take clearance of Environment & Forest	240	3
4	GAD and Final Report for Construction of Proposed Bridge along with schedule required as per EPC/BOT document (Final Report)	365	6

1.7 Present Status:

- Consultants had carried out detailed reconnaissance survey, studied various alternative alignments for the proposed Bridge and submitted 'Alignment Option and Inception Report including QAP' vide letter no. TCPL/364/Y2K-17/03 dated 7th January, 2017. In this report, 7 alternative alignments were studied and presented for approval. The details of each alternative have been discussed in this report separately.
- Principal approval to the Alternative No. 7 with certain suggestions was given by the Principal Chief Engineer, PWD (NH) Goa during presentation held on 1st March 2017.
- A meeting cum presentation was held on 15th March 2017 with Chief Engineer (P-6), MoRT&H, New Delhi. During this meeting various 7 alternatives were presented.
- Modified proposal of Alignment Options incorporating suggestions made by the Principal Chief Engineer, PWD (NH) Goa during presentation held on 1st March 2017 was submitted by the consultants vide letter no. TCPL/364/Y2K-17/06 dated 31st March 2017 for further submission to MoRT&H.

- The Site Visit was held on 22nd June 2017 with the Chief Engineer (P-6) MoRT&H), PWD (NH) Goa officers and Consultants Team. During this visit, various alternative alignments were inspected including alternative – 7.
- Approval to the alignment (Alternative – 7) was received from the PWD (NH) Goa vide E-mail dated 31st August 2017 along with letter of approval given by the Chief Engineer (P-6), MoRT&H (letter no. NH-12014/1/2017-Goa (P-6) dated 9th August 2017).
- Consultants have submitted report on **'Selection of the best alignment & geometrics'** i.e. Stage – II submission for the approved alignment i.e. Alternative – 7 vide letter no. TCPL/364/Y2K-17/10 dated 25th September, 2017.
- General Arrangement Drawings (GAD's) showing 3 different alternatives for the type of superstructure for the proposed major Bridge across River Zuari was prepared and submitted by the consultants vide letter no. TCPL/364/Y2K-17/18 dated 15th December, 2017.
- Approval to the type of superstructure i.e. PSC Pre-cast Segmental Box Girder superstructure including Cable Stayed Bridge portion for navigational span was received from PWD (NH) Goa vide letter F8024/PWD/WDXV/(NH)/ASW/2017-18/464 dated 17th Jan. 2018.

Chapter – 2

PROJECT APPRECIATION

2.0 PROJECT APPRECIATION

The consultants had carried out detailed Reconnaissance survey and collected the details along the project corridor. The information collected as well as conclusion from Reconnaissance survey is as follows;

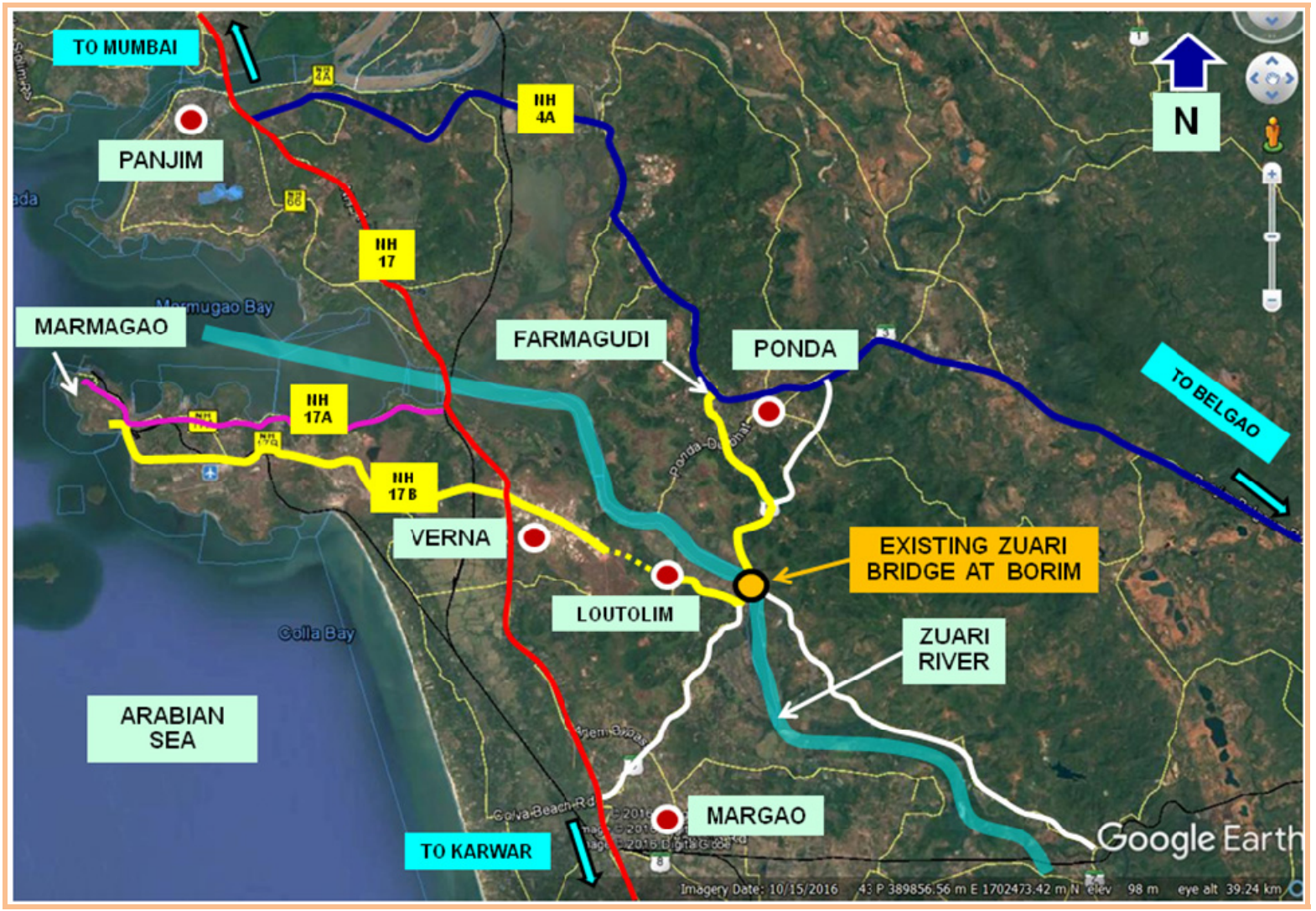
2.1 Project Corridor:

The Project road is a section of NH-17B (NH-566). NH-17B which is declared as National Highway in July 1999 originates from intersection with NH-4A at Farmagudi (Ponda), proceeding via. Borim, Loutulim, Verna & terminating at Marmagoa port. There is missing link of this NH between village Loutulim & Verna Industrial Estate.

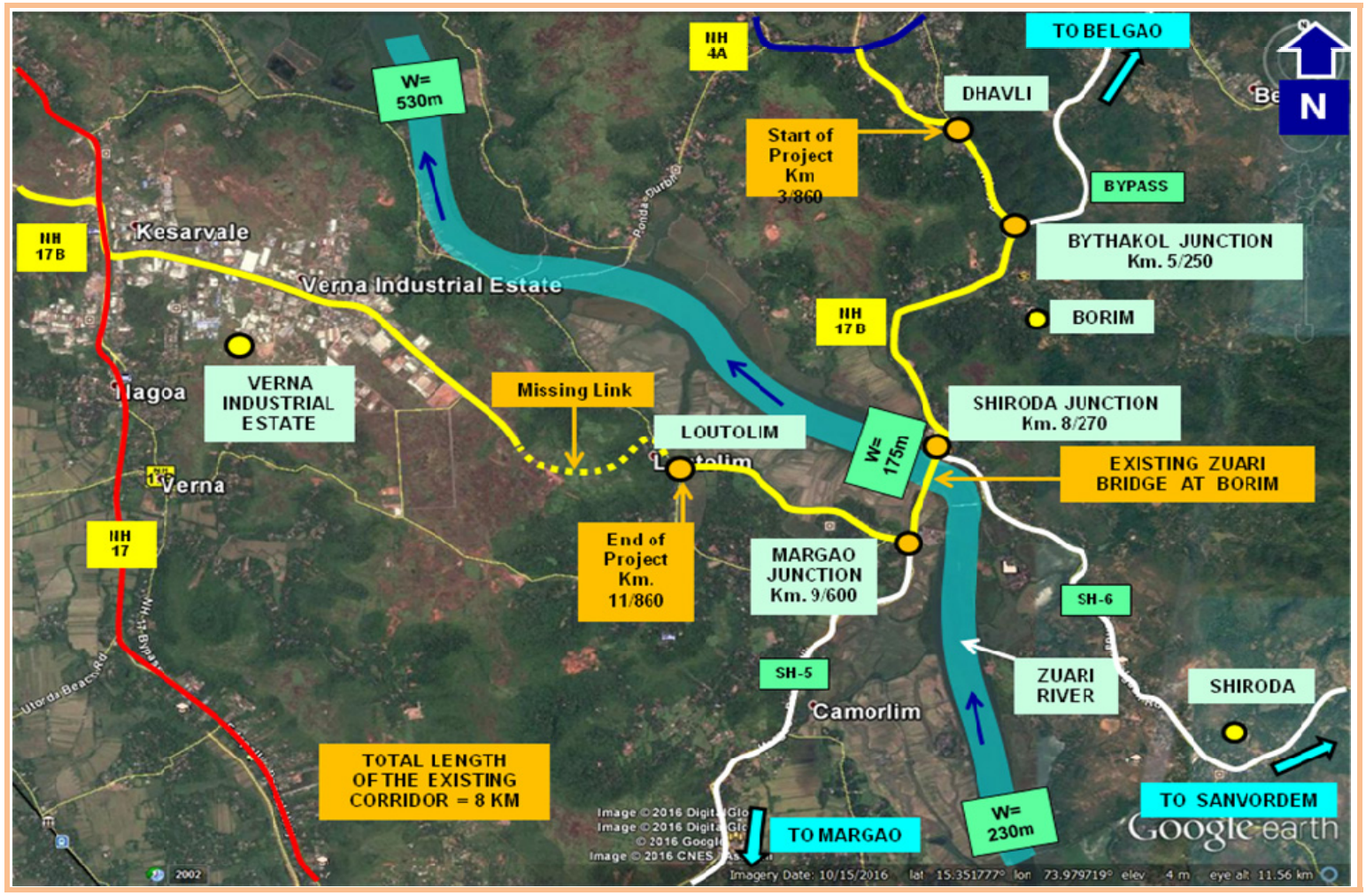
The Project road under consideration is located between Km. 3/860 to Km. 11/860 of NH-17B i.e. 8 Km. The project corridor located in two districts South Goa & North Goa out of which majority length passes through North Goa district. A key map is enclosed with this report.

2.2 About River Zuari:

- Zuari river is the largest river in the state of Goa (92 Km long).
- Zuari originates at Hemad - Barshem in the western ghat & flush out into the Arabian Sea at Cabo Aguada (near port city Vasco da Gama).
- It is a tidal river (tide affected river at Borim).
- It is backbone of Goa's agricultural industry as well as mining industry.
- In the interior region of Goa, it is referred to as River Khushavati (near Quepem), River Guloli near Netravali) & River Ugem (near Sanguem & Ugem).
- There is Salaulim dam across river Zuari (Guloli) near Sanguem.
- It flows in the southern-western direction & bifurcate the Goa state as South Goa & North Goa.
- It is being used for the navigation for the transportation of iron ore.
- There are following major bridges across river zuari;
  a) on NH-17 near Cortalim
  b) on Konkan Railway near Cortalim – adjoining to NH-17
  c) on NH-17B near Borim
  d) Pipe Line Bridge near Borim – adjoining to NH-17B
  e) on Sanvordem – Dhabadora road near Sanvordem.


TO MUMBAI
PANJIM
NH 4A
NH 17
MARMAGAO
Mormugao Bay
FARMAGUDI
PONDA
TO BELGAO
NH 17A
NH 17B
VERNA
EXISTING ZUARI BRIDGE AT BORIM
LOUTOLIM
ZUARI RIVER
Colla Bay
ARABIAN SEA
MARGAO
TO KARWAR
N
Google Earth

INDEX MAP



PROJECT CORRIDOR

2.3 About Existing Bridge Across River Zuari at Borim:

- Existing bridge across River Zuari at Borm was opened to traffic in 1986.
- Existing bridge is 2 lane bridge with footpaths on either side.
- Length of the existing bridge is 431m with additional span of 35m for crossing of SH-6 road.
- There is central navigational span (balance cantilever span) of 122m with navigational channel of 90m and vertical clearance of 13.7m.
- Existing two lane bridge is burdened for carrying present manifold traffic.
- Typical problems manifested in the balance cantilever prestressed span of the bridge.

2.4 Climate:

The temperature in the project corridor being in the tropical zone and located near the Arabian Sea, Goa generally experiences a hot and humid climate all around the year. In Goa, the month of May is considered as the hottest month as it usually carries day temperatures of almost **35°C** (**95°F**) with high humidity. Goa experiences a short winter season in the mid month of December and February. Usually in the night, the temperature goes down to 21°C (**68°F**) and in the day it rises up to 28°C (84°F). The nights are considered as cool as compared to day. The details of the same are as follows;

During Summer :- Max 35ºC and Min 32ºC

During Winter :- Max 28ºC and Min 21ºC

Average annual rainfall in this area is about 3000 mm.

2.5 Terrain:

Project corridor passes through rolling terrain. The initial portion from Km. 3/860 to Km. 5/200 is passing through hillock portion resulting steep gradient to existing road.

2.6 Land use:

In majority length, land use along project road is partially agricultural as well as plantation. At villages/ town locations there are residential/ commercial structures along the existing road. The details of stretch wise land use are as follows;

Table 2.1

From 'Km'	To 'Km'	Side	Land Use	Remarks
3/860	4/260	RHS	Built-up	
3/860	4/250	LHS	Plantation	Hilly portion
4/250	5/450	BOTH	Plantation	Hilly portion

5/450	6/000	BOTH	Built-up	
6/000	6/850	RHS	Built-up	
6/000	6/850	LHS	Agricultural	Few Built-up sections in scattered location
6/850	8/600	BOTH	Built-up	
8/600	9/450	BOTH	Agricultural	Includes Zuari River channel
9/450	10/450	BOTH	Built-up	
10/450	11/050	BOTH	Agricultural	
11/050	11/860	BOTH	Built-up + Open Land	

2.7 Major Junctions:

Following are the major junctions on the project road.

There three major junctions (junction with SH/ NH) in the project corridor i.e. at Bythakol with NH – 17C. In addition to this there is an important junction at start of project corridor near Dhavli (road leading to Ponda city). Details of major / important junctions are as follows;

Table 2.2

Major/ Important Junctions on Project Road

Sr. No.	Existing Chainage	Location / Identification	Type	Remark
1	3/860	Dhavli	Y	Rotary junction (road leading to Ponda city)
2	5/200	Bythakol	Y	Rotary junction SH - bypass to Ponda city
3	8/200	Shiroda	Y	Rotary junction SH-6 – road leading to Shiroda
4	9/520	Margao	T	SH-5 road leading to Margao

2.8 Villages along the Project Highway:

The following villages / towns are located along the project road

Table 2.3

Villages / Towns on Project Road

Sr. No.	Name of village / towns	Existing chainage		Habitation on LHS / RHS of road
		From	To	
1	Dhavali	3/860	4/260	RHS
2	Borim	5/450	8/600	LHS & RHS
3	Loutulim	9/500	11/860	LHS & RHS

2.9 Existing Road alignment:

The details of project road are explained at Para 2.1 above. There are acute / substandard horizontal curves in the project stretch where realignment is required.

Table 2.4

Sr. No.	Location		Side on which Improvement is required	Remark
	From 'Km'	To 'Km'		
1	4/760	5/160	RHS	Series of curves before Bythakol junction
2	6/680	6/860	LHS	Near Durbhat road junction
3	7/160	7/340	LHS	Between Durbhat road junction & Shirdoa junction
4	7/500	7/600	RHS	-------- do --------
5	8/240	8/360	RHS	Near Shiroda junction
6	10/220	10/380	LHS	After Margao junction
7	11/200	11/320	LHS	Between Margao junction & Loutulim village junction
8	11/460	11/780	LHS	--------- do ----------

.

2.10 Existing ROW:

As per the available information and site observations the available ROW of the project road varies from 10m to 12m from Dhavli junction (Km. 3/860) to Margao junction (Km. 9/600). From Margao junction to Loutulim (Km. 11/860) width of ROW is 20m. Additional width of ROW is available at junction locations, at high bank portion of approaches of existing bridge etc.

2.10.1 Existing roadway:

a. Carriageway:

Existing road is having carriageway width of 7.00m (Two lane).

b. Shoulders:

Soft shoulders of about 1.0 m to 1.5m exist on either side of the carriageway.

Most of the length of existing road is at same/ lower level as that of the adjacent ground level. Longitudinal drains along the existing roads are available in certain stretch along the project length.

2.10.2 Existing Pavement:

Existing road consists of flexible pavement and the same is in fair condition.

2.10.3 Existing structures on the Project Road:

a. Major bridges :

There is only one major bridge across river Zuari along the project corridor. Details of the existing Zuari bridge are as follows;

- It is a high level bridge with central nevigation span of 122m (90m nevigable channel)
- Year of construction 1986.
- Total length of the bridge = 460m (including span of Shiroda underpass)
- Width of carriageway 7.5m & 1.5m footpaths on either side
- Type of foundation – Well foundation
- Type of substructure :-
  a) Piers for navigational span : – RCC hollow piers
  b) Piers for remaining spans : – RCC rectangular piers
  c) Spill through abutments
- Type of superstructure :-
  a) for navigational span & either side span of nevigation channel :- Balance cantilever span with PSC box girder
  b) for remaining span – PSC Box Girders
- Wearing course :- RCC wearing course
- Width of river at existing bridge location = 175m

Table 2.5

Major Bridges

Sr. No.	Location	Span Arrangement
1	Km. 8/550 (Near Borim)	(1 x 122m) + (2 x 61m) + (4 x 38m) & (1 x 35m viaduct across SH-6)

b. Minor bridges :

There is only one minor bridge in project corridor. The detail of minor bridge is as follows;

Table 2.6

Minor Bridges

Sr. No.	Location	Span Arrangement
1	Km. 6/900 (Near Sakvar bus stop)	1 Span X 6.00m

c. Culverts

In the entire project corridor cross drainage works are observed. Mainly there are Pipe and Slab culverts across the project road. It is also observed that there are some structures which cannot be identified, as they are in buried condition. The total numbers of pipe culverts & Slab culverts are as follows;

Table 2.7

Culverts

Sr. No.	Type of Structure	Nos.
1)	Slab Culvert	15
2)	Pipe Culvert	08
3)	Arch Culvert	01
4)	Unidentified / Buried	05
	Total	**29**

d. Religious Places in Project Corridor:

Following are the religious places located within ROW/ closer to ROW/ outside ROW;

a) Church within ROW at Km. 5/580 between Petrol pump & UCO bank
b) Saibaba temple close to existing road at Km. 7/450
c) Church closer to ROW at Km. 8/450 near existing Zuari River Bridge

e. Utilities along & across the project corridor:

The utilities such as over head electrical line, underground OFC line, water supply line are located along and across the road in majority length. The major utilities are as follows;

a) High Tension tower electrical line located at D/s of existing bridge
b) Water supply line 600mm dia. located at RHS in partial length & at LHS in partial length
c) Over head electrical line along & across the existing road.

2.10.4 Trees & Mangroves in the Project corridor:

a) Trees :-

There are large numbers of trees located along both side of the existing road in entre length.

b) Mangroves:-

Mangroves located along both side banks of the Zuari River. The width of the mangroves varies from 25m to 125m. Beyond 500m on D/s side of the existing bridge width of mangroves is less (25m to 30m)

2.11 Traffic Pattern:-

a) Existing Traffic Pattern

Present traffic crossing the existing bridge across Zuari near Borim has different patterns depending on various aspects in the vicinity of the project corridor. The following aspects are observed in distinguishing present traffic pattern;

a) Over existing bridge across river Zuari on NH-17 near Cortalim, entry for heavy vehicle is prohibited. Hence, heavy commercial traffic coming from Panjim side and leading towards Verna/ Margao/ Karwar & vice versa is plying on NH-17B presently via. Farmagudi, Borim.
b) There is missing link of NH-17B between Loutulim and Verna Industrial Area. Hence heavy commercial traffic leading towards Verna Industrial Area is plying via. Arlem bypass (bypass to Margao city) by travelling additional length.

Following are the present traffic patterns crossing the existing bridge across river Zuari near Borim;

i) Heavy commercial traffic from Panjim, leading to Verna/ Marmagao port/ Margao via. Farmagudi, Borim & vice versa.
ii) Commercial traffic from Belgaum (Belagavi), leading to Verna/ Marmagao port/ Margao via. Amigo junction, Borim & vice versa.

iii) Local traffic from Ponda to Margao & vice versa
iv) Local traffic from Shiroda to Margao & vice versa
v) Local traffic from Ponda/ Shiroda, leading to Loutulim, Airport, Marmagao port & vice versa.

b) Future Traffic Pattern

Future traffic crossing the existing bridge across Zuari near Borim will have different patterns depending on various aspects in the vicinity of the project corridor. The following aspects will change present traffic present traffic pattern;

a) As explained above, over existing bridge across river Zuari on NH-17 near Cortalim, entry for heavy vehicle is prohibited. Hence, heavy commercial traffic coming from Panjim side and leading towards Verna/ Margao/ Karwar & vice versa is plying on NH-17B presently via. Farmagudi, Borim. Now, construction of new bridge across River Zuari aon NH-17 is in progress. After completion of this bridge traffic from Panjim & leading towards Margao will get shifted over this new bridge on NH-17.
b) As explained above, there is missing link of NH-17B between Loutulim and Verna Industrial Area. Hence heavy commercial traffic leading towards Verna Industrial Area is plying via. Arlem bypass (bypass to Margao city) by travelling additional length. Now, construction of this missing link is in progress. Hence, in future, the traffic leading to Verna MIDC will follow missing link inplace of Arlem bypass road.

Following will be the future traffic patterns crossing the existing bridge across river Zuari near Borim;

i) Commercial traffic from Belgaum (Belagavi), leading to Verna/ Marmagao port/ via. Amigo junction, Borim, Loutulim & vice versa.
ii) Commercial traffic from Belgaum (Belagavi), leading to Margao/ Karwar via. Amigo junction, Borim, Margao junction & vice versa.
iii) Local traffic from Ponda to Margao & vice versa
iv) Local traffic from Shiroda to Margao & vice versa
v) Local traffic from Ponda/ Shiroda, leading to Loutulim, Airport, Marmagao port & vice versa.

2.12 Traffic data on Project Road (Data collected from PWD)

Table: 2.7

Date of completion of Survey		Fast / Power Driven Vehicles						Slow Vehicles		Total
		Car/ JeepsTaxies / Van / Three Wheeler (Auto include)	Two Wheeler (Motor Cycle, Scooters etc.)	LCV (Light commercial vehicles Mini Truck)	Bus	Two Axle / truck / Tanker	Multi-axle Truck/ Truck / Trailer / Tanker	Cycle / Rickshaw / Other Human Power	Bullock cart, Horse cart / Other Animal Drawn	
22.02.2013	Vehicle numbers	6635	7504	3630	1245	52	2724	35	6	**21831**
	PCU	*3318*	*7504*	*5445*	*3735*	*156*	*12258*	*18*	*36*	***32470***

Location : Near TopCola, Borim Source : PWD WDXV(NH), Ponda Goa

Date of completion of Survey		Fast / Power Driven Vehicles						Slow Vehicles		Total
		Car/ JeepsTaxies / Van / Three Wheeler (Auto include)	Two Wheeler (Motor Cycle, Scooters etc.)	LCV (Light commercial vehicles Mini Truck)	Bus	Two Axle / truck / Tanker	Multi-axle Truck/ Truck / Trailer / Tanker	Cycle / Rickshaw / Other Human Power	Bullock cart, Horse cart / Other Animal Drawn	
22.02.2013	Vehicle numbers	2804	2208	415	153	7	535	14	1	**6137**
	PCU	*1402*	*2208*	*623*	*459*	*21*	*2408*	*7*	*6*	***7134***

Location : Near Margao Junction Source : PWD WDXV(NH), Ponda Goa

2.13 Conclusion of Reconnaissance survey:

- Existing bridge across River Zuari is weak to carry present traffic hence strengthening of existing bridge is being done by the (NH) PWD, GOA alternatively.
- Existing project road is located in valley portion and there are hilly portion on either side from Dhavli to existing bridge.
- Width of the present available ROW is inadequate i.e. 10m to 20m only.
- In majority length, there are habitations along both sides of the existing road.
- In majority length, existing road is at lower level or at original ground level. As per IRC:SP:84-2014 manual, such stretches shall be raised to bring top of subgrade at least 0.5m above general ground level or to bring subgrade bottom level 1m above the HFL/ high tide level.
- Drainage condition in project corridor is satisfactory.
- River Zuari at existing bridge location is Tidal River.
- <u>From Reconnaissance survey it is revealed that;</u>
  a) Present traffic on the project corridor is substantial. The traffic data collected from concern PWD shows that the corridor is due for minimum 4 lane divided carriageway road.
  b) Partial commercial (Heavy vehicle) traffic coming from Panjim and leading towards Verna/ Margao/ Karwar will get diverted after completion of Bridge across Zuari on NH-17 near Cortalim.
  c) Quantum of Two Axle/ multi axle trucks is substantial among all the vehicle categories.
- There is forest land along the existing road at LHS between Dhavli junction & Bythakol junction for a length of about 450m.
- Large numbers of trees will get affected in improvement/ widening of project road. Quantum of the same will be depending on selection of alternative alignment.
- Mangroves are observed along the both side banks of the River Zuari and shall be taken in to account during preparation of the proposal.

2.14 Improvements / upgrading the existing Project Roads:

a) Roadways:

i) Improvement of existing road envisages rehabilitation / upgrading to 4 /6 lane with paved shoulder configuration. The carriageway configuration is proposed as given below;

4/6 Lane Divided Highway Without Service Road & With Raised Median

(Open Country Plain/ Rolling Terrain)

		4 Lane road with Paved shoulders	**6 Lane road with Paved shoulders**
Median	:	5.00 m	5.00 m
Carriageway	:	2 x 7.00 m	2 X 10.5 m
Paved Shoulder	:	2 x 1.50 m	2 x 1.50 m
Soft Shoulder	:	2 x 2.00 m	2 x 2.00 m
Raised Footpath	:	-----	1.75m

Source :- IRC:SP:84-2014 Manual – Fig. 2.4 & IRC:SP:87-2013 Manual – Fig. 2.4

Note:- **Width of the median will be reduced to 2.5m (if required) to minimize the width of the proposed ROW.**

4/6 Lane Divided Highway With Service Road & With Raised Median

(Built-up section Plain/ Rolling Terrain

		4 Lane road	**6 Lane road**
Median	:	2.5 m	2.5 m
Carriageway	:	2 x 7.00 m	2 x 10.50 m
Paved Shoulder	:	2 x 2.00 m	2 x 2.00 m
Raised Footpath	:	2 x 2.00 m	2 x 2.00 m
Service Road	:	2x (7.5 m or 5.5 m)	2x (7.0 m or 5.5 m)
Raised Footpath	:	2 x 1.5 m	2 x 1.5 m

Source :- IRC:SP:84-2014 Manual – Fig. 2.6 & IRC:SP:87-2013 Manual – Fig. 2.8

iii) Geometrical Improvement / realignments:

Major locations which require geometrical improvement / realignments are given at Table No. 2.4 in Para No. 2.8 above. However, for proposed new bridge across river Zuari, alternative alignment no.7 is approved by the MoRT&H which include realignment/ new alignment and the same is discussed in this report separately.

b) Structures:

i) Culverts:

New pipe culverts of NP-4 pipes with adequate diameter will be provided as per site requirements. Existing culverts having poor condition will be proposed for

reconstruction and culverts with good / fair condition will be widened. The width of all culverts will be proposed as follows;

Width of Culvert - equal to width of roadway

(Source: - IRC:SP:84-2014 – Fig. 7.1A & 7.1B & IRC:SP:87-2013 Manual – Fig. 7.1)

ii) Minor Bridges:

Widening / reconstruction / new construction of minor bridges will be proposed as follows;

		4 Lane road	**6 Lane road**
Carriageway	:	2 x 8.5 m	2 x 10.50 m
Footpath	:	2 x 1.50 m	2 x 1.50 m
Paved Area	:	---	2 x 1.50 m
Total Width	:	2 x 12.50	2 x 15.20 m

(Source: - IRC:SP:84-2014 – Fig. 7.2A & IRC:SP:87-2013 – Fig. 7.2)

iii) Major Bridge:-

New construction of Major bridges will be proposed as follows;

		4 Lane road
Carriageway	:	2 x 12 m
Footpath	:	2 x 1.50 m
Paved Area	:	---
Total Width	:	2 x 16.00 m

(Source: - IRC:SP:84-2014 – Fig. 7.3)

For the proposed major Bridge across River Zuari, new bridge to 6 lane standards as given in IRC:SP:84-2014 – Fig. 7.3 consisting above mentioned configuration is proposed.

2.15 Immediate Repairs to Existing Bridge/ road surface:

- Strengthening of existing bridge across Zuari has been undertaken by the PWD (NH), Goa.
- Existing road is in fair/ good condition and hence no immediate repair work is required except routine maintenance of road and drains.

Chapter – 3

ALTERNATIVE ALIGNMENTS

3.0 ALTERNATIVE ALIGNMENTS:

As per scope of work, consultants had studied 7 alternative alignments and Alignment Option cum Inception Report was submitted to the PWD (NH) Goa & MORTH for approval. The detail of these 7 alternatives which was submitted in the Alignment Option Report is reproduced in this chapter as below.

3.1 General:

The scope of work includes identification of alternative alignments for the proposed River Bridge across River Zuari. The realignment minimum up to 2 Km or more, if situation warrants for smooth flow of traffic is included in the scope of work. Accordingly, various alternatives have been studied and explained in this chapter. The emphasis while study of the alternative alignments has been given for the followings;

- the proposed alignment shall be economical,
- smooth flow of traffic shall be ensured,
- to provide best possible geometrics,
- least disturbance to the mangroves located along the banks
- access to the local traffic shall be ensured,
- least numbers of structures shall be affected,
- to ensure minimum adverse impact to the environment,
- to minimize the numbers of tree cutting.

Basically, the alternatives alignments are studied for the proposed new Bridge across River Zuari and its approaches. The stretch between Bythakol junction to Loutulim end is undertaken and covered in this alternative alignments as per demands of each alternative. For the road stretch between Dhavli and Bythakol junction, eccentric widening of existing road to 4/ 6 lane road will be proposed and necessary local realignment/ curve improvement will be proposed as per site situation. The locations of realignments/ curve improvement have been explained in Chapter – 2.

3.2 Constraints:

Followings are the main constraints in the project corridor which were considered during the study of the alternative alignments;

- width of available ROW is inadequate (varies from 10m to 20m),
- there is habitation closer to the existing road in majority length,
- from Dhavli junction to existing bridge location, there is hillock on either side of the existing road,

- large numbers of trees are located in hillock portion as well as along the existing road,
- mangroves located along the banks of River Zuari,
- Margao junction (junction of NH-17B with SH-5) is located at close distance of 720m from the River Bank.

3.3 Alternative Alignments:

Considering the constraints, 7 alternative alignments had been studied taking in to account the various issues mentioned at sr. no. 6.1. Out of 7 alternatives, 5 alternatives were proposed at D/s of the existing bridge and remaining 2 were proposed at U/s side of the existing bridge. The details of each alternative such as location, merits, de-merits, possible junction improvements etc. are as follows;

3.3.1 Alternative Alignment No. 1:

- **Location:**

  Alternative 1 alignment for the new Zuari Bridge was proposed at a distance of 950m at D/s side of the existing Zuari River Bridge. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 6.25 Km against present 8.00 Km.

- **Proposed Bridge Location:-**
  - 950m at D/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 430m,
  - the alignment of the proposed bridge in River portion = straight & at right angle to the flow,
  - Width of mangroves along the banks of River Zuari = 20m to 40m.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & road leading to Borim village, through campus of Topcola company (which is not functional now),
  - from Borim road to Durbhat junction, through agricultural land located at LHS of existing NH-17B road,
  - from Durbhat junction to River Zuari, through agricultural land located at Borim side bank of the River & at RHS of existing NH-17B road

- from River Zuari to existing NH-17B at Loutulim end, through agricultural land located at Loutulim side bank of the River & will join the existing NH-17B road at a chainage Km. 11/250.

➢ **Land Use:**

Land use alogn the proposed alignment is as follows;

- between Bythakol junction & road leading to Borim village, through campus of Topcola company – Open land with trees,
- from Borim road to Durbhat junction - agricultural land
- from Durbhat junction to River Zuari - agricultural land (paddy field)
- from River Zuari to existing NH-17B at Loutulim end - agricultural land (paddy field)

➢ **Geometry of the alignment:**

For the alternative 1 alignment, following geometry (horizontal & vertical) is possible;

- the alignment of the proposed bridge will be straight in River portion & at right angle to the flow,
- design speed of 100 Km/Hr for bridge & both side approaches,
- design speed of maximum 80 Km/Hr for realignment stretch between Durbhat junction & Bythakol junction to minimize numbers of affected structures,
- approach on Loutulim side will be in curve (with design speed of 100 Km/Hr) so as to provide grade separated intersection at Loutulim end,
- since, entire alignment will be passing through plain land, for vertical geometry, flatter longitudinal gradients as specified in IRC codes are possible.

➢ **Affected Structures:**,

In this proposed realignment, approximately 09 numbers of existing structures will be affected. The details are as follows;

- 3 abandon structures located in TopCola company campus ,
- 2 small shops of temporary nature located adjoining existing road near Borim road junction,
- 4 shops cum houses of semi-permanent nature at Durbhat road junction.

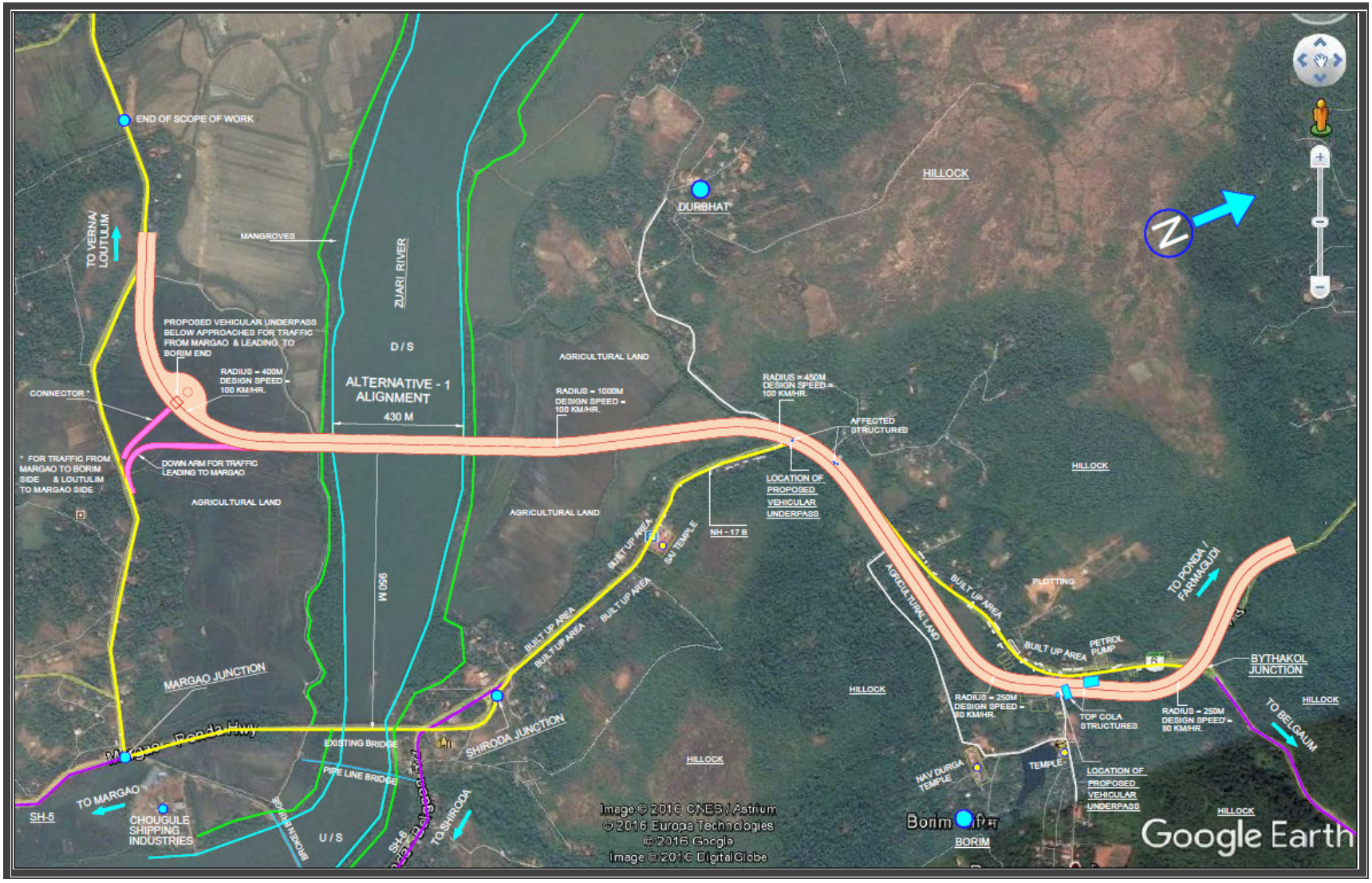
➢ **Grade Separators proposed:**

- Flyover along NH-17B at Bythakol junction
- Vehicular underpass at Loutulim end for traffic coming from Margao on NH-17B
- Vehicular underpasses at Borim junction & Durbhat junction

- **<u>Accesses to the local traffic on NH-17B</u>:**
  - Up & down ramp from new bridge approach (Borim side) will be provided for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
  - This local traffic will use proposed vehicular underpasses at Borim & Durbhat junction for right turn to avoid conflict with the traffic of NH-17B.
  - Local traffic crossing the Zuari River can use existing bridge till its balance life span.
  - After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

- **<u>Merits & De-merits</u>:**

  Various merits & demerits of the alternative alignment no.1 are given below.
  - Saving in length of the NH-17B will be 1.75 Km.
  - Since, majority length will be passing through open/ agricultural land, tree cutting involved will be less.
  - Increase in length of traffic from Bythakol to Margao and vice versa direction will be 680m.
  - Flatter gradients for vertical geometry can be provided.
  - Less area of mangroves will be affected since width of mangroves along the banks of River Zuari is less at this location (between 20m to 40m).
  - Grade separated junctions can be provided at major junctions located in realignment stretch.
  - Existing available land within the existing ROW can be utilized for a length of 500m.



ALTERNATIVE ALIGNMENT NO. - 1

3.3.2 Alternative Alignment No. 2:

- **Location:**

  Alternative 2 alignment for the new Zuari Bridge was proposed at a distance of 470m at D/s side of the existing Zuari River Bridge. This realignment was proposed for stretch of NH-17B between Bythakol junction and Margao junction. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 8.22 Km against 8.00 Km.

- **Proposed Bridge Location:-**
  - 470m at D/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 330m,
  - the alignment of the proposed bridge in River portion = straight & at right angle to the flow,
  - Width of mangroves along the banks of River Zuari = 20m to 40m at Borim side bank & 150m at Loutulim side bank.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & road leading to Borim village, through campus of Topcola company (which is not functional now),
  - from Borim road to Durbhat junction, through agricultural land located at LHS of existing NH-17B road,
  - from Durbhat junction to River Zuari, through agricultural land located at Borim side bank of the River, just behind the habitation located along the existing road at RHS.
  - from River Zuari onwards, through agricultural land located at Loutulim side bank of the River & will join the existing NH-17B road at a chainage Km. 9/450 near Margaon junction (in front of Chougle shipping industry).
  - from Margaon junction to Loutulim end, existing NH-17B route will be followed.

- **Land Use:**

  Land use alogn the proposed alignment is as follows;
  - between Bythakol junction & road leading to Borim village, through campus of Topcola company – Open land with trees,
  - from Borim road to Durbhat junction - agricultural land
  - from Durbhat junction to River Zuari - agricultural land (paddy field)

- from River Zuari to existing NH-17B at Loutulim end - agricultural land (paddy field)

➢ **Geometry of the alignment:**

For the alternative 2 alignment, following geometry (horizontal & vertical) is possible;

- the alignment of the proposed bridge will be straight in River portion & at right angle to the flow,
- design speed of maximum 80 Km/Hr for bridge & both side approaches,
- design speed of maximum 80 Km/Hr for realignment stretch between Durbhat junction & Bythakol junction to minimize numbers of affected structures,
- Immediately after the new bridge, the proposed alignment will in curvature (with max. design speed of 80 Km/Hr) for both side approaches.
- For Margao side approach, steeper gradient (more than 1:30) may be required.

➢ **Affected Structures:**,

In this proposed realignment, approximately 16 numbers of existing structures will be affected. The details are as follows;

- 3 abandon structures located in TopCola company campus ,
- 2 small shops of temporary nature located adjoining existing road near Borim road junction,
- 4 shops cum houses of semi-permanent nature at Durbhat road junction.
- 3 shops + 4 houses of semi – permanent to permanent nature at Margaon junction (affected due to proposed at grade junction improvement)

➢ **Grade Separators proposed:**

- Flyover along NH-17B at Bythakol junction
- Vehicular underpasses at Borim junction & Durbhat junction

➢ **Accesses to the local traffic on NH-17B:**

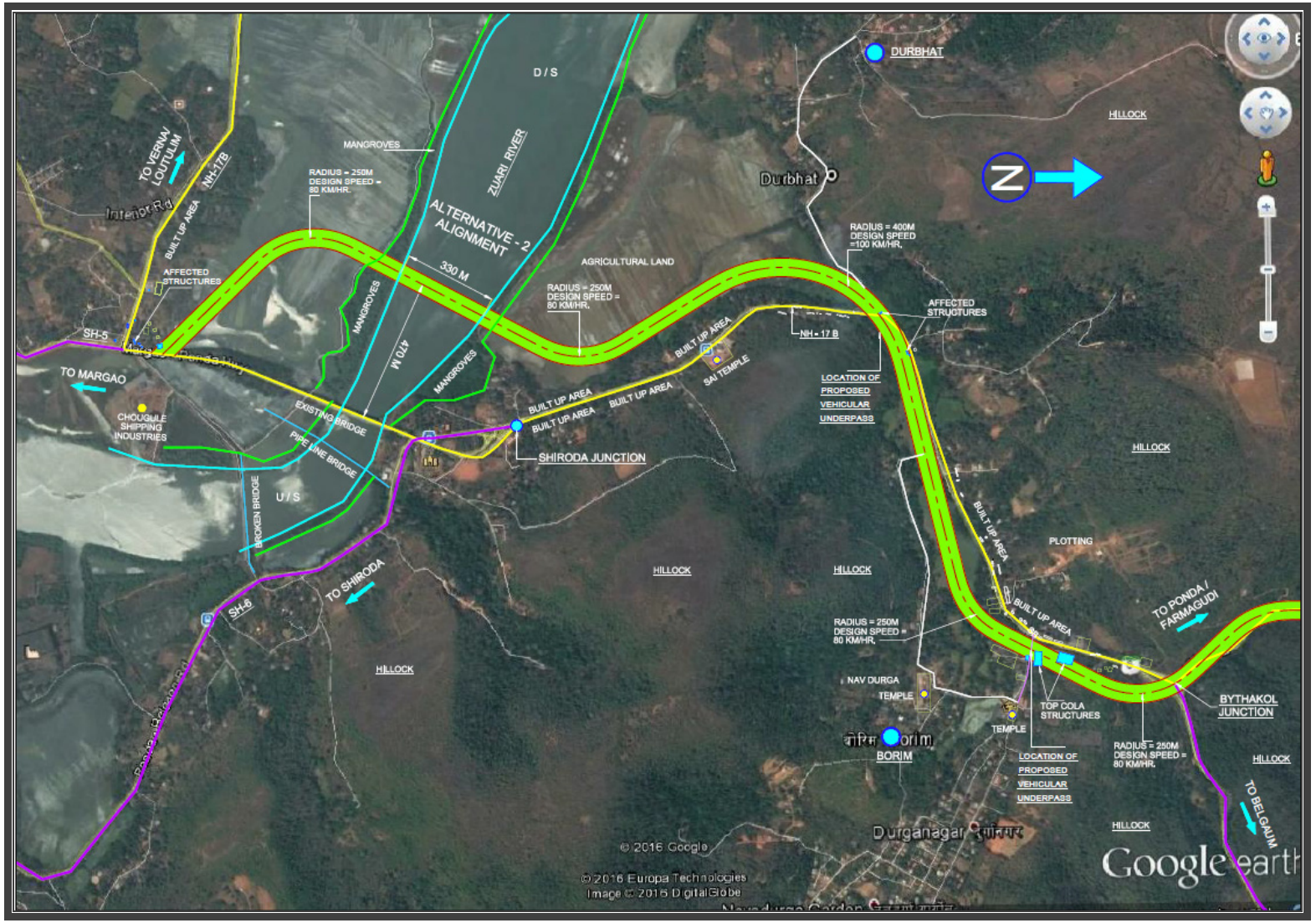
- Up & down ramp from new bridge approach (Borim side) will be provided for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
- This local traffic will use proposed vehicular underpasses at Borim & Durbhat junction for right turn to avoid conflict with the traffic of NH-17B.
- Local traffic crossing the Zuari River from Borim side to Margao side can use existing bridge till its balance life span for one way traffic only. Both way traffic will not be possible due to improvement of Margaon at grade junction. Refer drawing no. 869-ZB-JL-002 of drawing volume.

- After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

➢ **Merits & De-merits:**

Various merits & demerits of the alternative alignment no.2 are given below.

- Increase in length of the NH-17B will be 0.22 Km.
- Since, majority length will be passing through open/ agricultural land, tree cutting involved will be less.
- Length of the stretch for traffic from Bythakol to Margao and vice versa direction will not be changed.
- Since approaches are proposed along the boundary of agricultural land, there will not be bifurcation of this land in 2 parts.
- For Margao side approach, steeper gradient (more than 1:30) may be required.
- Approximately 16 numbers of existing structures will be affected.
- More area of mangroves will be affected since width of mangroves along the Loutulim side bank of River Zuari is more at this location (150m).
- Margao junction can be improved as at-grade junction only. Provision of grade separator along NH-17B will lead to increase in numbers of affected structures.



ALTERNATIVE ALIGNMENT NO. - 2

3.3.3 Alternative Alignment No. 3:

- **Location:**

  Alternative 3 alignment for the new Zuari Bridge was proposed at a distance of 950m at D/s side of the existing Zuari River Bridge. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 6.10 Km against 8.00 Km.

- **Proposed Bridge Location:-**
  - 950m at D/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 430m,
  - the alignment of the proposed bridge in River portion = straight & at right angle to the flow,
  - Width of mangroves along the banks of River Zuari = 20m to 40m.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & Durbhat junction, through hillock located at RHS of existing NH-17B road,
  - at Durbhat junction, for a smaller length of 275m, through open land (having dense trees) located at LHS of existing NH-17B road,
  - from Durbhat junction to River Zuari, through agricultural land located at Borim side bank of the River & at RHS of existing NH-17B road
  - from River Zuari to existing NH-17B at Loutulim end, through agricultural land located at Loutulim side bank of the River & will join the existing NH-17B road at a chainage Km. 11/250 i.e. between Margao junction and Loutulim end.

- **Land Use:**

  Land use alogn the proposed alignment is as follows;
  - between Bythakol junction & Durbhat junction – Open land (hillock) with dense trees in majority length and plotting is being done in a length of 200m,
  - at Durbhat junction (LHS of existing road) – Open land with dense trees & habitation in smaller length,
  - from Durbhat junction to River Zuari - agricultural land (paddy field)
  - from River Zuari to existing NH-17B at Loutulim end - agricultural land (paddy field)

- **Geometry of the alignment:**

  For the alternative 3 alignment, following geometry (horizontal & vertical) is possible;

  - the alignment of the proposed bridge will be straight in River portion & at right angle to the flow,
  - design speed of 100 Km/Hr for bridge & both side approaches,
  - design speed of 100 Km/Hr for realignment stretch between Durbhat junction & Bythakol junction except at Durbhat junction for a length of 500m where max. design speed will be restricted to 80 Km/Hr. to minimize numbers of affected structures,
  - approach on Loutulim side will be in curve (with design speed of 100 Km/Hr) so as to provide grade separated intersection at Loutulim end,
  - since, the alignment between Bythakol junction and Durbhat junction will be passing through hillock portion, for vertical geometry, steeper longitudinal gradient may be involved in this stretch.

- **Affected Structures:**,

  In this proposed realignment, approximately 06 numbers of existing structures will be affected at Durbhat road junction. The details are as follows;

  - 5 shops of semi permanent nature,
  - 1 residential structure of semi permanent type,

- **Grade Separators proposed:**

  - One way flyover at Bythakol junction for traffic from new bridge and leading towards Belgaum.
  - Vehicular underpass at Loutulim end for traffic coming from Margao on NH-17B.
  - Vehicular underpasses at Durbhat junction.

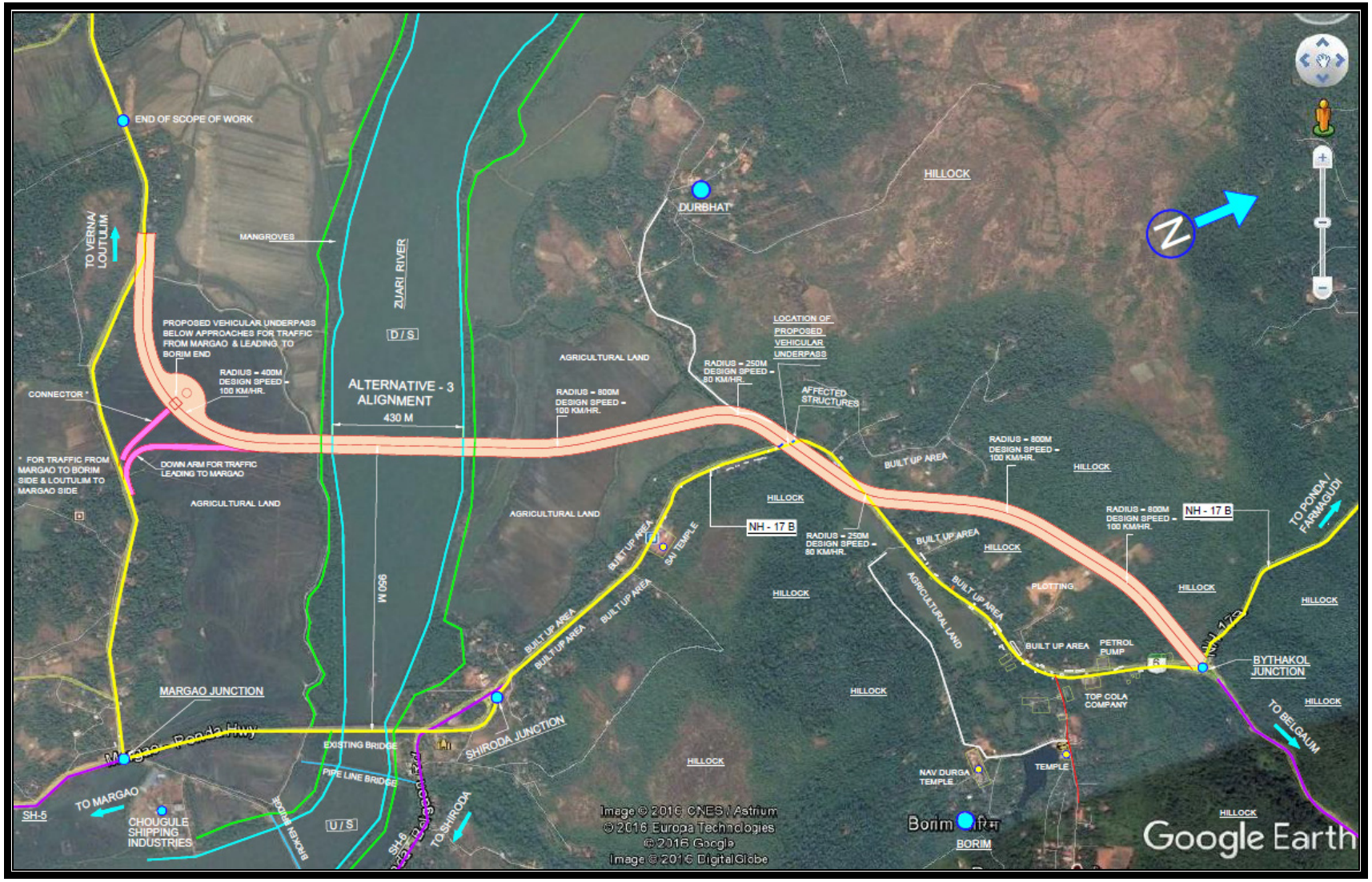
- **Accesses to the local traffic on NH-17B:**

  - Up & down ramp from new bridge approach (Borim side) will be provided for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
  - This local traffic will use proposed vehicular underpasses at Durbhat junction for right turn to avoid conflict with the traffic of NH-17B.
  - Local traffic crossing the Zuari River can use existing bridge till its balance life span.
  - After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

- **Merits & De-merits:**,

  Various merits & demerits of the alternative alignment no.3 are given below.

  - Saving in length of the NH-17B will be 1.9 Km.
  - Since, for a length of 1.6 Km the proposed alignment will be passing through hillock portion located at RHS of existing road, tree cutting involved will be more.
  - Increase in length for traffic from Bythakol to Margao and vice versa direction will be 550m.
  - Steeper gradients for vertical geometry for the stretch passing through hillock portion may be involved.
  - Deep cutting for a length of 1.6 Km may be required for the stretch passing through hillock portion located at RHS of existing NH-17B road.
  - Less area of mangroves will be affected since width of mangroves along the banks of River Zuari is less at this location (between 20m to 40m).
  - Grade separated junctions can be provided at major junctions located in realignment stretch.



ALTERNATIVE ALIGNMENT NO. – 3

3.3.4 Alternative Alignment No. 4:

- **Location:**

  Alternative 4 alignment for the new Zuari Bridge was proposed at a distance of 470m at D/s side of the existing Zuari River Bridge. This realignment was proposed for stretch of NH-17B between Bythakol junction and Margao junction. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 8.1 Km against 8.00 Km.

- **Proposed Bridge Location:-**
  - 470m at D/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 330m,
  - the alignment of the proposed bridge in River portion = straight & at right angle to the flow,
  - Width of mangroves along the banks of River Zuari = 20m to 40m at Borim side bank & 150m at Loutulim side bank.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & Durbhat junction, through hillock located at RHS of existing NH-17B road,
  - at Durbhat junction, for a smaller length of 275m, through open land (having dense trees) located at LHS of existing NH-17B road,
  - from Durbhat junction to River Zuari, through agricultural land located at Borim side bank of the River, just behind the habitation located along the existing road at RHS.
  - from River Zuari onwards, through agricultural land located at Loutulim side bank of the River & will join the existing NH-17B road at a chainage Km. 9/450 near Margaon junction (in front of Chougle shipping industry).
  - from Margaon junction to Loutulim end, existing NH-17B route will be followed.

- **Land Use:**

  Land use alogn the proposed alignment is as follows;
  - between Bythakol junction & Durbhat junction – Open land (hillock) with dense trees in majority length and plotting is being done in a length of 200m,
  - at Durbhat junction (LHS of existing road) – Open land with dense trees & habitation in smaller length,
  - from Durbhat junction to River Zuari - agricultural land (paddy field)

- from River Zuari to existing NH-17B at Loutulim end - agricultural land (paddy field).

➢ **Geometry of the alignment:**

For the alternative 4 alignment, following geometry (horizontal & vertical) is possible;

- the alignment of the proposed bridge will be straight in River portion & at right angle to the flow,
- design speed of maximum 80 Km/Hr for bridge & both side approaches,
- design speed of maximum 100 Km/Hr for realignment stretch between Durbhat junction & Bythakol junction,
- immediately after the new bridge, the proposed alignment will in curvature (with max. design speed of 80 Km/Hr) for both side approaches,
- for Margao side approach, steeper gradient (more than 1:30) may be required,
- since, the alignment between Bythakol junction and Durbhat junction will be passing through hillock portion, for vertical geometry, steeper longitudinal gradient may be involved in this stretch.

➢ **Affected Structures:**,

In this proposed realignment, approximately 13 numbers of existing structures will be affected. The details are as follows;

- 5 shops of semi permanent nature & 1 residential structure of semi permanent type at Durbhat junction,
- 3 shops + 4 houses of semi – permanent to permanent nature at Margaon junction (affected due to proposed at grade junction improvement).

➢ **Grade Separators proposed:**

- One way flyover at Bythakol junction for traffic from new bridge and leading towards Belgaum.
- Vehicular underpasses at Durbhat junction

➢ **Accesses to the local traffic on NH-17B:**

- Up & down ramp from new bridge approach (Borim side) will be provided for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
- This local traffic will use proposed vehicular underpasses at Durbhat junction for right turn to avoid conflict with the traffic of NH-17B.
- Local traffic crossing the Zuari River from Borim side to Margao side can use existing bridge till its balance life span for one way traffic only. Both way traffic

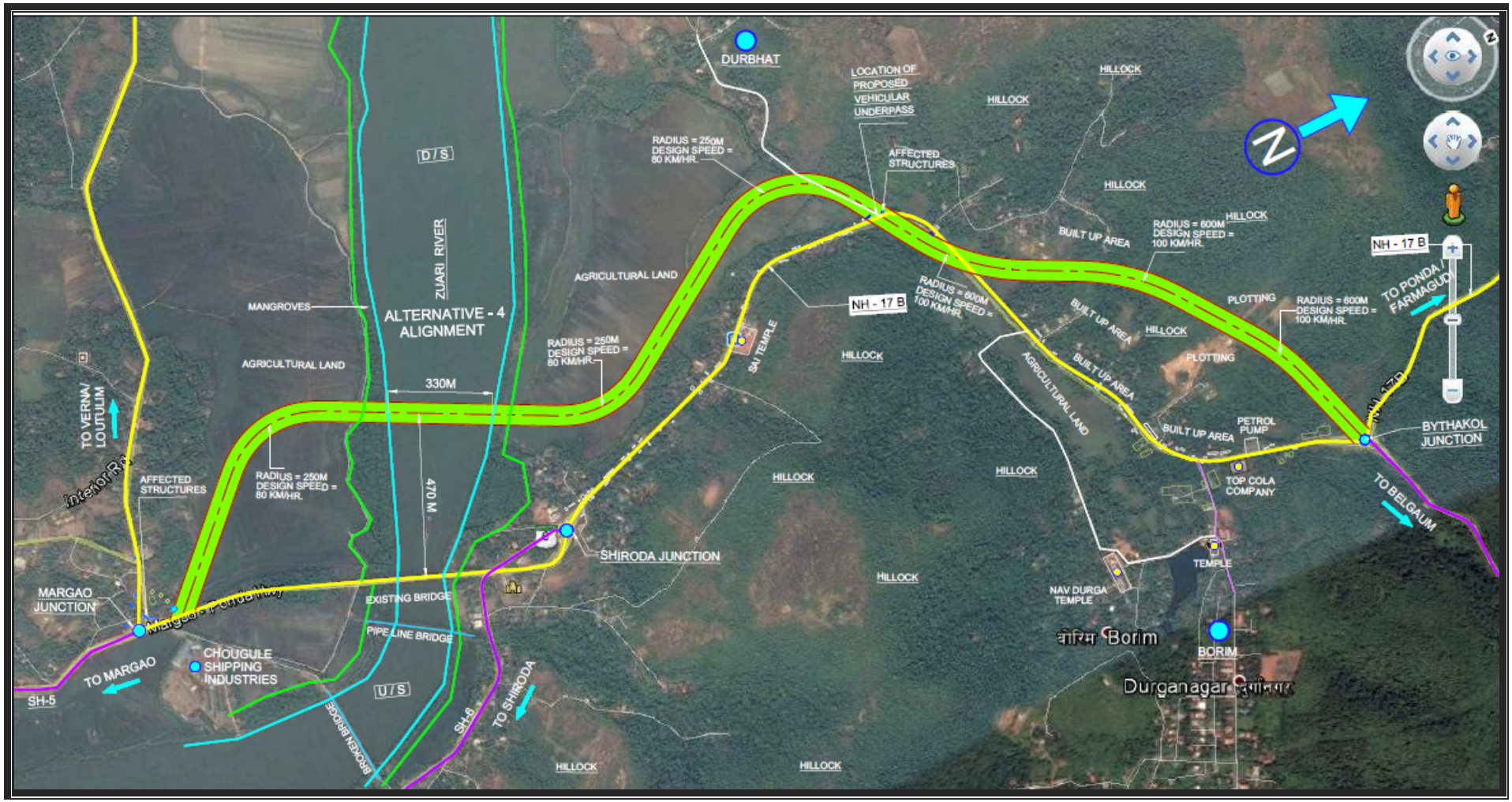
will not be possible due to improvement of Margaon at grade junction. Refer drawing no. 869-ZB-JL-002 of drawing volume.

- After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

➢ **Merits & De-merits:**

Various merits & demerits of the alternative alignment no.4 are given below.

- Increase in length of the NH-17B will be 0.1 Km.
- In the stretch between Bythakol junction & Durbhat junction the proposed alignment will be passing through hillock, tree cutting involved will be more in this stretch.
- Length of the stretch for traffic from Bythakol to Margao and vice versa direction will not be changed.
- Since approaches are proposed along the boundary of agricultural land, there will not be bifurcation of this land in 2 parts.
- For Margao side approach, steeper gradient (more than 1:30) may be required.
- Since, for a length of 1.6 Km the proposed alignment will be passing through hillock portion located at RHS of existing road, tree cutting involved will be more.
- Steeper gradients for vertical geometry for the stretch passing through hillock portion may be involved.
- Deep cutting for a length of 1.6 Km may be required for the stretch passing through hillock portion located at RHS of existing NH-17B road.
- Approximately 13 numbers of existing structures will be affected.
- More area of mangroves will be affected since width of mangroves along the Loutulim side bank of River Zuari is more at this location (150m).
- Margao junction can be improved as at-grade junction only. Provision of grade separator along NH-17B will lead to increase in numbers of affected structures.



ALTERNATIVE ALIGNMENT NO. – 4

3.3.5 Alternative Alignment No. 5:

- **Location:**

  Alternative 5 alignment for the new Zuari Bridge was proposed at a distance of 220m at U/s side of the existing Zuari River Bridge. This realignment was proposed for stretch of NH-17B between Bythakol junction and Margao junction. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 8.1 Km against 8.00 Km.

- **Proposed Bridge Location:-**
  - 220m at U/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 230m,
  - the alignment of the proposed bridge in River portion = straight & at right angle to the flow,
  - Width of mangroves along the banks of River Zuari = 30m to 40m.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & Durbhat junction, through hillock located at RHS of existing NH-17B road (Behind habitation & petrol pump located at RHS),
  - from Durbhat junction to River Zuari, through hillock located at LHS of existing NH-17B road (Behind habitation & Sai temple located at LHS) & crossing Shiroda road i.e. SH-6.
  - at River location, the alignment of the proposed bridge will be in between existing pipe line bridge & old broken bridge,
  - from River Zuari onwards, through agricultural land located between approach of existing bridge & approach of old broken bridge,
  - further, the alignment will join the existing NH-17B road at a chainage Km. 9/450 near Margaon junction (in front of Chougle shipping industry).
  - from Margaon junction to Loutulim end, existing NH-17B route will be followed.

- **Land Use:**

  Land use along the proposed alignment is as follows;
  - between Bythakol junction & Durbhat junction –open land (hillock) with dense trees in majority length and plotting is being done in a length of 200m,
  - from Durbhat junction to Shiroda road (SH-6) – open land (hillock) with dense trees in entire length (habitation for partial length in hillock portion)

- from SH-6 to River Zuari – habitation along the existing SH-6 on both sides
- from River Zuari to existing NH-17B at Margao junction - agricultural land (paddy field)

➢ **Geometry of the alignment:**

For the alternative 5 alignment, following geometry (horizontal & vertical) is possible;

- the alignment of the proposed bridge will be straight in River portion & at right angle to the flow,
- design speed of maximum 80 Km/Hr for bridge & both side approaches,
- design speed of 80 to 100 Km/Hr for realignment stretch between Bythakol junction & River,
- Immediately after the new bridge, the proposed alignment at Borim side approach will in curvature (with max. design speed of 80 Km/Hr).
- Height of the proposed bridge will be more than the minimum requirement due to topography of the Borim side approach portion (hillock), hence for Margao side approach, steeper gradient (more than 1:30) may be required.
- since, the alignment between Bythakol junction and Durbhat junction will be passing through hillock portion, for vertical geometry, steeper longitudinal gradient may be involved in this stretch.

➢ **Affected Structures:**,

In this proposed realignment, approximately 17 numbers of existing structures will be affected. The details are as follows;

- 10 residential structures of semi permanent to permanent nature at Borim side approach portion from SH-6 to hillock portion,
- 3 shops + 4 houses of semi – permanent to permanent nature at Margaon junction (affected due to proposed at grade junction improvement).

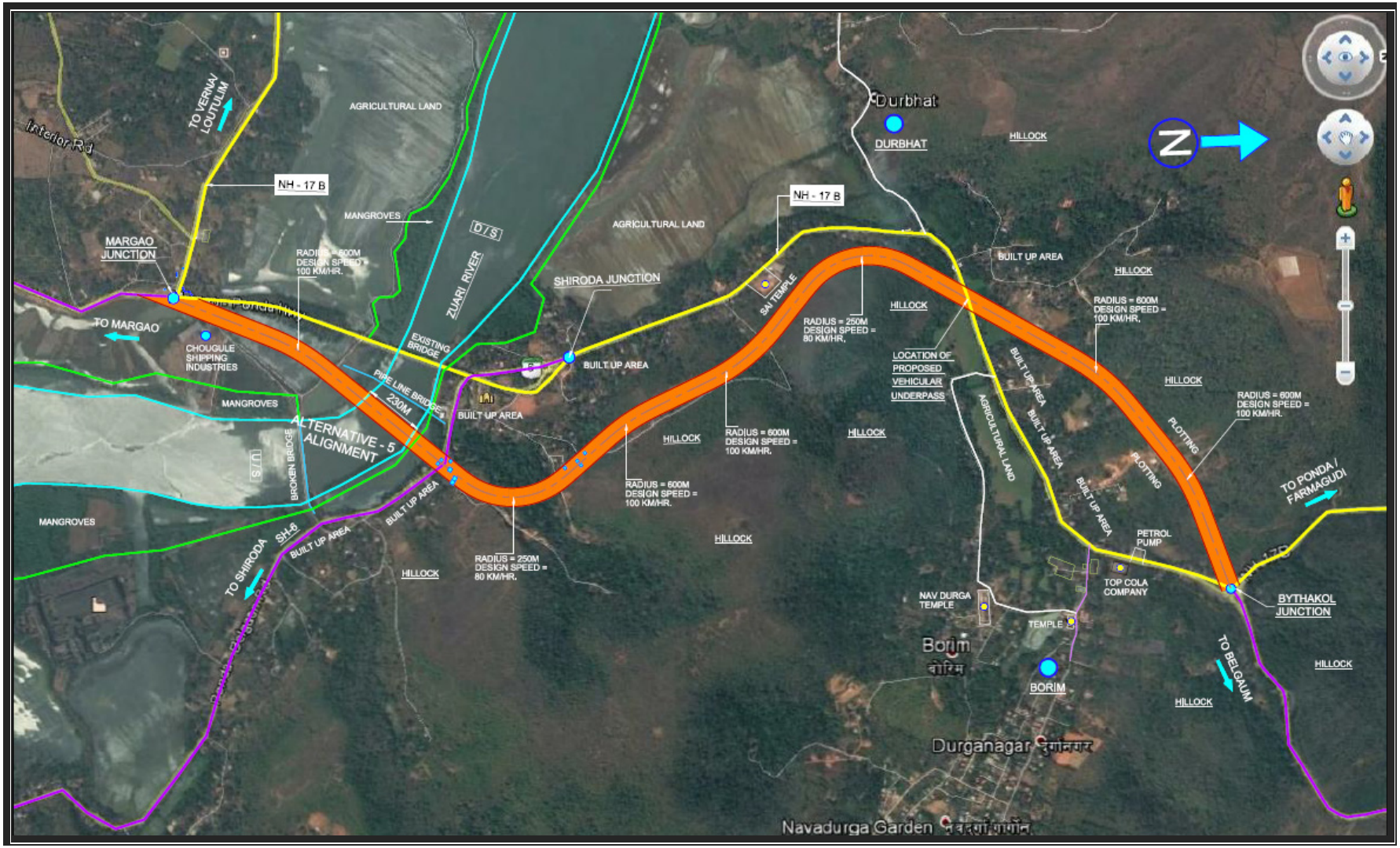
➢ **Grade Separators proposed:**

- One way flyover at Bythakol junction for traffic from new bridge and leading towards Belgaum
- Vehicular underpasses before Durbhat road junction across existing NH-17B
- For SH-6, crossing will be provided below the viaduct of the proposed bridge

- **<u>Accesses to the local traffic on NH-17B</u>:**
  - Up & down ramp from new bridge approach (Borim side) will not be feasible for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
  - Proposed vehicular underpasses before Durbhat junction will be useful for local traffic crossing the new alignment.
  - Local traffic from Shiroda/ Borim will have to take U- turn at Bythakol junction to use new bridge for leading towards Margao/ Verna/ Loutulim etc.
  - Local traffic crossing the Zuari River from Loutulim side to Borim side can use existing bridge till its balance life span for one way traffic only. Both way traffic will not be possible due to improvement of Margaon at grade junction. Refer drawing no. 869-ZB-JL-003 of drawing volume.
  - After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

- **<u>Merits & De-merits</u>:**

  Various merits & demerits of the alternative alignment no.5 are given below.
  - Increase in length of the NH-17B will be 0.1 Km.
  - Length of the stretch for traffic from Bythakol to Margao and vice versa direction will increase by 0.1 Km.
  - For Margao side approach, steeper gradient (more than 1:30) may be required.
  - Since, for a length of 3.3 Km the proposed alignment will be passing through hillock portion, tree cutting involved will be more as compared to all alternatives.
  - Steeper gradients for vertical geometry for the stretch passing through hillock portion may be involved.
  - Deep cutting for a length of 3.3 Km may be required for the stretch passing through hillock portion (Between Bythakol junction and River).
  - Approximately 17 numbers of existing structures will be affected.
  - Height of the proposed bridge will be more due to topography at Borim side approach (hillock between SH-6 & Borim village).
  - Less area of mangroves will be affected since width of mangroves along the both side banks of River is less at this location (30m to 40m).



ALTERNATIVE ALIGNMENT NO. – 5

3.3.6 Alternative Alignment No. 6:

- **Location:**

  Alternative 6 alignment for the new Zuari Bridge was proposed at a distance of 220m at U/s side of the existing Zuari River Bridge. This realignment was proposed for stretch of NH-17B between Bythakol junction and Margao junction. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 7.3 Km against 8.00 Km.

- **Proposed Bridge Location:-**
  - 220m at U/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 230m,
  - the alignment of the proposed bridge in River portion = straight & at right angle to the flow,
  - Width of mangroves along the banks of River Zuari = 30m to 40m.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & road leading to Borim village, through campus of Topcola company (which is not functional now),
  - between borim village road & Navdurg temple, through open land as well as through habitation,
  - from Navdurg temple to River Zuari, through hillock located between Borim village & SH-6 i.e. at LHS of existing NH-17B road (Behind habitation & Sai temple located at LHS) **(a tunnel is proposed for this hillock portion between Borim village & SH-6 road)**.
  - at River location, the alignment of the proposed bridge will be in between existing pipe line bridge & old broken bridge,
  - from River Zuari onwards, through agricultural land located between approach of existing bridge & approach of old broken bridge,
  - further, the alignment will join the existing NH-17B road at a chainage Km. 9/450 near Margaon junction (in front of Chougle shipping industry).
  - from Margaon junction to Loutulim end, existing NH-17B route will be followed.

- **Land Use:**

  Land use along the proposed alignment is as follows;
  - between Bythakol junction & road leading to Borim village, through campus of Topcola company – Open land with trees,

- between Borim village road & Navdurg temple – Open land as well as built-up area,
- between Navdurg temple & SH-6 – open land (hillock) with dense trees and habitation in partial length,
- at Shiroda road (SH-6) – Built-up area along both side of SH-6
- from River Zuari to existing NH-17B at Margao junction - agricultural land (paddy field)

➢ **Geometry of the alignment:**

For the alternative 6 alignment, following geometry (horizontal & vertical) is possible;

- the alignment of the proposed bridge will be straight in River portion & at right angle to the flow,
- design speed of maximum 80 Km/Hr for Margao side approach,
- design speed of 100 Km/Hr for realignment stretch between Bythakol junction & River,
- Height of the proposed bridge will be more than the minimum requirement due to topography of the Borim side approach portion (hillock), hence for Margao side approach, steeper gradient (more than 1:30) may be required.
- Due to proposed tunnel between Borim village & SH-6, for the alignment between Bythakol junction and River flatter longitudinal gradient will be possible.

➢ **Affected Structures:**,

In this proposed realignment, approximately 20 numbers of existing structures will be affected. The details are as follows;

- 7 residential structures of semi permanent to permanent nature between Borim village road & start of hillock near Navdurg temple,
- 6 residential structures of semi permanent to permanent nature between SH-6 to hillock portion,
- 3 shops + 4 houses of semi – permanent to permanent nature at Margaon junction (affected due to proposed at grade junction improvement).

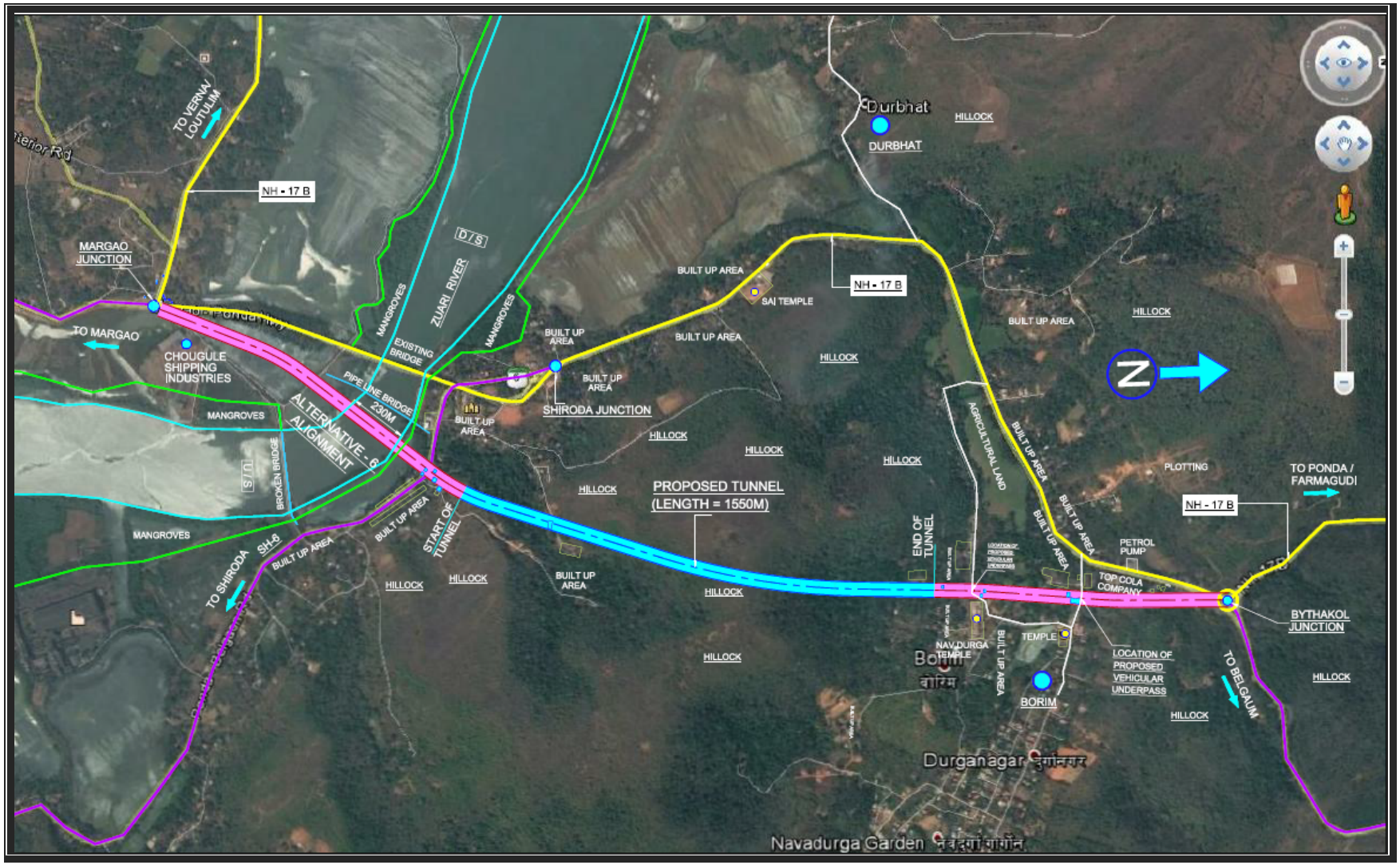
➢ **Grade Separators proposed:**

- Flyover along NH-17B at Bythakol junction
- Vehicular underpasses at Borim village road
- Vehicular underpasses at road crossing near Navdurg temple, Borim
- For SH-6, crossing will be provided below the viaduct of the proposed bridge

- **<u>Accesses to the local traffic on NH-17B</u>:**
  - Up & down ramp from new bridge approach (Borim side) will not be feasible for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
  - Proposed vehicular underpasses at Borim village will be useful for local traffic crossing the new alignment.
  - Local traffic from Shiroda/ Borim will have to take U- turn at Bythakol junction to use new bridge for leading towards Margao/ Verna/ Loutulim etc.
  - Local traffic crossing the Zuari River from Loutulim side to Borim side can use existing bridge till its balance life span for one way traffic only. Both way traffic will not be possible due to improvement of Margaon at grade junction. Refer drawing no. 869-ZB-JL-003 of drawing volume.
  - After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

- **<u>Merits & De-merits</u>:**

  Various merits & demerits of the alternative alignment no.6 are given below;
  - Saving in length of the NH-17B will be 0.7 Km.
  - Length of the stretch for traffic from Bythakol to Margao and vice versa direction will decrease by 0.7 Km.
  - For Margao side approach, steeper gradient (more than 1:30) may be required.
  - Height of the proposed bridge will be more due to topography at Borim side approach (hillock between SH-6 & Borim village)
  - Approximately 20 numbers of existing structures will be affected.
  - Less area of mangroves will be affected since width of mangroves along the both side banks of River is less at this location (30m to 40m).
  - From visual inspection & available information, it is observed that a soil strata at hillock location (location of the proposed tunnel) is having soft strata beneath the top soil. Hence, concrete lining may be required for majority length of the tunnel.
  - The project cost of this alternative will be more as compared to all other alternatives.
  - Access to the local traffic cannot be provided between Bythakol junction & Margao junction.



ALTERNATIVE ALIGNMENT NO. – 6

3.3.7 Alternative Alignment No. 7:

- **Location:**

  Alternative 7 alignment for the new Zuari Bridge was proposed at a distance of 1780m at D/s side of the existing Zuari River Bridge. With this alternative, total length of the NH-17B between Dhavli junction and Loutulim end from existing Km. 3/860 to Km. 11/860 will be 5.6 Km against 8.00 Km.

- **Proposed Bridge Location:-**
  - 1780m at U/s side of the existing Zuari River Bridge,
  - Width of Zuari River at this location = 380m,
  - the proposed bridge will be in skew with respect to the flow of the River,
  - Width of mangroves along the banks of River Zuari = 30m to 40m.

- **Path:**

  From Bythakol junction to Loutulim end the alignment will be passing as follows;
  - between Bythakol junction & Durbhat junction, through hillock located at RHS of existing NH-17B road,
  - at Durbhat junction, for a smaller length of 275m, through open land (having dense trees) located at LHS of existing NH-17B road,
  - from Durbhat junction to River Zuari, through agricultural land located at Borim side bank of the River & at LHS of road leading to Durbhat,
  - from River Zuari to existing NH-17B at Loutulim end, through agricultural land located at Loutulim side bank of the River & will join the existing NH-17B road at a chainage Km. 12/000 i.e. at start point of missing link project work near Loutulim village.

- **Land Use:**

  Land use along the proposed alignment is as follows;
  - between Bythakol junction & Durbhat junction – Open land (hillock) with dense trees in majority length and plotting is being done in a length of 200m,
  - at Durbhat junction (LHS of existing road) – Open land with dense trees & habitation in smaller length,
  - from Durbhat junction to River Zuari - agricultural land (paddy field) except for a length of 500m where the alignment will be passing through open land near Durbhat village.

- from River Zuari to existing NH-17B at Loutulim end - agricultural land (paddy field)

➢ **Geometry of the alignment:**

For the alternative 7 alignment, following geometry (horizontal & vertical) is possible;

- the proposed bridge will be in skew with respect to the flow of river,
- design speed of 100 Km/Hr for bridge & both side approaches,
- design speed of 100 Km/Hr for realignment stretch between Durbhat junction & Bythakol junction,
- approach on Borim side will be in curve (with design speed of 100 Km/Hr) to avoid the habitation located in open land near Durbhat village,
- since, the alignment between Bythakol junction and Durbhat junction will be passing through hillock portion, for vertical geometry, steeper longitudinal gradient may be involved in this stretch.

➢ **Affected Structures:**,

In this proposed realignment, approximately 06 numbers of existing structures will be affected at bank of river as well as at Durbhat road junction. The details are as follows;

- 4 shops of semi permanent nature,
- 2 residential structure of semi permanent type,

➢ **Grade Separators proposed:**

- Flyover at Bythakol junction for traffic from new bridge and leading towards Belgaum & vice versa.
- Vehicular underpasses 2 nos. near Durbhat junction at the crossing of existing NH-17B.
- Trumpet at Loutulim end for traffic coming from Margao on NH-17B & Down ramp for traffic from Borim end and leading to Margaon.

➢ **Accesses to the local traffic on NH-17B:**

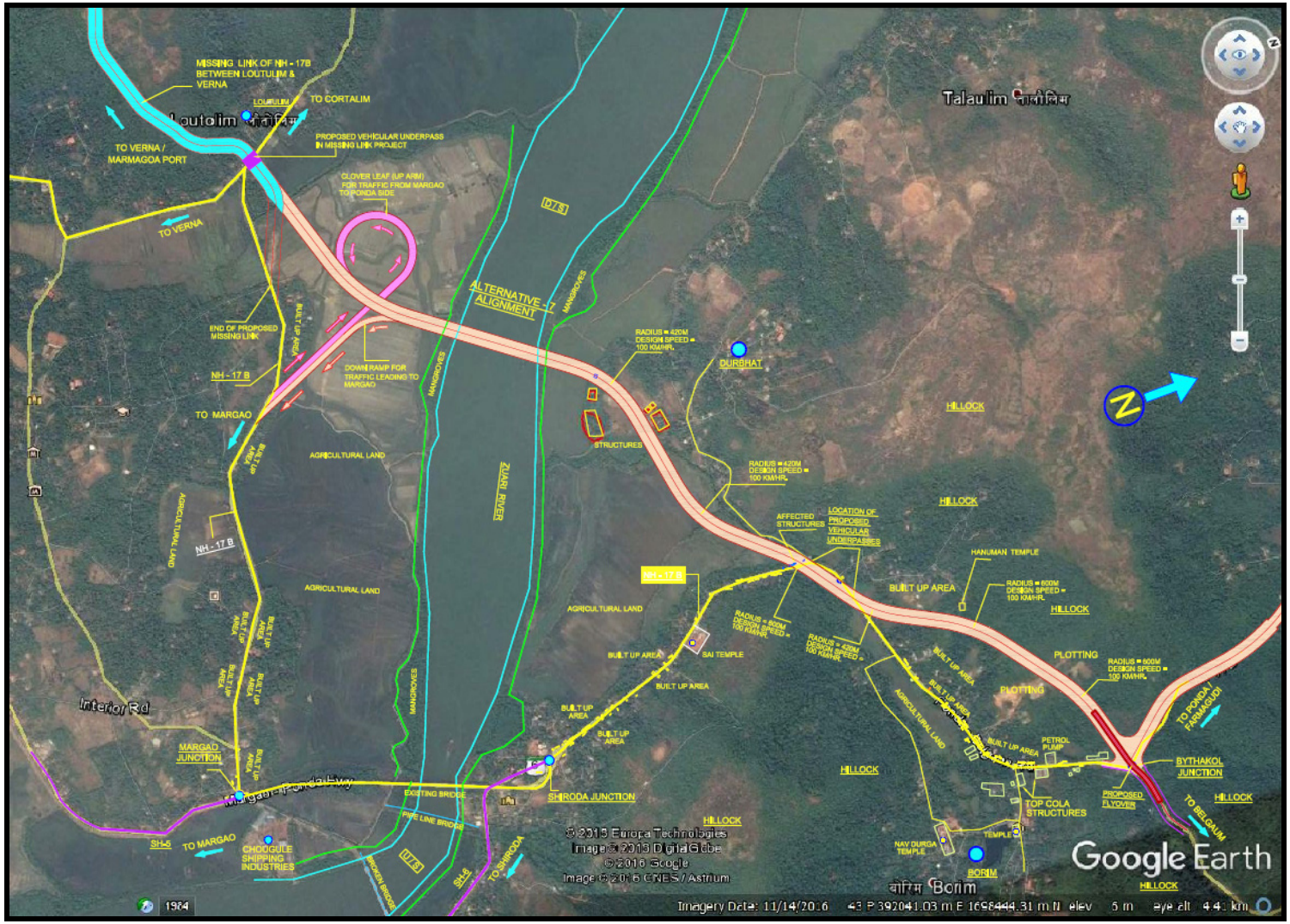
- Up & down ramp from new bridge approach (Borim side) will be provided for local traffic from Shiroda/ Borim & leading to Margao/ Verna & vice versa.
- This local traffic will use proposed vehicular underpasses at Durbhat junction for right turn to avoid conflict with the traffic of NH-17B.

- Local traffic crossing the Zuari River can use existing bridge till its balance life span.
- After opening of new alignment NH-17B for traffic, existing road can be utilized for local traffic.

➢ **Merits & De-merits:**,

Various merits & demerits of the alternative alignment no.7 are given below.

- Saving in length of the NH-17B will be 2.4 Km.
- Since, for a length of 1.6 Km the proposed alignment will be passing through hillock portion located at RHS of existing road, tree cutting involved will be more in this stretch.
- Increase in length for traffic from Bythakol to Margao and vice versa direction will be 2.3 Km.
- Steeper gradients for vertical geometry for the stretch passing through hillock portion between Bythakol junction & Durbhat junction may be involved.
- Deep cutting for a length of 1.6 Km may be required for the stretch passing through hillock portion located at RHS of existing NH-17B road.
- Less area of mangroves will be affected since width of mangroves along the banks of River Zuari is less at this location (between 20m to 60m).
- Grade separated junctions can be provided at major junctions located in realignment stretch.
- **For proper merging of proposed alignment of Zuari Bridge with the missing link modification in the alignment of missing link will be required as shown in the drawing enclosed herewith. Also, there is proposed vehicular subway and its approach in REW at Loutulim end which shall be joined to the proposed alignment of Zuari Bridge. Thus, after completion of missing link work, the approaches of subways needs to modified during construction of approaches of proposed Zuari Bridge.**



ALTERNATIVE ALIGNMENT NO. – 7

COMPARISION TABLE FOR MERRTIS & DE-MERRITS OF THE ALTERNATIVE ALIGNMENTS

DESCRIPTION	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7
+ Increase/ - decrease in length of NH-17B	- 1.75 Km	+ 0.22 Km	- 1.90 Km	+ 0.10 Km	+ 0.10 Km	- 0.7 Km	- 2.4 Km
Increase/ decrease in length for the path of traffic leading to Margao	+ 0.68 Km	0.00 Km	+ 0.55 Km	0.00 km	+ 0.10 Km	- 0.7 Km	+ 2.3 Km
Access to the local traffic within short distance	Possible	Possible	Possible	Possible	Not Possible	Not Possible	Possible
Design speed for the proposed alignment	80 to 100 Km/hr.	80 Km/Hr.	100 Km/Hr.	80 to 100 Km/hr.	80 to 100 Km/hr.	80 to 100 Km/hr.	100 Km/Hr.
Approximate nos. of structures affected in proposed realignment portion	09	16	06	13	17	20	06
provision of grade separator at major junctions	Possible	Not at Margao end	Possible	Not at Margao end	Not at Margao end	Not at Margao end	Possible
Extent of Tree cutting Involved (Lower to higher)	1	1	2	2	3	2	2
vertical gradient involved in approaches	Flatter	Flatter	Flatter	Flatter	Steeper at Margao end	Steeper at Margao end	Flatter
vertical gradient involved in rest realignment	Flatter	Flatter	Steeper at hillock	Steeper at hillock	Steeper at hillock	Flatter	Steeper at hillock
Deep cutting involved	No	No	Yes at hillock	Yes at hillock	Yes at hillock	Yes for smaller length	Yes at hillock
Extent of area of mangroves likely to be affected (Lower to higher)	1	4	1	4	2	2	3
Approximate area of additional land required	38.5 Hect.	45 Hect.	38 Hect.	44.5 Hect.	45 Hect.	40 Hect.	44.8 Hect.

Note:- 1) For alternative No. 5 & 6 - Height of proposed bridge will be more than the minimum required for the reasons explained at respective sr. no.

2) For provision of grade separator at Loutulim end, proposal of ongoing project of missing link needs to be modified for the reasons explained at respective sr. no.

3.4 Consultants Recommendation:

Considering various issues mentioned at sr. no. 6.1. , merits & de-merits of each alternative, consultants had recommend the following sequence;

1st – Alternative No. 1.

2nd – Alternative No. 3

3rd - Alternative No. 7

Alternative Alignment No. 1 was recommended for the proposed new bridge across River Zuari i.e. alignment proposed at 950m at D/s side of the existing Zuari River Bridge & involving realignment from Bythakol junction to River via. agricultural land located at LHS of the existing NH-17B road. Following points had been considered behind recommendation of this alternative;

- the alignment of the proposed bridge in River portion will be straight & at right angle to the flow,
- Width of mangroves along the banks of River Zuari at this location is less i.e. 20m to 40m,
- Design speed of 100 Km/Hr. is possible for entire length except for a smaller length near Topcola campus where design speed is restricted to 80 Km/Hr.
- Entire length of the realignment is passing through plain land only.
- No steeper gradients will be involved in entire realignment.
- Saving in length of the NH-17B will be 1.75 Km.
- No deep cutting will be involved in this alignment.
- Provision of grade separators at all major junctions can be made in this alternative.
- Access to the local traffic from Shiroda, Borim etc. can be given in short distance by providing up & down ramps from the proposed bridge.
- Tree cutting involved in this alternative will be very less as compared to all other alternative
- Traffic from Borim / Bythakol end and leading to Margao is substantial; hence facility for this traffic shall also be given. With this alternative, distance of the path for Margao junction to Bythakol junction will increase by only 0.68 Km.

- Only 9 no's structures will be affected. Out of these 9 structures, 3 structures are belongs to Topcola company which is not functional now and these are abandoned structures.
- There will not be any effect on ongoing project of missing link. Refer details of alternative 7 in this regard.
- Total area of additional land required is less than 4 alternatives out of 7 alternatives.

3.5 Stretch from Dhavli Bypass Junction to Bythakol junction:-

As explained earlier, for the stretch from Dhavli bypass junction to Bythakol junction, widening of existing road to the 4/6 lane divided carriageway road is proposed with curve improvement wherever necessary. A drawing showing proposed alignment with required curve improvements (to design speed minimum 80 Km/Hr.) is enclosed in the drawing volume. As instructed by the client i.e. (NH) PWD Goa, a flyover is proposed at Dhavli bypass junction for two way traffic coming from Bythakol junction and leading to Ponda city.

Chapter – 4

ENGINEERING SURVEYS, INVESTIGATIONS & ANALYSIS

4.0 ENGINEERING SURVEYS, INVESTIGATIONS AND ANALYSIS

4.1 GENERAL

In this chapter, methodology adopted for surveys and investigations, data collection and its analysis is mainly covered. As per TOR, different types of field studies, engineering surveys and investigations have been carried out to gather data and information necessary for Feasibility Study. The aim of the investigations is to develop an adequate supportive database for selecting and preparing the most appropriate proposal to meet the functional and structural efficiency and safety requirements of the project. The engineering surveys and investigations have been carried out in line with the specifications laid down in the Quality Assurance Plan submitted earlier along with Inception Report.

The major aspects of surveys and investigations relevant to the present study cover the following:

- Collection of Available Data
- Reconnaissance and Investigations

a) Road Inventory and Geometrics:

- Carriageway Type/width (m)
- Land use and road side environment
- Right of Way Details
- Intersections and Junctions
- Carriageway shoulder details
- Road side drainage

b) Topographic Survey:

- Fixing of GPS pillars and Benchmark pillars
- Carrying out GPS survey
- Carrying over the Benchmark levels from GTS benchmarks to Benchmark pillars
- Collecting the physical details of the Project Highways
- Data processing and preparation of drawing for further design work

c) Traffic

- Classified Traffic Volume Count Survey
- Turning Movement Survey
- O - D Survey

- Axle Load Survey

d) Inventory & Condition of structures

- Inventory of Cross Drainage Works and Bridges
- Condition and Structural Adequacy of Culverts and Bridges
- Hydraulic Adequacy of Structures

e) Geotechnical Investigation and Sub-Soil Exploration

- Geotechnical Investigations for bridges

4.2 Inventory Survey of Existing Road:

4.2.1 Road Inventory

The detailed inventory survey was carried out through dimensional measurements and visual inspections to note all the features of the existing road which are to be used for identification of improvements. The data collected from inventory survey is enclosed as **Annexure – I.** The general description of items and terminology used in inventory survey is given below.

• Terrain:	P- Plain (0-10%), R- Rolling (10-25%), M- Mountainous (25-60%), S – Steep (>60%) (Percentage Slope of Terrain)
• Land use:	R- Rural, A- Agricultural, SU- Semi Urban, U- Urban, UC- Urban Commercial, I- Industrial
• Earthwork in fill:	I (0-0.5 m high), II (0.5-1.0 m), III (>1.0m)
• Surface Type:	B – Bitumen, C – Concrete, GR – Gravel
• Shoulder Type:	S – Sealed, G – Gravel, E – Earthen
• Trees with girth: more than 0.30 m	N – Nil, F – Few (0-10 Nos), M – Medium- (10- 50 Nos), L – Large (>50 Nos) in every 200m length.
• Road Side Drain:	CD- Covered Drain, LD- Lined Drain, UD- Unlined Drain, NO- No Drain
• Condition of Drain:	FC – Fully Choked, FD – Damaged, G – Good condition
• Soil Type:	BC –Black Cotton, M –Murum, SN – Sandy,
• Condition of Carriageway:	G –Good, F –Fair, P –Poor, VP –Very Poor
• Utility Crossing:	Location and Type of Utility

• Other features: Villages name
• Submergence of road
• Road / Rail junction details: T- T-intersection, Y- Y- intersection, + Four arm junction, L.C - Manned/ Unmanned Level Crossing

The detailed data collected from inventory survey is tabulated and given in Annexure.

4.3 Topographic Survey:

The basic objective of the topographic survey is to capture the essential ground features along the alignment in order to consider improvements and for working out improvements, rehabilitation and upgrading costs. The detailed topographic surveys should normally be taken up after the completion of reconnaissance surveys. The detailed topographical survey was carried out by using GPS, total station and Auto Level.

The topographic survey was carried out in 2 stages;

i) Establishment of control points

ii) Ground surface survey

4.3.1 Establishment of G.P.S. points:

The reference pillars of prescribed size (150 x 150 x 450 mm) are fixed at important junctions to establish GPS points.

List of G.P.S. pillars with co ordinates is given in Table 5.4.

The GPS data was collected with following control parameters:

PDOP cutof	-	5
Logging Interval	-	1 sec
Elevation mask	-	15 deg.
Min. No. of satellites	-	7
Min observation time	-	1 hour 30 minutes
Linear Measurement unit	-	Metre
Angular Measurement unit	-	Degree Minutes Second (D M S)
Datum	-	WGS – 84
Projection	-	UTM-WGS 1984 datum, Zone 43 North, Meter; Cent. Meridian 75d E
Geoid	-	EGM-96

Base station for the Project road was established at regular intervals. GPS base station observations were made using 3 numbers of surve grade DGPS receivers.

The list of Reference/ Control pillars established along Project Highway is given below;

List of station points with Co-ordinates
Table:- 4.1

Existing Ch.	Side	Identification Mark	Easting	Northing	Elevation
GPS POINTS					
3+860	CENTER	GPS 2	393214.321	1700970.292	32.233
8+135	CENTER	GPS 3	393003.727	1697734.665	6.308
8+220	CENTER	GPS 4	393031.113	1697649.391	8.795
11+940	RHS	GPS 5A	390603.787	1697296.048	3.523
STATION POINTS					
3+920	LHS	G 75	393257.652	1700924.855	33.328
4+040	RHS	G 74	393310.501	1700820.792	35.463
4+680	RHS	G 68	393585.821	1700264.841	52.358
4+740	RHS	G 67	393585.535	1700208.458	49.813
5+160	RHS	G 63	393806.613	1699863.335	23.598
5+240	RHS	G 62	393806.053	1699806.444	21.408
6+720	RHS	G 49	392733.296	1699010.536	5.698
6+840	RHS	G 48	392645.876	1698929.197	5.618
11+680	RHS	G 32	390865.74	1697291.851	4.428
11+840	LHS	G 33	390706.426	1697283.438	4.298

TOPOGRAPHICAL SURVEY

4.3.2 Ground surface survey:

After establishment of control points detailed Topographic Survey was undertaken. All the physical features along the project corridor (along existing road as well as proposed alignment) for facilitating proposals for the final centre line of the proposed road were taken. The corridor for survey was at least 30 m on the either side of the proposed centre

line of the proposed carriageway or land boundary and additional width for interchanges and intersections, and at high embankment location such as approaches to bridges / ROB's and also at the locations where the improvement of curves were required as per reconnaissance survey.

Levels along centre line of the existing/ proposed alignment were taken at every 25 m interval and at all intermediate breaks in ground. The said spacing was suitably reduced at horizontal curves and at structure locations.

Cross sections were taken at every 50 m interval, and at each cross-section the survey was extended up to 30 m on each side of the existing road centre line with survey points at 3-5 m apart and at all variations in the natural ground or breaks in level.

The topographic survey contained the details of all physical and topographical features within the survey corridor such as Junctions, Utilities, rail crossing, and structures. The details of trees, adjoining buildings, compound wall etc. were also noted.

At the location of proposed major Bridge across River, the details such as ground level, banks lines, mangroves along the bank, nalla's joining the river etc. were collected. Cross sectional details of the river were taken along proposed centreline, at U/s side and at D/s side. The details such as bed levels, water levels etc. were recorded. For collection of under ground details of bed levels, a boat along with GPS, rope with counter weight etc. were used. At every location, co-ordinates at water level were recorded and the depth of such points was recorded using rope and counter weight.

The survey data thus collected is processed & converted to graphic tiles by using software MX ROAD / AutoCAD Civil 3D.

4.4 Traffic Survey:

4.4.1 Objectives of Traffic study:

The objective of the study was to appreciate the existing traffic demand and the estimate of the present travel characteristics. Based on the present demand figures and the catchment areas, the traffic projection scenario can be build up which will ultimately help in getting desired inputs for various designs. It was proposed to use the outputs from the traffic study for following design parameters;

i) to finalise demand for the number of lanes based on the section wise forecasted traffic figures

ii) to finalise improvement proposal for major junctions based on the turning movement traffic survey

iii) to design the crust of pavement of proposed road/ approaches

The details of existing traffic pattern observed during reconnaissance survey had been explained Inception report. In order to fulfill above objectives, we had proposed to undertake various traffic surveys. Methodology of each type of proposed traffic surveys, data collection as well as the data analyses were given in the Inception Report. **The locations of each type of traffic survey had been decided based on the present traffic pattern & the same was discussed with the Employer during meeting cum presentation held on 24th Nov. 2016 in the office of the Superintending Engineer, (NH), PWD, at Panjim Goa**. The details of traffic surveys such as type of various traffic surveys, data and analysis is explained in separate chapter. However, the type & locations of various traffic surveys carried out are given below.

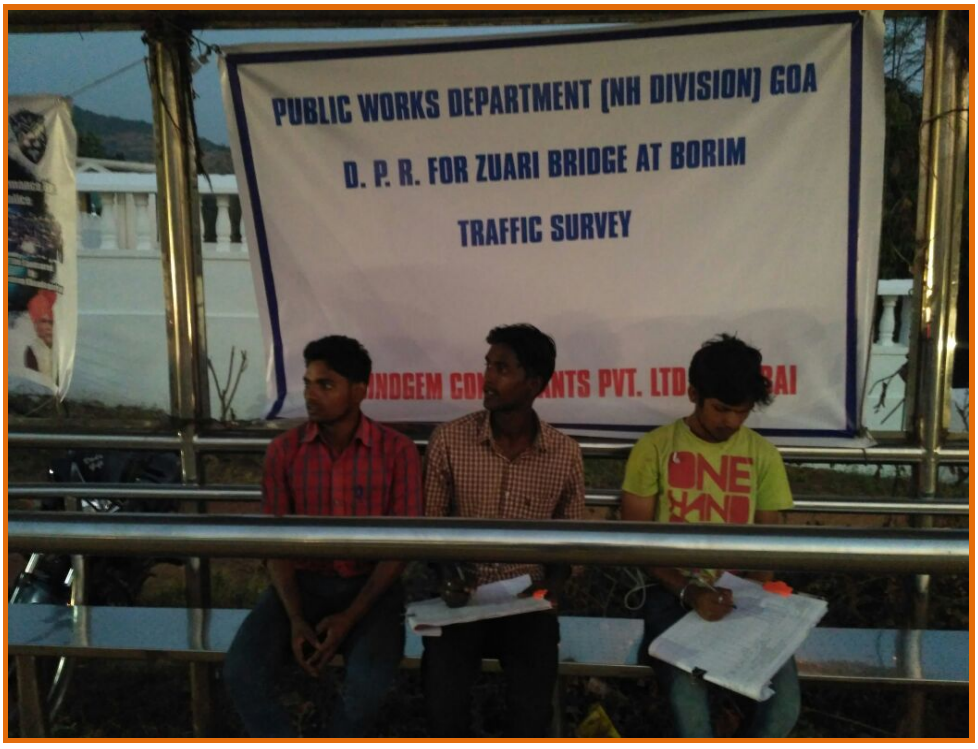
4.4.2 Types of Traffic Surveys:

4.4.2.1 Classified Traffic Volume surveys:

The classified traffic volume count survey has been carried out for 7 days.

Traffic Survey Locations - Table: - 4.2

Station No.	Name of Location for Traffic Volume Count and O-D Survey
Traffic Volume Count Survey	
1	At Ch. 8/500 Km between Shiroda Junction and Existing bridge



TRAFFIC SURVEY – VOLUME COUNT

4.4.2.2 Origin-Destination Surveys:

The Origin and Destination survey along with Commodity Movement Survey has been carried out for 1-day (24 hours, both directions) at the locations mentioned in this report. These are essentially required to estimate the traffic which will get diverted on another route in future and traffic which will retain in this corridor. The roadside interviews have been conducted on random sample basis.

Traffic Survey Locations - Table :- 4.3

Name of Location for Traffic Volume Count and O-D Survey
Origin – Destination Survey
At Ch. 6/900Km near Sakvar Bus stop

4.4.2.3 Turning movement counts:

The turning movement surveys for estimation of peak hour traffic have been carried out at each major junction in the project corridor. The methodology adopted for the surveys is as per IRC: SP:41-1994. The locations of turning movement surveys have been given in this report.

The data derived from the survey has been analysed to identify requirements of suitable remedial measures, such as construction of underpasses, flyovers, interchanges, grade-separated intersections along the project road alignment.

The turning movement surveys have been carried out at all major junctions (intersection with SH/NH). In this project corridor there are three major junction & other junctions are minor junctions i.e. intersection with village/ town road etc. The locations of turning movement survey are as below;

Turning Movement Survey Locations - Table: - 4.4

Sr. No.	Name of Junction on Project road	Type of Junction	Remark
1.	At Km. 5/200 at Bythakol Junction	Y	Rotary junction SH - bypass to Ponda city
2.	At Km. 8/200 at Shiroda Junction	Y	Rotary junction SH-6 – road leading to Shiroda
3.	At Km. 9/520 at Loutulim Junction	T	SH-5 road leading to Margao

4.4.2.4 Axle Load Survey:

Axle Load survey has been carried out by using Axle Load Pads for 1 day (24 hours) in both the directions at location mentioned below on the project road on a random sample basis as specified in IRC: 37- 2012.

The Axle load data has been collected axle configuration-wise. The vehicles plying on the road were selectively stopped and weighed by using Axle Pad. Assistance of local Police was taken to stop and weigh the vehicles. The number of standard axles per each type of truck will be calculated on the basis of results obtained. The data collected has been analysed and VDF worked out for design of pavement.

The Axle Load survey has been conducted at following location on the Project Highway.

Location of Axle Load Survey - Table :- 4.5

Sr. No.	Location of Axle Load Survey
1	At Ch. 6/900 Km near Sankvar Bus Stop

4.5 Inventory and Condition Survey of Bridges and Culverts:

Bridges and Cross Drainage (CD) structures are the common features in any road network and they play an important role in keeping the road network free from flooding, over topping and breaching during floods and providing connectivity over the water bodies. Any wrong placing, sizing and design of these structures may disrupt the transportation and drainage system of the area concerned. The purpose of major and minor bridges and other cross drainage (CD) structures in road are mainly

- To divert and allow free passage for the surface flow interrupted by the road embankment from one side to other.
- To allow cross drainage of the waste water of village / town areas through which the road passes.
- To allow water passage for Irrigation channels, watercourses etc.
- To cross over the rivers, tributaries, stream / nallahs, rivulets, canals, drains etc.

Studying the condition of existing bridges and CD structures and proposing the remedial measures for distresses is an integral part of any feasibility report. The details of the survey and related data analysis are discussed in the subsequent section.

The new major Bridge across River Zuari at Borim is proposed at about 1700m D/s side and almost new alignment in approach portion between Bythakol junction to end of the corridor. Hence, the details of existing structures have been recorded to form a base / guideline for the new / proposed structures along the new alignment.

4.5.1 Inventory and condition survey of bridges and culverts:

An experienced team of engineers was deployed to carry out the survey of structures on the Project Highways. The structures comprise of bridges (major and minors) and culverts.

For bridges survey was carried out in accordance with the guidelines as stipulated in IRC-SP:35. The data collected has been compiled in tabular form and presented in Annexure. The following information has been collected during the survey work.

- Chainage / structure No., type of structure, span / length, carriageway width, no of vents, diameter / size of vent and height of road above bed level.

- Type of foundation, substructure, superstructure, railing, bearing, expansion joints, wearing coat and material used in construction.
- Visual structural condition of superstructure, substructure, foundation, railing, wearing coat, bearing, drainage spout and expansion joint.
- Condition of protection works, information regarding scour and erosion, condition of vents at inlet and outlet.
- Submergence characteristic and duration of traffic disruption.
- Type and condition of headwalls, wing walls and return walls.
- Information about HFL (from flood marks), recorded markings and local inquiry, lowest bed level, scour etc.
- Channel characteristic and land use characteristics on upstream and downstream sides of the structure.

4.5.2 Review of Data and Findings:

i) Inventory survey:

The details of structures are as given below;

Details of Structures - Table: - 4.6

No. of Structures						
Pipe Culvert	**Slab Culvert**	**Canal Crossing**	**Minor Bridge**	**Major Bridge**	**ROB**	**Vehicular Underpass**
09	20	00	01	01	00	01

ii) Condition Survey of Existing Structures:

The condition of existing structures along the Project Highways has been compiled structure wise in tabular form and presented in Annexure to Main Report. Major defects observed for both Bridges and Culverts during condition survey are discussed below. The culverts and bridges are dealt separately.

4.6 Hydrological and Hydraulic Investigations:

4.6.1 A separate report on Hydrological study is prepared and submitted with this report.

4.7 Geo-technical investigations of bridges and structures:

4.7.1 Purpose of Investigation:

The purpose of investigation is to explore subsurface conditions at specified locations by drilling boreholes to different depths in order to identify the thickness and sequences of various strata and to ascertain the sub surface profile of soils in road alignment and bed rock to determine the most suitable foundation levels of structures.

The disturbed and undisturbed samples of soil, rock and ground water obtained from the boreholes shall be tested in the laboratory to assess engineering properties of the soil and rock and to generate necessary data required for deciding the suitability and type of foundations to be adopted as well as for road embankment & pavement.

Aggressive conditions due to the presence of sulphates, chlorides and alkalinity in soil and water and its effect on RCC, steel and other construction materials has been studied.

4.7.2 Proposal of Geotechnical Investigation:

Proposal of geotechnical Investigation was prepared and submitted to the client vide consultants letter no. TCPL/364/Y2K-17/08 dated 14th September, 2017. The location of proposed bore holes with purpose which was submitted to the client is given below;

Bore Hole No.	Description
BH-01	At Dhavli bypass junction – for the proposed grade separator
BH-02 & BH-03	At hill portion at RHS of existing alignment – at Cutting locations
BH-04 & BH-05	At Bythakol junction – for the proposed grade separator
BH-06 & BH-07	At Durbhat – for the proposed grade separators
BH-08 & BH-09	At Borim side bank of River – for the viaduct & approaches of the River Bridge on Borim side bank
BH-10 & BH-11	For proposed River Bridge – in River portion
BH-12 , BH-13 & BH-14	At Loutolim side bank of River – for the viaduct & approaches of the River Bridge on Loutolim side bank

Taking trial bores in the River portion was the challing work among all other bore holes due to continusous movements of Barges transporting iron ore through the Zuari River Channel. The locations of trial bores in the river channel were decided in accordance with the proposed pier/ pylon locations and considering the movement of barges. A floting platform was prepared and anchors were fixed in the river bed for stability of platform.

A separate report on geotechnical investigation covering, the detailed bore logs, test results of sample collected and recommandations of the Geotechnical expert is submitted with this report.

The subsoil investigation for structures in general covers the following:

- SPT test as per IS Standards and collection of disturbed / undisturbed soil samples from boreholes at specified interval or as directed by the Engineer.
- Collection of rock core samples from the boreholes and determination of RQD and Crushing strength where rock is encountered during boring.
- Laboratory tests on disturbed / undisturbed soil samples and rock core samples and on ground water samples as directed.
- Accurate measurement of the ground water table.
- Assess the safe bearing capacity and depth of foundation.

TRIAL BORE IN RIVER PORTION

TRIAL BORE IN APPROACH PORTION

SOIL/ ROCK SAMPLES COLLECTED FROM TRIAL BORE

4.8 Pavement Investigations:

4.8.1 Subgrade Investigation:

4.8.1.1 Test Pit:

Out of total project corridor, only initial length of 500m of existing road will be utilised in the proposed alignment. In remaining length, there is re alignment/ new alignment. Hence, trial pits 2 nos. are taken in this 500m stretch only.

Test pits (60cm x 60cm x 100cm) in sub grade soil were taken and following tests were carried out;

1) Field Density Test for existing embankment soil and sub grade.
2) Atterberg's Limit (a) Liquid Limit (b) Plastic Limit (c) Plasticity Index.
3) Grain Size Distribution of soil.
4) Soil Classification
5) Moisture Density relationship (Heavy Compaction) for each soil sample.
6) California Bearing Ratio (C.B.R) Test (Soaked and Un-soaked conditions).

4.8.1.2 Existing pavement composition:

The existing pavement composition generally found is as given below.

i) Bituminous Layer - 75 to 100 mm

ii) WBM - 120 to 200 mm

iii) Soling - avg. 150 mm

4.8.1.3 Laboratory test on test sample:

Various samples and materials obtained from fields were tested in field laboratory. For this purpose, a field testing laboratory was established at Bidkin and following tests were conducted as per I.S. standard as below.

Testing of Soil from embankment, Sub grade & borrow area

Sr. No.	Test	Method as per IS Code	Remarks
1	Field Dry Density test using Sand Replacement Method	IS:2720 (Part - 28)	Field moisture using Rapid Moisture Meter. As per IS: 2720 (Part – 2)
2	Atterberg's limit (L.L, PL, PI) using Cassagrande Testing equipment	IS:2720 (Part - 05)	
3	Modified Maximum Dry Density test and determination of O.M.C (Heavy compaction)	IS:2720 (Part- 08)	
4	Laboratory CBR value (a) Soaked CBR (b) Un-soaked CBR At three energy levels	IS:2720 (Part - 16)	
5	Free Swelling Index of soil	IS:2720 (Part - 40)	
6	Soil Classification and Sieve Analysis (Grain size analysis of soil.) According to Indian Soil Classification system (ISC) as per IS: 1498	IS:2720 (Part - 04)	

4.9. Material Investigation

4.9.1 Type of Material:

Following Materials are required for road improvement & construction.

1. Soil for Sub Grade with CBR > 8%
2. G.S.B Material with CBR >25%
3. Graded Material (Stone Metal) for Base course.
4. Bitumen Grade 60/70, 30/40, 10/20.
5. Cement for construction of structure and concrete road pavement.
6. Reinforcement Steel (TMT) and Mild Steel for structure.
7. Aggregate, Sand / Crushed Stone Sand for concrete work.

4.9.2 Sources of Materials:

The main material for construction of road will be Granular soil and stone metal. The materials are available at various quarries as given in the Quarry Chart. The materials like cement, and steel will have to be procured from available suppliers at nearby towns like Margao, Ponda, etc. The bitumen is available from Manglore refinery. Sand of Madai River is available at Amona near Navelim. Metal is available in quarry located at Genjem.

4.9.2.1 Samples of various types of material:

The samples were collected from the sources i.e. existing quarries shown in Quarry Chart and tested. Following samples were collected from quarries.

1) Granular Soil for embankment & sub grade construction.
2) Metal for sub base and base.
3) Metal for Concrete Work & Bituminous Work.
4) Sand for concrete work.

4.9.2.2 Testing of Material:

Soil for embankment and sub grade was tested as described in 5.5.3 above except field density test. It is found that materials required for construction and improvements of road as per MoRT&H Specifications are available within reasonable distance in the corridor area. The stone metal is tested for following tests.

Tests on Aggregate

Sr. No	Aggregate	Method as per IS Code	Remarks
1	Flakiness and Elongation Index test and combined Index	IS:2386 (Part-1)	
2	Water absorption and Specific Gravity test for a) Coarse Aggregate (Metal) b) Fine Aggregate (Sand)	IS:2386 (Part – 3)	
3	Impact value of stone metal	IS:2386 (Part – 4)	
4	Soundness test of aggregate	IS:2386 (Part – 5)	

4.9.3 Finding of Results:

It is found that materials required for construction and improvements of road as per MoRT&H Specifications are available within reasonable distance in the corridor area. The test results of various materials are as follows;

Table No. 4.7
Field & Laboratory Test Results of Existing Subgrade Material

Sr. No.	Ch.	Side	Sieve Analysis (% Passing)			Atterberg's Limit			Free swelling Index (%)	Modified Proctor Test		C.B.R (%)	
			Gravel %	Sand %	Silt %	Liquid Limit (%)	Plastic Limit (%)	Plasticit Index (%)		M.D.D (Gm/cc)	O.M.C (%)	Un - soaked %	Soaked %
1	0/100	LHS	31.15	64.55	4.30	42.10	30.37	11.73	12.00	1.865	14.50	12.75	9.00
2	0/450	RHS	47.00	50.15	2.85	32.40	24.50	7.90	11.00	2.10	12.90	13.80	9.50

Table 4.8
Test Results of Quarry Materials – Earthwork

Sr. No.	Location	GRADATION (% Passing)			ATTERGERGE'S LIMIT			Free swelling Index (%)	PROCTOR TEST		C.B.R (%)	
		Gravel %	Sand %	Silt & Clay %	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)		M.D.D (Gm/cc)	O.M.C (%)	UN SOAKED %	SOAKED %
1	Local Quarry	48.78	45.28	5.94	33.45	20.50	12.95	5.00	2.02	12.50	15.50	11.65
2	Local Quarry	62.80	30.00	7.20	28.98	20.50	8.48	4.00	2.09	15.00	18.52	14.50
3	Local Quarry	61.96	34.52	3.52	22.50	18.35	4.15	0.00	2.130	13.00	21.35	16.75
4	Local Quarry	78.64	19.60	1.76	25.70	18.70	7.00	0.00	2.12	10.00	17.65	13.25
5	Local Quarry	48.78	45.28	5.94	33.45	20.50	12.95	10.00	1.98	12.00	15.50	11.50

Table No. 4.9
Test results of Quarry Materials - Stone Material

LOCATION	GRADATION 20 MM METAL(% Passing)							GRADATION 10 MM METAL(% Passing)							Aggregate Impact Value (%)	WATER ABSORPTION %		FLAKINESS INDEX %		SPECIFIC GRAVITY		STRIPING VALUE %	LOS ANGELES ABRASION VALUE %
	40.0 MM	20.0 MM	16.0 MM	12.5 MM	10.0 MM	4.75 MM	2.36 MM	20.0 MM	16.0 MM	12.5 MM	10.0 MM	4.75 MM	2.36 MM	0.075 MM		20 MM	10 MM	20 MM	10 MM	20 MM	10 MM		
Dhamase quarry and Crusher at Gamjem village	100	94.80	34.95	2.95	0.18	0.15	0.15	100	100	100	100	2.83	0.77	0.67	14.14	0.57	0.60	16.34	15.62	2.66	2.47	100	11.52
Nanu Quarry at Nanus Village	100	96.32	49.89	16.67	1.64	1.24	1.24	100	100	100	98.10	5.86	1.64	0.13	11.33	0.30	0.68	17.04	24.12	2.65	2.72	100	15.50

Table 4.10
Test Results of River Sand

Sr. No.	LOCATION / CHAINAGE	SOURCE OF SAND	FINENESS MODULUS	WATER ABSORPTION (%)	SPECIFIC GRAVITY	SILT CONTENT (%)
1	Amona sand quarry	Madai River	2.60	1.90	2.47	3.95

Chapter – 5

TRAFFIC SURVEY & ANALYSIS

5.0 TRAFFIC SURVEY AND ANALYSIS

Project Corridor:

The Project road is a section of NH-17B (NH-566). NH-17B which is declared as National Highway in July 1999 originates from intersection with NH-4A at Farmagudi (Ponda), proceeding via. Borim, Loutulim, Verna & terminating at Marmagoa port. There is missing link of this NH between village Loutulim & Verna Industrial Estate. The Project road under consideration is located between Km. 3/860 to Km. 11/860 of NH-17B i.e. 8 Km. The project corridor located in two districts South Goa & North Goa out of which majority length passes through North Goa district.

5.1 Present status of project corridor:

- Existing bridge across River Zuari at Borim was opened to traffic in 1986.
- Existing bridge is 2 lane bridge with footpaths on either side.
- Length of the existing bridge is 431m with additional span of 35m for crossing of SH-6 road.
- There is central navigational span (balance cantilever span) of 122m with Navigational channel of 90m and vertical clearance of 13.7m.
- Existing two lane bridge is burdened for carrying present manifold traffic.
- Typical problems manifested in the balance cantilever prestressed span of the Bridge.

5.2 Importance of project corridor:

- The stretch under consideration is an important connection between South Goa & North Goa.
- It is an important corridor for commercial traffic from Belgaum and leading to Verna Industrial Estate, Marmagao port, etc.
- It is an alternate route to NH-17 for traffic diversion in case of any emergency.

5.3 Objectives of the study:

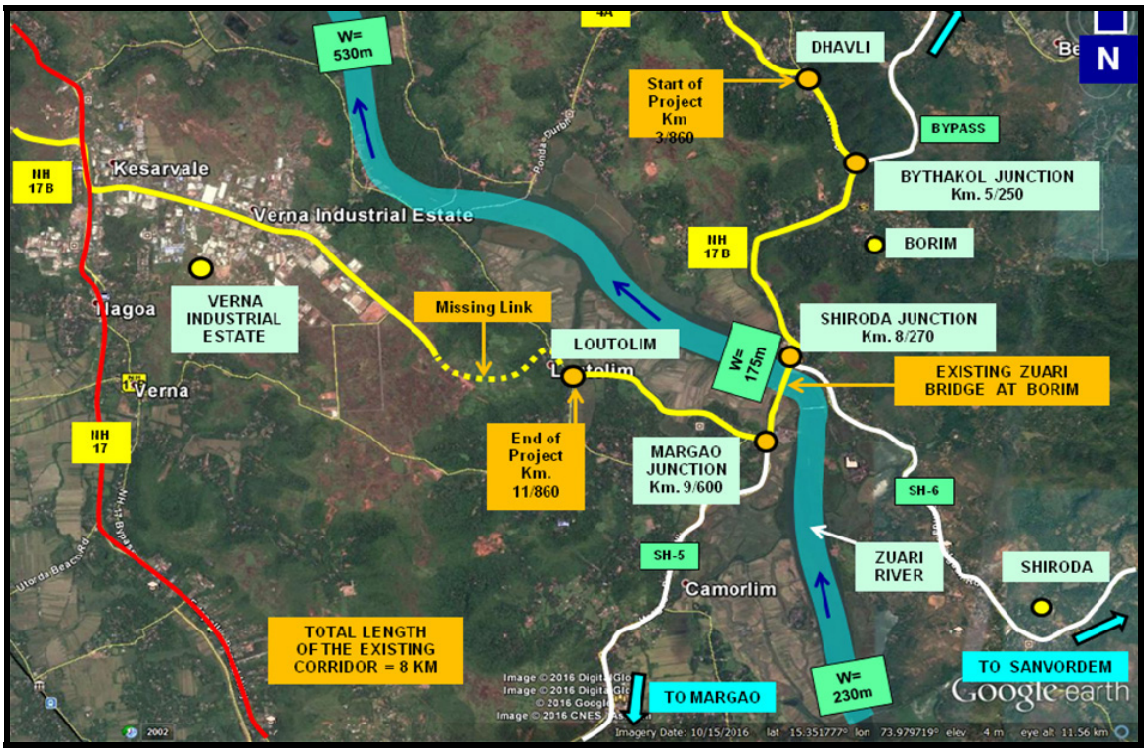
The primary objectives of this traffic study are to.

- Determine the characteristic of traffic movements on the project road.
- Collect historical data on traffic growth on project road.
- Estimate future traffic growth rate.

- Determine travel pattern as well as type and weight of commodities carried by goods vehicles.
- Determine spectrum of axle loads and vehicle damage factor of different types of commercial vehicles.
- Determine turning movements of traffic at major road intersections and identify requirements of suitable remedial measures such as construction of underpasses, flyovers grade separated interchanges.
- Indentify traffic pattern and need for bypasses to congested locations.
- Indentify requirements of grade separations for pedestrians to improve traffic safety.

Figure 5.1

Plan showing Project Road



5.4 Identification of homogeneous sections:

After site visit and reconnaissance survey, it was observed that project corridor is about 8 Km in length. The total stretch contains similar characteristics of traffic throughout the stretch.

5.5 Surveys

To fulfil the objectives, the following traffic surveys were carried out at site.

- Traffic Volume Count Survey at following location for 7 days.

Table 5.1

Schedule of Traffic Volume Count Survey

Sr. No	Location	Chainage	Survey Period
A	**NH-17B Zuari River Bridge**		
1	Between Shiroda Junction and Existing bridge	8/550	16/11/2016 to 22/11/2016

- Origin & Destination Survey at following location was carried out.

Table 5.2

Schedule of Origin & Destination Survey

Sr. No	Location	Chainage	Survey Period
A	**NH-17B Zuari River Bridge**		
1	Near Sakvar Bus stop	6/900	06/12/2016

- Turning Movement Survey for 24 hours at 3 Junctions

Table 5.3

Schedule of Turning Movement Survey

Sr. No	Location	Type of Junction	Chainage	Survey Date
A	**NH-17B Zuari River Bridge**			
1	Bythakol Junction with Newly declared NH	3 arm junction	5/200	08/11/2016
2	Shiroda Junction with SH-6 – road leading to Shiroda	3 arm junction	8/200	10/11/2016
3	Loutulim Junction with SH-5 road leading to Margao	3 arm junction	9/520	14/11/2016

Figure 5.2 Traffic Survey Locations

5.6 Approach for traffic survey:

Locations for traffic surveys have been identified and formats designed on the basis of objectives of the study and data to be collected during the survey. The surveys were carried out as described in TOR. Special teams consisting of Traffic Engineer and enumerators were constituted to carry out the surveys. The activity included:-

- Training of enumerators
- Constitution of survey teams
- Carrying out surveys

The traffic survey locations and sections of the road where traffic volume is homogeneous are identified during reconnaissance. The Table 3.1, 3.2, 3.3 present schedule of traffic surveys carried out on the project road.

5.7 Classified Traffic Volume Count

5.7.1 Traffic characteristics on project road

- The survey was carried out for 7 days (continuous & direction wise).
- This was carried out manually and counts were recorded at 15 minutes interval.
- The vehicle classifications as suggested in IRC code were followed.
- The summary of all data collected from traffic volume survey on the project road is presented in Table 5.4.

Table 3.4

Traffic Volume on Project road (ADT)

Type of Vehicles	Average Daily Traffic (ADT) in terms of Vehicles per day
	NH-17B Zuari River Bridge
	Ch. 8/550
Two Wheeler	13027
Three Wheeler (Auto)	4
Car/ Jeep / Van / Taxi	10986
6 Seater / Utility	347
Mini Bus	87
Govt. Bus	160
Private Bus	529
Goods Auto	0
LCV	856
2 - Axle Trucks	2916
3 - Axle Trucks	489
Multi Axle Trucks	369
Construction Equipment	5
Govt. Vehicles	0
Ambulance	0
Fire Fighting	0
Tractor With Trailer	4
Tractor Without Trailer	1
Cycle	14
Cycle Rickshaw	0
Animal Drawn	0
Hand Cart	0
TOTAL	**29794**

Source: Traffic Survey, November - 2016.

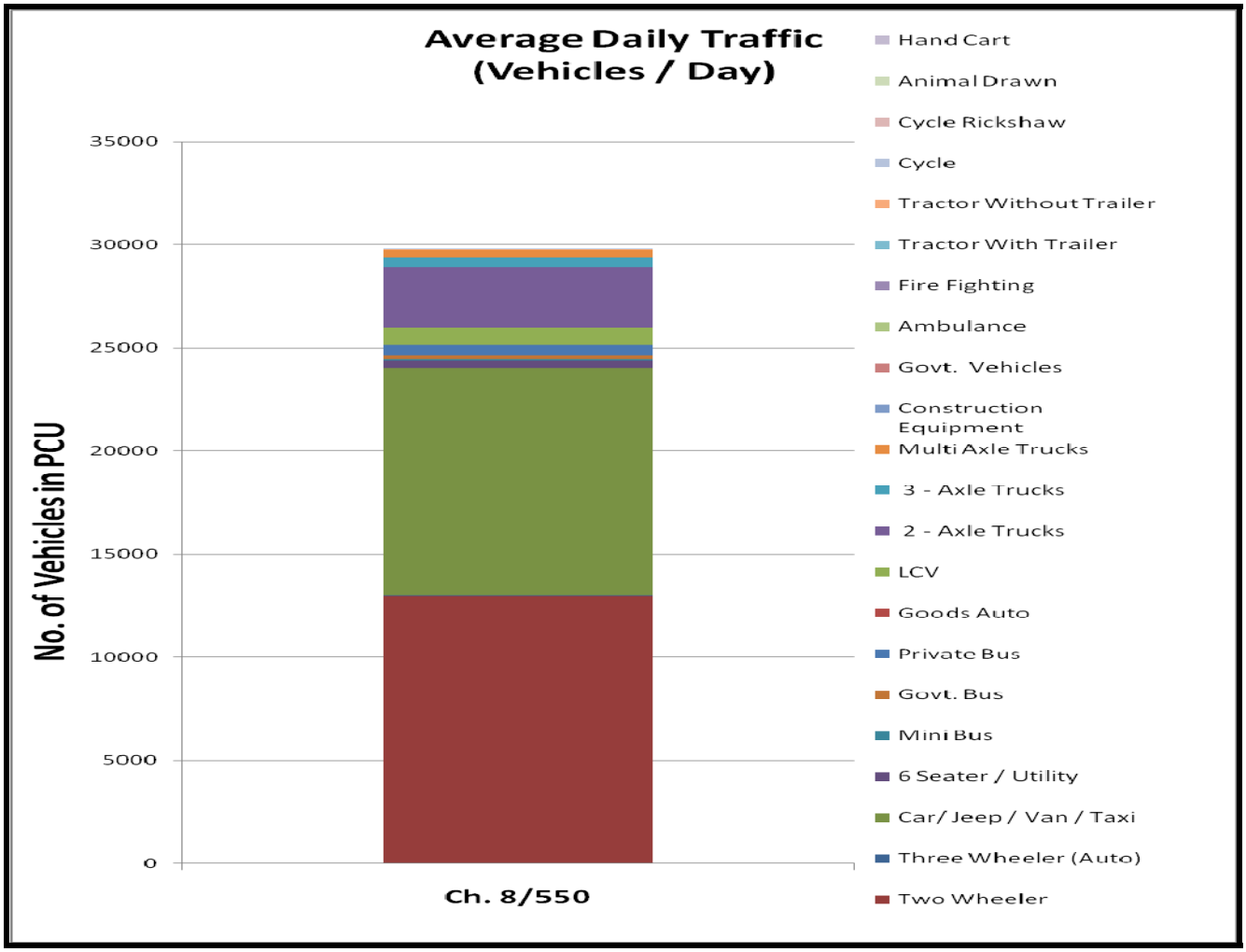


Figure 5.3

Average Daily Traffic at Traffic Survey Location (Vehicles / Day)

5.7.2 Percentage Variation of Traffic:-

Traffic volume count surveys were undertaken continuously for 7 days. Following observations can be made from the data.

The variation observed between highest and lowest traffic is to the tune of +16.27% to -14.54%. Highest traffic recorded is on Thursday.

Table 5.5

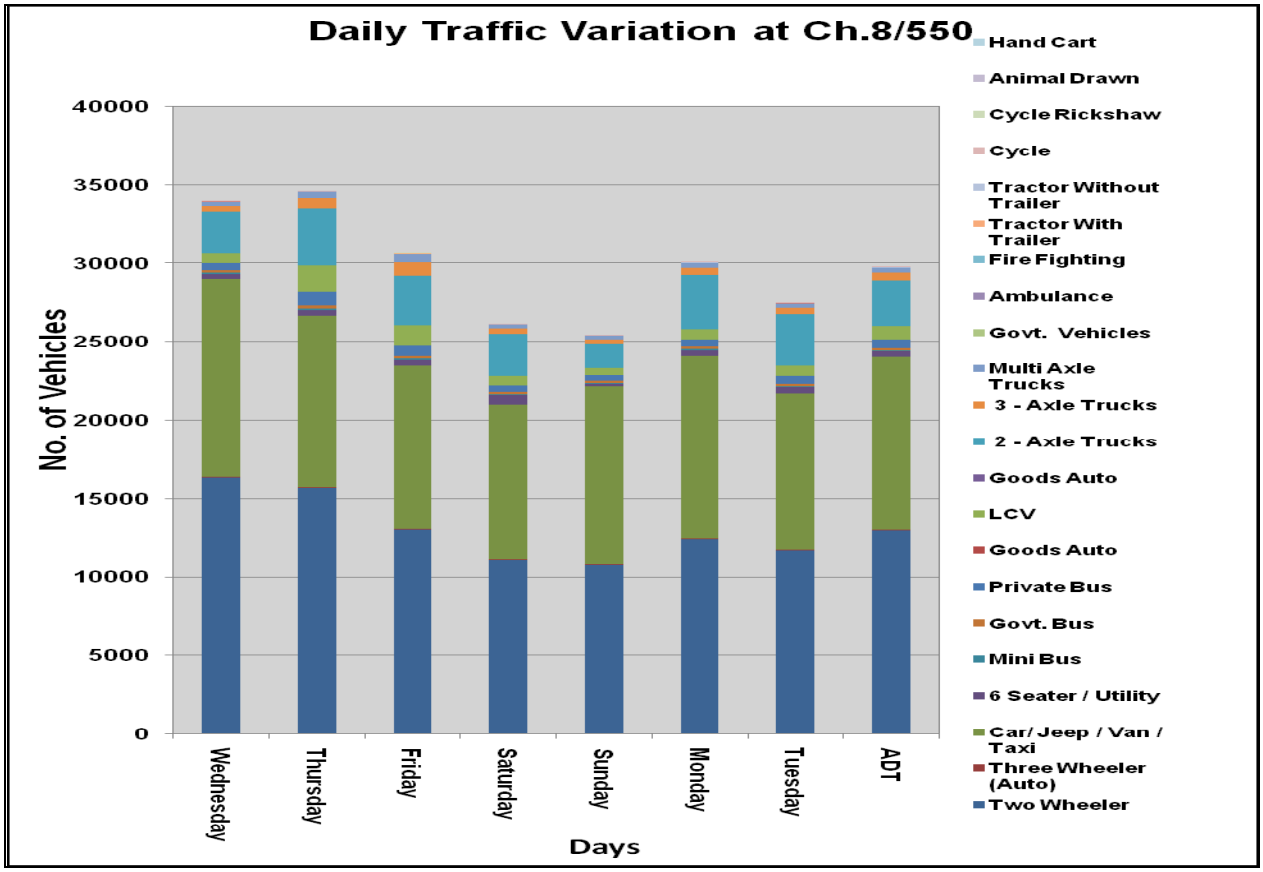
Daily Traffic Variation at Ch. 8/550

Type of Vehicles		16/11/16 Wednesday	17/11/16 Thursday	18/11/16 Friday	19/11/16 Saturday	20/11/16 Sunday	21/11/16 Monday	22/11/16 Tuesday	ADT (Vehicles /day)	% Composition of Vehicles
Two Wheeler		16343	15716	13095	11103	10797	12445	11687	**13027**	43.72
Three Wheeler (Auto)		9	6	5	3	1	1	1	**4**	0.01
Car/ Jeep / Van / Taxi		12654	10947	10379	9903	11345	11645	10032	**10986**	36.87
6 Seater / Utility		318	335	330	564	163	354	366	**347**	1.16
Mini Bus		74	134	108	67	74	72	77	**87**	0.29
Govt. Bus		147	185	182	144	145	154	160	**160**	0.54
Private Bus		471	859	651	427	355	465	478	**529**	1.78
Goods Auto		0	0	0	0	0	0	0	**0**	0.00
LCV		617	1672	1326	586	449	664	680	**856**	2.87
2 - Axle Trucks		2670	3681	3127	2680	1529	3455	3272	**2916**	9.79
3 - Axle Trucks		379	627	867	379	305	443	422	**489**	1.64
Multi Axle Trucks		304	464	566	296	265	368	319	**369**	1.24
Construction Equipment		2	2	7	7	7	9	4	**5**	0.02
Exempted Vehicles	**Govt. Vehicles**	0	0	0	0	0	0	0	**0**	0.00
	Ambulance	0	0	0	0	0	0	0	**0**	0.00
	Fire Fighting	0	0	0	0	0	0	0	**0**	0.00
Tractor With Trailer		5	1	3	1	6	3	7	**4**	0.01
Tractor Without Trailer		1	1	1	1	1	1	4	**1**	0.00
Cycle		3	11	12	18	18	20	15	**14**	0.05
Cycle Rickshaw		0	0	2	0	0	0	0	**0**	0.00
Animal Drawn		0	0	0	0	0	0	0	**0**	0.00
Hand Cart		0	0	0	0	0	0	0	**0**	0.00
TOTAL		**33997**	**34641**	**30661**	**26179**	**25460**	**30099**	**27524**	**29794**	**100.0**

Source: Traffic Survey, November 2016.

Figure 5.4

Daily Traffic Variation at Ch. 8/550



5.7.3 Maximum and Minimum Traffic in a Week:

The maximum and minimum traffic observed in a week is as follow.

Table 5.9
Maximum and Minimum Traffic

Particulars	Survey Location
	Ch. 8/550
Maximum Traffic Day	**Thursday**
No. of Vehicles	34641
% of ADT	116.26
Minimum Traffic Day	**Sunday**
No. of Vehicles	25460
% of ADT	85.45

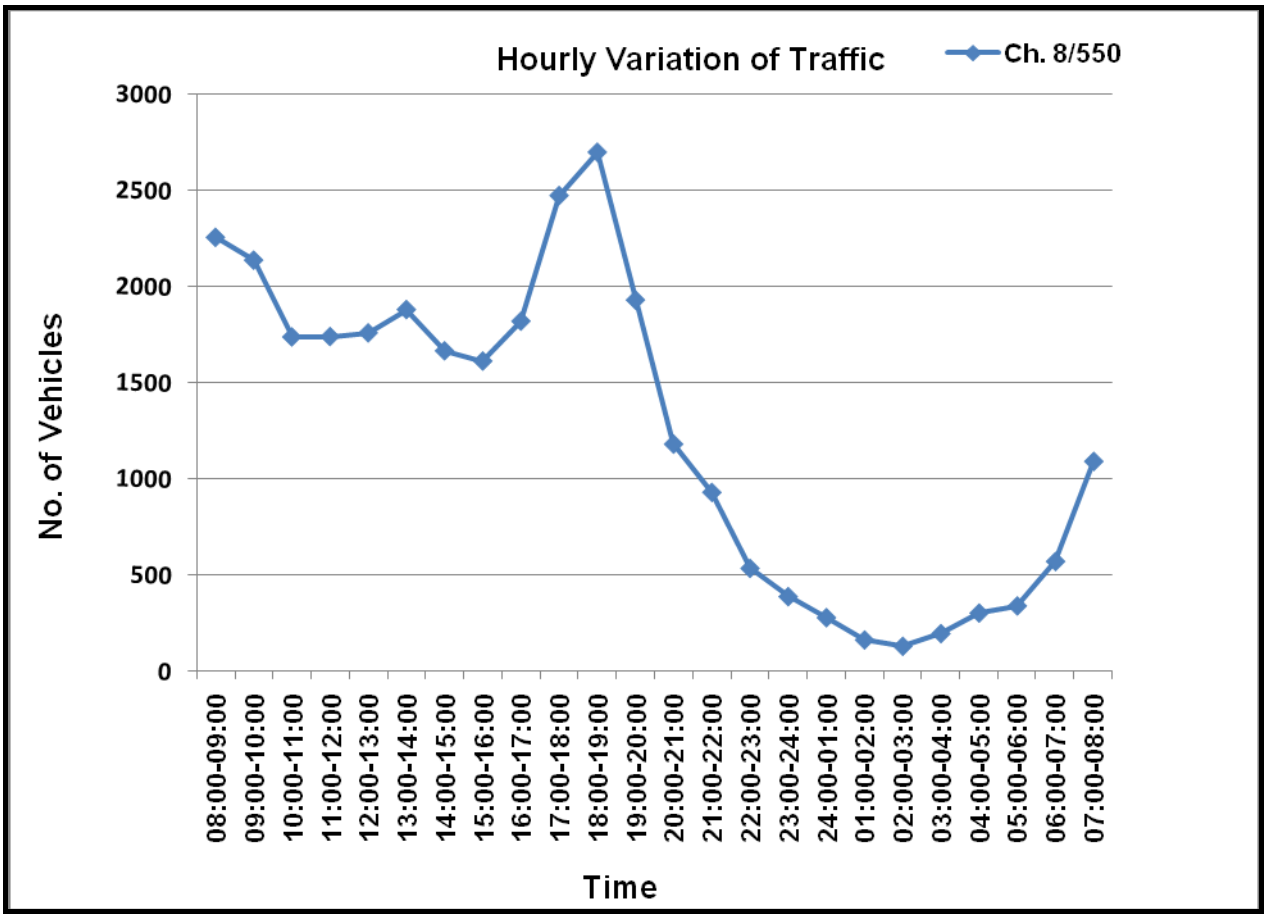
Source: Traffic Survey, November 2016.

5.7.4 Hourly variation & directional distribution of traffic

Figure 3.10 presents the hourly variation of traffic.

Figure: 5.8

Hourly Variation of Traffic



- Peak Hour Factor (PHF) is defined as ratio between the numbers of vehicles counted during peak hour to the total number of vehicles counted in a day. The Peak Hour Factors calculated is presented in table 5.10.

Table 5.10

Peak Hour Traffic

Sr. No.	Survey Location	Peak Hour Volume (Veh/Hr)	Peak Hour Factor (PHF)%	Peak Hour
A	**NH-17B Zuari River Bridge**			
1	Ch. 8/550	2697	9.05	06.00 pm to 07.00 pm

Source: Traffic Survey, November, 2016.

5.7.5 Directional Distribution:

The directional distribution is as given below.

Table 5.13

Directional Distribution of traffic

Sr. No.	Survey Location	UP Direction (%)	Down Direction (%)
A	**NH-17B Zuari River Bridge**		
1	Ch. 8/550	46.85	53.15

5.7.6 Composition of Traffic:

The composition of traffic is shown in table 5.11

Table 5.11

Composition of Traffic in Percentage

Type of Vehicles	Traffic Composition (in %)
	NH-17B Zuari River Bridge
	Ch. 8/550
Two Wheeler	43.70
Three Wheeler (Auto)	0.00
Car/ Jeep / Van / Taxi	36.90
6 Seater / Utility	1.20
Mini Bus	0.30
Govt. Bus	0.50
Private Bus	1.80
Goods Auto	0.00
LCV	2.90
2 - Axle Trucks	9.80
3 - Axle Trucks	1.60
Multi Axle Trucks	1.20
Construction Equipment	0.00
Govt. Vehicles	0.00
Ambulance	0.00
Fire Fighting	0.00
Tractor With Trailer	0.00
Tractor Without Trailer	0.00

Type of Vehicles	Traffic Composition (in %)
	NH-17B Zuari River Bridge
	Ch. 8/550
Cycle	0.00
Cycle Rickshaw	0.00
Animal Drawn	0.00
Hand Cart	0.00
TOTAL	**100.0**

- It can be seen from the above table that two wheelers and car constitutes 80% of total traffic. The commercial traffic is about 20% for this stretch.

5.7.7 Annual Average Daily Traffic (AADT):

To derive AADT from ADT observed in, the seasonality in traffic is considered and seasonal correction factor for the respective months has been applied.

The consumption of Petrol/ Diesel is directly proportional to traffic intensity. Hence, Fuel consumption data of Petrol Pumps along the project road was collected. Following Table shows the summary of average and month wise consumption of petrol and diesel at these petrol pumps.

Table 5.12
Summary of Average Month-wise consumption of Petrol & Diesel

Month	Petrol & Diesel Consumption in Liters		Total Petrol & Diesel Consumption (Liters)
	Petrol	Diesel	
Apr-15	183000	577000	760000
May-15	192000	572000	764000
Jun-15	170000	538000	708000
Jul-15	156000	524000	680000
Aug-15	165000	539000	704000
Sep-15	180000	540000	720000
Oct-15	178000	602000	780000
Nov-15	189000	567000	756000
Dec-15	182000	618000	800000
Jan-16	183000	576000	759000
Feb-16	190000	646000	836000
Mar-16	216000	604000	820000
Average	**182000**	**575250**	**757250**
AADT Factor in Month of November	**1.00**		

As seen from the above table, The AADT factor for project roads is 1.00 for November month. The average daily traffic observed is multiplied by above AADT factors to derive the Annual Average Daily Traffic (AADT).

Table 5.13
Annual Average Daily Traffic (AADT in Vehicles / Day)

Type of Vehicles	Annual Average Daily Traffic (AADT) in terms of Vehicles per day
	Ch. 8/550
Two Wheeler	13027
Three Wheeler (Auto)	4
Car/ Jeep / Van / Taxi	10986
6 Seater / Utility	347
Mini Bus	87
Govt. Bus	160
Private Bus	529
Goods Auto	0
LCV	856
2 - Axle Trucks	2916
3 - Axle Trucks	489
Multi Axle Trucks	369
Construction Equipment	5
Govt. Vehicles	0
Ambulance	0
Fire Fighting	0
Tractor With Trailer	4
Tractor Without Trailer	1
Cycle	14
Cycle Rickshaw	0
Animal Drawn	0
Hand Cart	0
TOTAL	**29794**

5.7.8 Passenger Car Units (PCU):

The Traffic on the project road is characterised as mixed traffic condition resulting into complex interaction between various kinds of vehicles. To cater for this, IRC has

recommended converting different types into a common unit of "Passenger Car Unit - PCU". Each vehicle type is converted into equivalent PCU's based on their interference value. IRC has recommended conversion factors.

Since the project road is passing through predominantly in rural areas, the following PCU factors from IRC 64-1990 are adopted.

Table 5.14
Adopted PCU Factors

Type of Vehicle	PCU Factor	Type of Vehicle	PCU Factor
Two Wheeler	0.50	Multi Axle Trucks	4.50
Three Wheeler (Auto)	1.00	Construction Equipment	4.50
Car/ Jeep / Van / Taxi	1.00	Govt. Vehicles	1.00
6 Seater / Utility	1.00	Ambulance	1.50
Mini Bus	1.50	Fire Fighting	3.00
Govt. Bus	3.00	Tractor With Trailer	4.50
Private Bus	3.00	Tractor Without Trailer	1.50
Goods Auto	0.75	Cycle	0.50
LCV	1.50	Cycle Rickshaw	2.00
2 - Axle Trucks	3.00	Animal Drawn	8.00
3 - Axle Trucks	4.50	Hand Cart	3.00

On the basis of above PCU factors, AADT in terms of PCU on the project road are as follows.

Table 5.15
Annual Average Daily Traffic (AADT) in PCU/day

Type of Vehicles	Annual Average Daily Traffic (AADT) in terms of PCU per day
	Ch. 8/550
Two Wheeler	6514
Three Wheeler (Auto)	4
Car/ Jeep / Van / Taxi	10986
6 Seater / Utility	347
Mini Bus	131
Govt. Bus	480
Private Bus	1587

Goods Auto	0
LCV	1284
2 - Axle Trucks	8748
3 - Axle Trucks	2201
Multi Axle Trucks	1661
Construction Equipment	23
Govt. Vehicles	0
Ambulance	0
Fire Fighting	0
Tractor With Trailer	18
Tractor Without Trailer	2
Cycle	7
Cycle Rickshaw	0
Animal Drawn	0
Hand Cart	0
TOTAL	**33990**

5.8 Origin - Destination Survey

The objective of origin destination (O-D) survey is to gather information regarding travel characteristic of different road users on the project road. Results of O-D survey are used to describe the user characteristics both of passenger & goods vehicles such as distribution of local and through traffic as well as commodity type and weight of goods carried by commercial vehicles. The main emphasis of O-D survey is to capture goods movement characteristics, willingness to pay characteristics, trip frequencies etc.

5.8.1 Methodology

- The location of O-D Survey were same as that of traffic volume survey, details of O-D Survey conducted as part of this study are presented in Table 3.16

Table 5.16

Origin- Destination Survey Details

Sr. No	Chainage	Survey Date
1	6/900	06/12/2016

- Road side interview method, as detailed in IRC: 102-1988, was used for O-D Survey. The survey was carried out for both passenger and goods vehicles for 24 hours (in both direction) on a working day.
- Trained enumerators under supervision of traffic engineer collected trip characteristics.
- The O-D Survey elicited passenger mode characteristics like origin and destination, occupancy, trip purpose and length of trip by mode type.
- For commercial vehicles, the survey elicited characteristics like origin and destination, commodity type, trip length etc.

5.8.2 Zoning

The entire influence area was divided into major zones in such a way that the characteristics of inter-zonal & intra- zonal trips could be clearly analyzed and their influence assessed on project road.

With respect to passenger vehicles, trips were grouped as per major purposes of movement. They are-

- Work
- Education
- Business
- Social
- Shopping
- Recreation/Tourist
- Medical/Hospital
- Return Trips
- Other
- Personal Work

With respect to goods vehicles, the types of goods carried were broadly grouped into categories including the category of empty trucks.

They are -

- Food Grains
- Fruits/vegetables
- Fertilizers
- Petroleum
- Building Materials
- Textiles
- Household Goods
- Mineral Oils
- Heavy Machinery
- Empty
- New Vehicle

5.8.3 Influence Area for the Commercial and Passenger Traffic

The O-D Matrices derived from O-D data collected is analysed to assess the travel pattern of commercial and passenger vehicles. The Analysis shows the following observations.

5.8.3.1 NH-17B Zuari River Bridge -

The O-D survey was undertaken at Ch. 6/900 on this road. The analysis of collected data shows that, the influence area for commercial and passenger vehicles is South Goa district, North Goa District and also from Maharashtra and Karnataka State.

The following tables and charts shows the summarised information about sample size, commodity distribution, trip lengths, trip purposes and trip frequencies of commercial and passenger traffic along roads.

5.8.4 Sample Size

The sample size for each category of Goods vehicles is summarised in following tables.

Table 5.17

Sample size for Various Types of Good Vehicles

Sample Size For Various Types Of Goods Vehicles.		
Vehicle Type	**Ch. 6/900**	
	No. of Vehicles Interviewed	Sample Size (In %)
1 - Light Com Vehicle	34	8.20
2 - Two Axle Trucks	286	68.75
3 - Three Axle Trucks	70	16.80
4- Multi Axle Trucks	26	6.25
5- Tractor	00	0.00
Total =	**416**	**100**

Source: Traffic Survey, November 2016.

The sample size for each category of passenger vehicles is summarised in following tables.

Table 5.18

Sample size for Various Types of Passenger Vehicles

Sample Size For Various Types Of Passenger Vehicles.		
Vehicle Type	**Ch. 6/900**	
	No. of Vehicles Interviewed	Sample Size (In %)
1 – Car (Old)	277	45.80
2 - Car (New)	0	0.00
3 - Bus	0	0.00
4 - Three Wheeler	0	0.00
5 - Two Wheeler	328	54.20
Total =	**605**	**100**

Source: Traffic Survey, November 2016.

5.8.5 Commodity Distribution

The commodity carried out by good vehicles was recorded during O-D survey. A summary of commodity distribution of all goods vehicles at 4 survey locations are given in following tables.

Table 5.19
Commodity Distribution of Goods Vehicles at Ch. 6/900

Commodity	2 Axle		3 Axle		Multi Axle		LCV		Tractor	
	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %
1 - Food Grains	9	3.10	2	2.90	0	0.00	1	2.90	0	0.00
2 - Fruits/ Vegetables	2	0.70	1	1.40	0	0.00	3	8.80	0	0.00
3 - Fertilizers	5	1.70	2	2.90	0	0.00	5	14.70	0	0.00
4 - Petroleum	25	8.70	6	8.60	0	0.00	0	0.00	0	0.00
5 - Building Materials	130	45.50	20	28.60	10	38.50	4	11.80	0	0.00
6 - Textiles	2	0.70	0	0.00	0	0.00	0	0.00	0	0.00
7 - Household Goods	9	3.10	2	2.90	4	11.50	6	17.60	0	0.00
8 - Mineral Ore	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9 - Heavy Machinary	5	1.70	2	2.90	0	0.00	0	0.00	0	0.00
10 - Empty	97	33.90	35	50.00	12	50.00	15	44.10	0	0.00
11 - New Vehicle	2	0.70	0	0.00	0	0.00	0	0.00	0	0.00
12 - Other	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total =	**286**	**100**	**70**	**100**	**26**	**100**	**34**	**100**	**0**	**0.00**

Source: Traffic Survey, November 2016.

5.8.6 Goods Vehicles Lead Analysis

5.8.6.1 Trip Length

The data regarding trip length of commercial vehicles was collected during O-D survey. Following table presents the trip length observed at various survey locations.

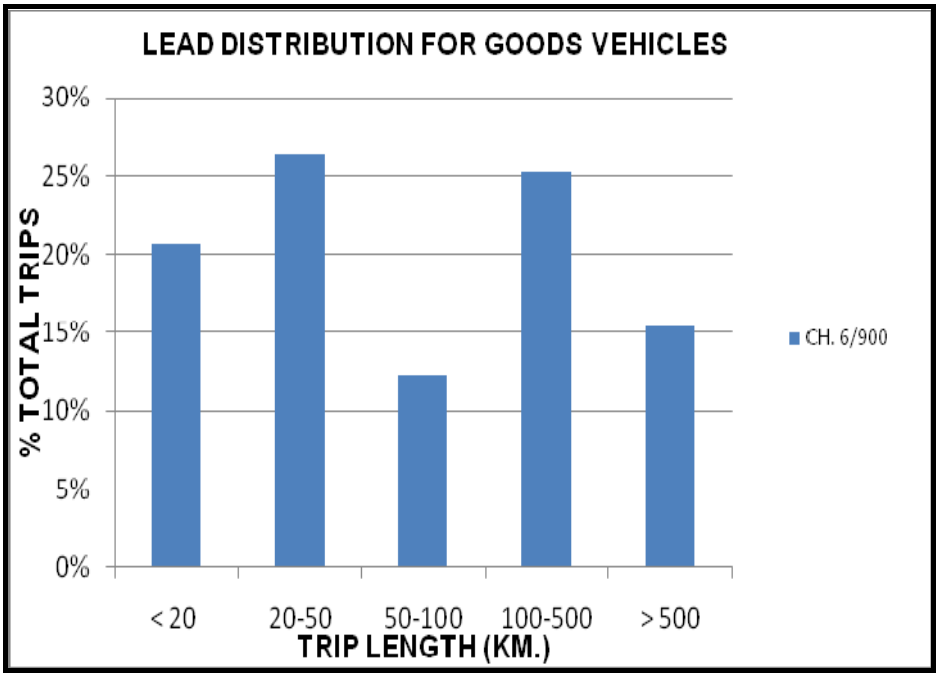
Table 5.23
%Trip Length of Commercial Vehicles

% Trip Length of Goods Vehicles	
Trip Length (Km)	**CH. 6/900**
	Goods Vehicles (%)
< 20	29.60
20-50	28.60
50-100	12.70
100-500	17.30
> 500	11.80

Source: Traffic Survey, November 2016.

Figure 3.9

Lead Distribution of Goods Vehicles



5.8.7 Passenger Vehicles, Lead, Occupancy and Trip Purpose

5.8.7.1 Trip Length

The data regarding trip length of passenger vehicles was collected during O-D survey. Following table presents trip length observed at various survey locations.

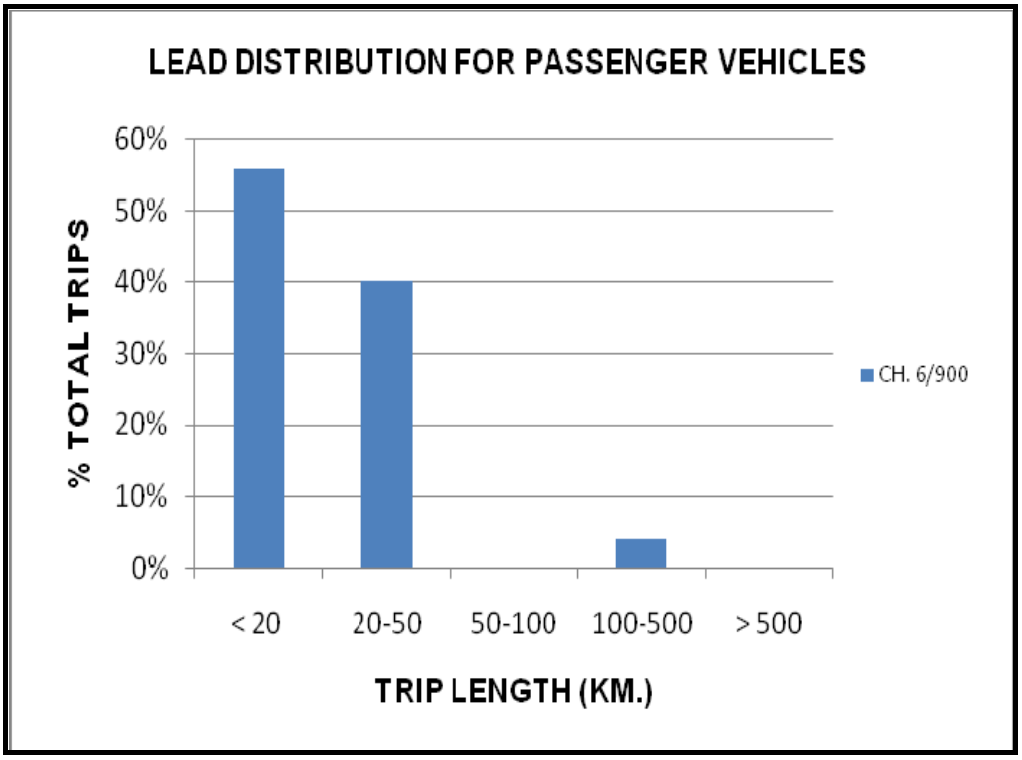
Table 5.24
% Trip length of Passenger Vehicles

% Trip Length of Passenger Vehicles	
Trip Length (Km)	**CH. 6/900**
	Passenger Vehicles (%)
< 20	55.90
20-50	40.20
50-100	0.00
100-500	4.00
> 500	0.00

Source: Traffic Survey, November 2016.

Figure 5.10

Lead Distribution of Passenger Vehicles



5.8.7.2 Trip Purpose Distribution

The trip purpose distribution of passenger vehicles namely cars, buses, two wheeler, three wheeler at O-D locations are given in following Tables.

Table 5.25
Trip Purpose Distribution at Ch. 6/900

Trip Purpose at CH.6/900								
Trip Purpose	Car / Jeep		Bus		Three Wheeler		Two Wheeler	
	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %	No. of Vehicles Interviewed	Vehicles In %
Commuter	0	0.00	0	100.00	0	100.00	0	0.00
1 - Work	176	72.40	0	0.00	0	0.00	210	80.40
2 - Education	60	1.30	0	0.00	0	0.00	50	4.30
3 - Business	0	3.90	0	0.00	0	0.00	0	2.20
4 - Social	2	3.90	0	0.00	0	0.00	5	0.00
5 - Shopping	0	2.60	0	0.00	0	0.00	8	2.20
6- Recreation	0	6.60	0	0.00	0	0.00	0	6.50
7- Health	18	0.00	0	0.00	0	0.00	16	0.00
8- Returns	0	1.30	0	0.00	0	0.00	4	0.00

9- Others	21	7.90	0	0.00	0	0.00	35	4.30
10- Tourist	0	0.00	0	0.00	0	0.00	0	0.00
Total =	**277**	**100.00**	**0**	**100.00**	**0**	**100.00**	**328**	**100.00**

Source: Traffic Survey, November 2016.

5.8.8 Travel Pattern

Table 5.29
% Trip Frequency at Ch. 6/900

% Trip Frequency at CH. 6/900									
Trip Frequency	**Car**	**Bus**	**Three Wheeler**	**Two Wheeler**	**2 Axle**	**3 Axle**	**Multi Axle**	**LCV**	**Tractor**
1 - Many times a day	0.00	0.00	0.00	0.00	15.00	5.70	0.00	41.10	0.00
2 - Daily	75.80	0.00	0.00	72.30	45.40	41.40	53.90	35.30	0.00
3 - 2/3 times a week	11.50	0.00	0.00	8.90	18.90	11.50	7.70	11.70	0.00
4 - Once in a week	6.90	0.00	0.00	12.90	4.10	11.40	7.70	0.00	0.00
5 - Once in a month	5.80	0.00	0.00	6.10	2.00	0.00	7.70	0.00	0.00
6 - Twice a month	0.00	0.00	0.00	0.00	5.90	8.60	3.90	3.00	0.00
7 - Occasionally	0.00	0.00	0.00	0.00	8.40	21.50	19.30	8.90	0.00
8 - Once in a year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 - 2/3 times a year	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total =	**100.0**	**0.0**	**0.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**0.0**

Source: Traffic Surveys, November 2016.

5.9 Intersection Turning Movement Survey

5.9.1 Objective

The objective of the turning movement survey was to understand traffic characteristics of each arm of intersection and to assess the need of signal control, grade separator etc. at the intersection to regulate safe traffic

5.9.2 Methodology

- Total 3 junctions were selected for conducting turning movement studies. The locations of intersection taken up for study are indicated in the following table.

Table 5.33
Intersection Turning Movement Survey

Sr. No	Location	Type of Junction	Chainage	Survey Date
A	**NH-17B Zuari River Bridge**			
1	Bythakol Junction with Newly declared NH	3 arm junction	5/200	08/11/2016
2	Shiroda Junction with SH-6 – road leading to Shiroda	3 arm junction	8/200	10/11/2016
3	Vasco Junction with SH-5 road leading to Margao	3 arm junction	9/520	14/11/2016

- The directional traffic counts were carried out for 24 hours.
- As per IRC:93-1985 (Guidelines on design and installation of road traffic signals) the traffic at intersection will require time separation i.e. signal control, when major road flow is more than 650 vehicles per hour (Both directions) and minor road flow is more than 200 vehicles per hour (One direction) for each of any 8 hours of an average day.
- As per IRC:92-1985, traffic will require space separation i.e. grade separation when total peak hour flow at the intersection is more than 10,000 per/hour.

5.9.3.1 Ch. 5/200 (Bythakol Junction with Newly declared NH)

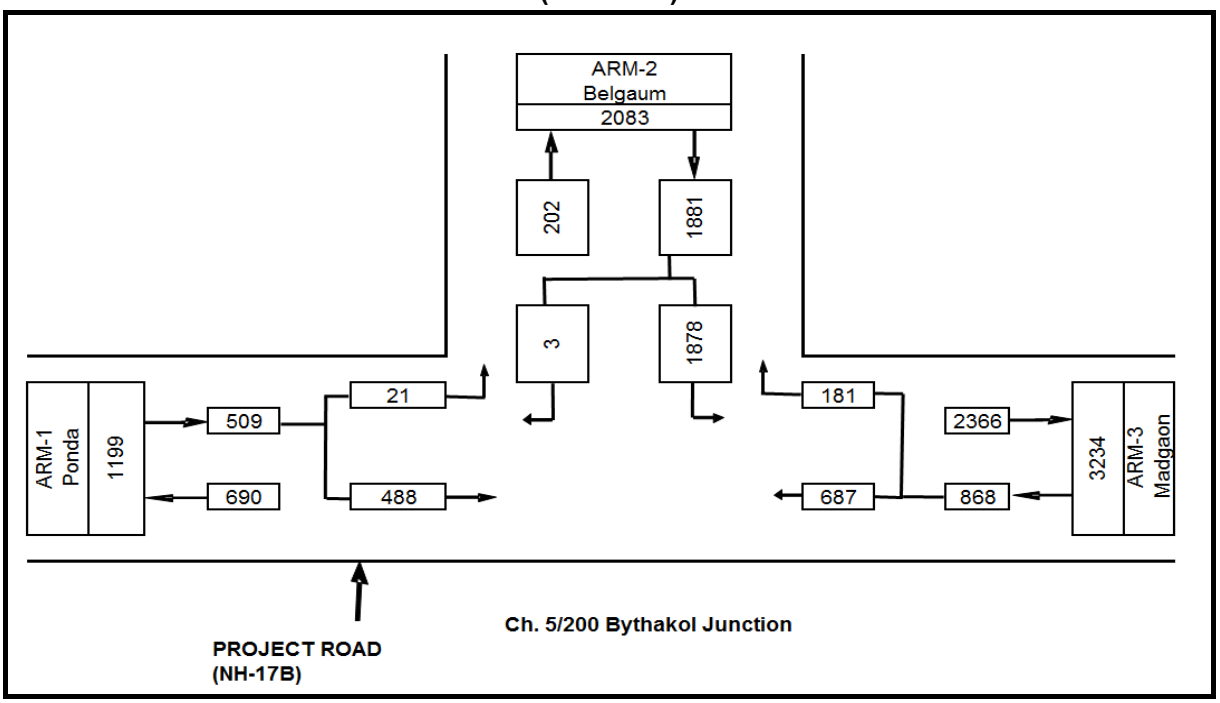
This is 3 arm junction on Ponda Margaon Road. This junction is formed due to crossing of Newly declared NH with the project road. The peak hour traffic at this junction is 3258 PCU/hour and the peak hour is 9.00 am To 10.00 am.

Table 5.34
Peak Hour Traffic at Bythakol Junction

Name of Intersection: Ch. 5/200 Bythakol Junction		**Peak Hour Time**		**Peak Hour Traffic**	
Date of Survey : 08/11/2016		**From**	**To**	**3258**	
Day :Tuesday		**9:00 AM**	**10:00 AM**	**PCU / hr**	
Traffic Direction		**Vehicles per Day**	**PCU per Day**	**Peak Hour Traffic**	**% Peak Hour Traffic in each direction**
From	**To**				
Margao	Ponda	10565	11885	687	21.223
Margao	Belgaum	3468	4844	181	5.592
Ponda	Margao	8029	8919	488	15.076
Ponda	Belgaum	274	427	21	0.645
Belgaum	Margao	7298	13522	1878	58.017
Belgaum	Ponda	155	225	3	0.093
Total Traffic in All arms		**29789**	**39822**	**3258**	**100.00**

- The traffic on both arms (major & minor) show requirement of signalization as per IRC specifications.
- The total peak hour traffic at intersection is not more than 10,000 PCU/hr. But existing NH project road intersects with newly declared NH road hence the Grade Separator is necessary at this junction as per IRC:SP:84 manual.

Figure 5.11
Turning Movement Diagram of Peak Hour Traffic (PCU/hr) at Bythakol Junction (Ch.5/200)



5.9.3.2 Ch. 8/200 (Shiroda Junction with SH-6)

This is 3 arm junction on Ponda Margaon Road. This junction is formed due to crossing of SH-6 with the project road. The peak hour traffic at this junction is 4073 PCU/hour and the peak hour is 06.00 PM to 07.00 PM.

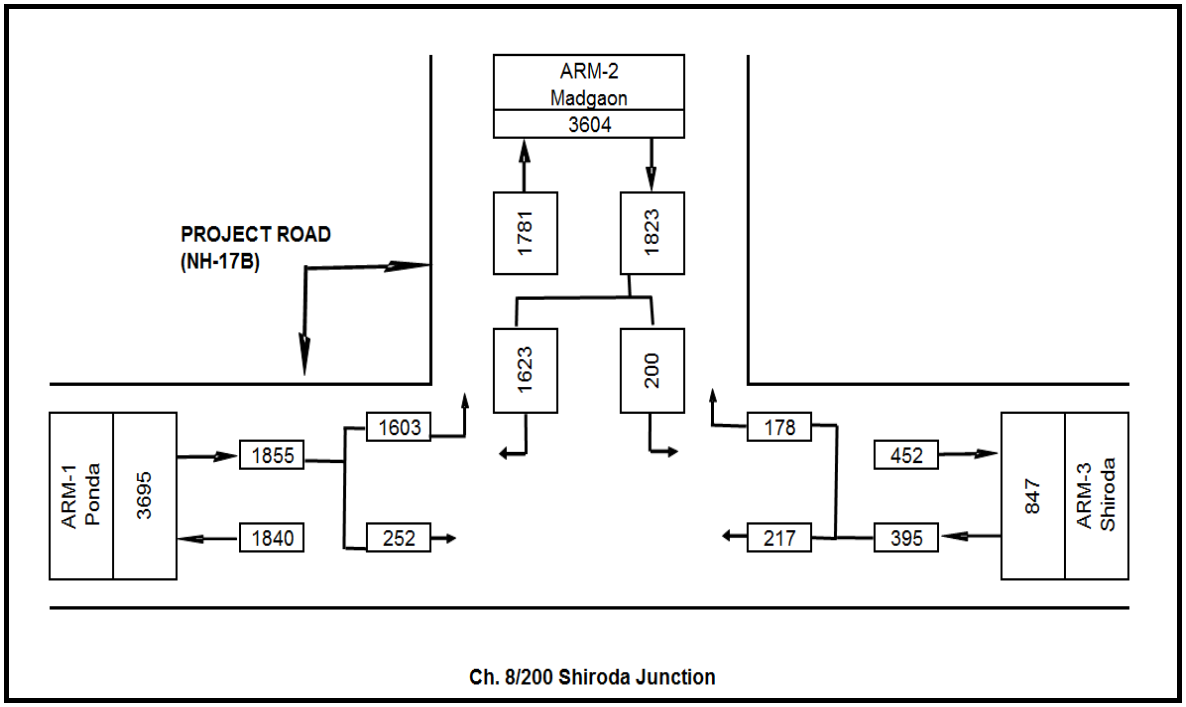
Table 5.35

Peak Hour Traffic at Shiroda Junction (Ch. 8/200)

Name of Intersection: Ch.8/200 Shiroda Junction		Peak Hour Time		Peak Hour Traffic	
Date of Survey : 10/11/2016		From	To	4073	
Day : Thursday		6:00 PM	7:00 PM	PCU / Hr	
Traffic Direction		Vehicles per Day	PCU per Day	Peak Hour Traffic	% Peak Hour Traffic in each direction
From	To				
Margao	Ponda	11086	13662	1623	39.848
Margao	Shiroda	2000	1666	200	4.910
Ponda	Margao	16214	17899	1603	39.357
Ponda	Shiroda	3857	3022	252	6.187
Shiroda	Ponda	3606	2940	217	5.328
Shiroda	Margao	2118	1770	178	4.370
Total Traffic in All arms		**38881**	**40959**	**4073**	**100.00**

- The traffic on either arms (major & minor) does not satisfy IRC specifications for signalization but due to realignment of project route this junction is out of scope. Hence, there is no improvement of junction is required.
- The total peak hour traffic at intersection is not more than 10,000 PCU/hr. Hence, at this junction, grade separator is not warranted.

Figure 5.12 - Turning Movement Diagram of Peak Hour Traffic (PCU/hr) at Shiroda Junction (Ch. 8/200)



5.9.3.3 Ch. 9/520 (Vasco Junction with SH - 5)

This is 3 armed junction. This junction is formed due to crossing of SH - 5 with the project road. The peak hour traffic at this junction is 4146 PCU/hour and the peak hour is 08.00 pm to 09.00 pm.

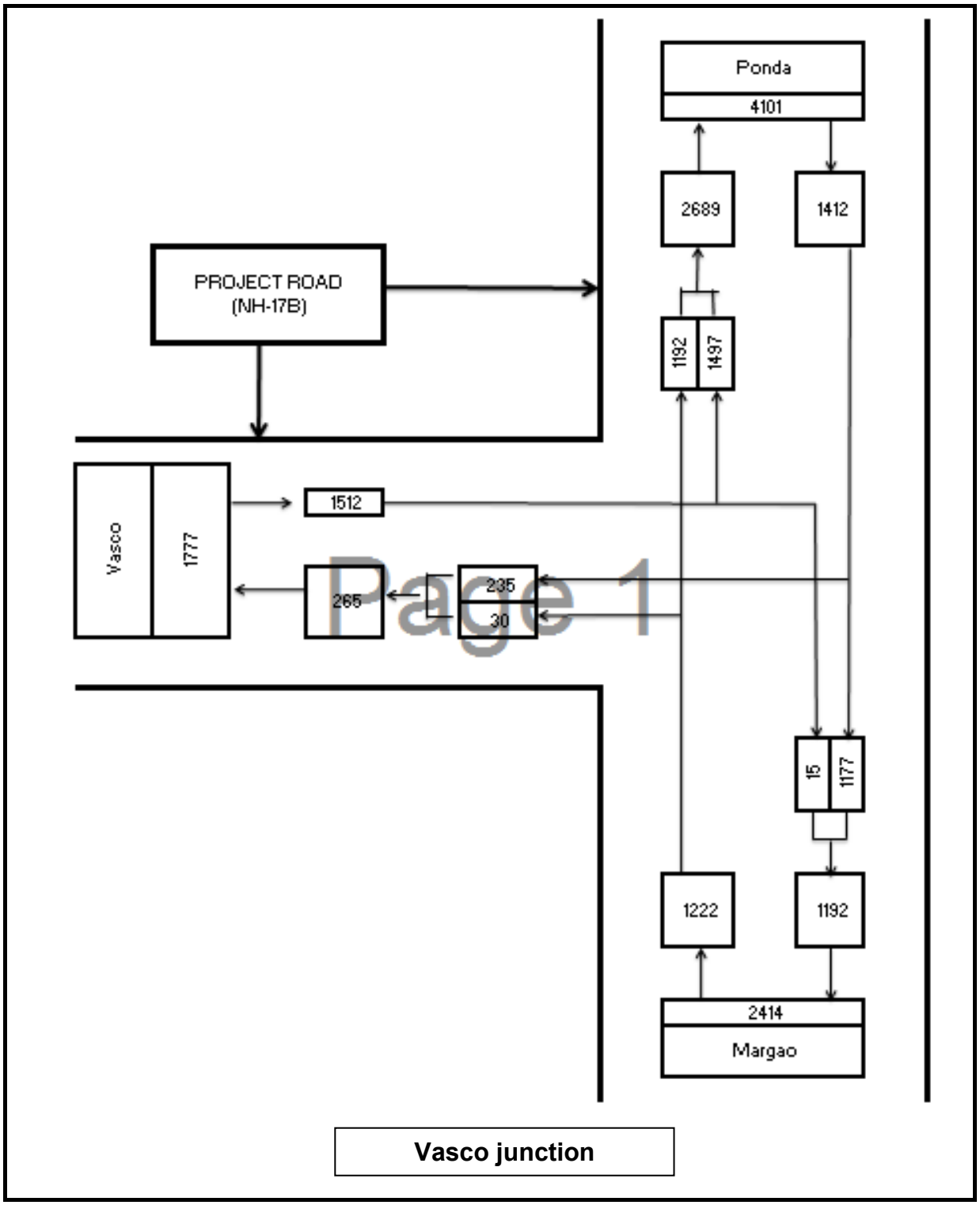
Table 5.36

Peak Hour Traffic at Vasco Junction (Ch. 9/520)

Name of Intersection: Ch. 9/520 Vasco Junction		**Peak Hour Time**		**Peak Hour Traffic**	
Date of Survey : 14/11/2016		**From**	**To**	**4146**	
Day : Monday		**8:00 PM**	**9:00 PM**	**PCU / hr**	
Traffic Direction		**Vehicles per Day**	**PCU per Day**	**Peak Hour Traffic**	**% Peak Hour Traffic in each direction**
From	**To**				
Margao	Ponda	14191	16260	1192	28.75
Margao	Vasco	402	331	30	0.72
Ponda	Margao	19225	19532	1177	28.39
Ponda	Vasco	5890	6645	235	5.67
Vasco	Ponda	7471	7969	1497	36.11
Vasco	Margao	282	248	15	0.36
Total Traffic in All arms		**47461**	**50985**	**4146**	**100.00**

- The traffic on either arms (major & minor) does not satisfy IRC specifications for signalization but due to realignment of project route this junction is out of scope. Hence, there is no improvement of this junction is proposed.
- The total peak hour traffic at intersection is not more than 10,000 PCU/hr. Hence, at this junction, grade separator is not warranted.

Figure 5.13
Turning Movement Diagram of Peak Hour Traffic (PCU/hr) at Vasco Junction (Ch.9/520)



5.10 Axle Load Survey :-

Axle Load survey has been carried out by using Axle Load Pads for 1 day (24 hours) in both the directions at location mentioned below on the project road on a random sample basis as specified in IRC: 37 (latest).

The Axle load data has been collected axle configuration-wise. The vehicles plying on the road were selectively stopped and weighed by using Axle Pad. Assistance of local Police was taken to stop and weigh the vehicles. The number of standard axles per each type of truck will be calculated on the basis of results obtained. The data collected will be analysed and VDF will be worked out for design of pavement.

The Axle Load survey has been conducted at following location on the Project Highway.

Table No. 5.37

Location of Axle Load Survey

Sr. No.	Location of Axle Load Survey
1	At Ch. 6/900 Km near Sankvar Bus Stop

The numbers of vehicles surveyed in Axle load survey are as follows;

Table No. 5.38

Bus	**74**
LCV	**83**
2 Axle	**453**
3 Axle	**124**
Multi Axle	**65**

5.10.1 Analysis of Axle Load Survey Data:

A Methodology:

Axle load survey was carried out on random sampling basis. Selected categories of goods vehicles and buses were stopped using police help. The enumerators guided the front wheel of the vehicle slowly on the calibrated Axle Load Pad and the readings were recorded on the specially designed format once the readings got stabilized. The vehicle was directed to move ahead slowly till the rear wheel properly mounted on the axle pad. The procedure was repeated while recording

the readings on the meter. In case of tandom axles, the second, third and subsequent axles were also directed on the Axle Load Pad in sequential manner and the measurements of weights were repeated. The survey was carried out for vehicles in both directions. The axle pad used was WL 103 Wheel Load Weigher of Haeni Company made in Germany which is a portable low profile instrument designed for the fast and accurate measurements of wheel, axle and total load of vehicles having tyred wheels. It comprises of a flat weighing platform with a laterally connected indicating device. The WL 103 Wheel Load Weigher has a maximum capacity of weighing 15 tonnes and minimum 50 kg.

B Analysis:

The objective of analysis is to estimate the Vehicle Damage Factor (Mode wise) in either direction as well as a weighted value for both directions. The aim of estimating mode wise VDF is to judge the extent of damages by different categories of goods vehicles having varying load patterns. In order to convert the axle load data into number of Equivalent Standard Axle Loads (ESALs) the axle loads were grouped in the interval of 0.90 Tonne. The equivalency factors derived from the "Forth Power Rule" was multiplied with the frequency of that class interval to achieve the equivalent standard axle load for the weight class of the sample by using the following formulae as given in para 5.4.3 of IRC: 37-2012.

Single axle with single wheel on either side $= \frac{(\text{axle load in KN})^4}{65}$

Single axle with dual wheel on either side $= \frac{(\text{axle load in KN})^4}{80}$

Tandem axle with dual wheel on either side $= \frac{(\text{axle load in KN})^4}{148}$

Tridem axle with dual wheels on either side $= \frac{(\text{axle load in KN})^4}{224}$

The summation of ESALs of all categories giving the total of ESALs for total vehicles has been considered.

The Vehicle Damage Factor (VDF) for each direction was obtained by dividing the Total ESALs by the number of vehicles surveyed. Heavy loading was observed in 2/3 axle trucks. Following table gives the V.D.F. of each type of commercial vehicle.

VDF values for diff. categories of Vehicles

Table No. 5.38

Traffic Direction	VDF	
	Traffic Direction	
	Ponda to Madgaon	Madgaon to Ponda
2 Axle	3.18	1.17
3 Axle	1.70	4.05
Multi Axle	3.09	2.47
Bus	1.64	1.30
LCV	0.25	0.18

5.11 CONCLUSIONS:

The conclusions of various traffic surveys carried out at site are as given below.

1. The Annual Average Daily Traffic on the Project road is as follows:

Table 5.39

Annual Average Daily Traffic on Project Road

Survey Location	AADT (Vehicles per Day)	AADT (PCU per Day)
NH-17B Zuari River Bridge		
Ch. 8/550	29794	33990

Source: Traffic Survey, November 2016.

2. Presently, commercial heavy vehicles are not allowed on existing Zuari Bridge at Cortalim along Panvel - Manglore National Highway 17, so vehicles coming from Panaji, Konkan, Mumbai and leading to Verna IDC, Vasco Airport, Madgaon and vice versa diverted to project route NH17-B via Ponda-Borim-Arlem Bypass-Verna IDC. As construction of new bridge across Zuari River on Panvel to Manglore road (NH-17) is in progress which will open for traffic before our project

route completion. So, this traffic i.e. 4965 PCU/Day will get diverted in future on NH-17.

3. After Diversion of traffic in future the Annual Average Daily Traffic on Project Road will be as shown in table below:

Annual Average Daily Traffic on Project Road

Table 5.40

Survey Location	AADT (Vehicles per Day)	AADT (PCU per Day)
NH-17B Zuari River Bridge		
Ch 8/550	28311	29025

Source: Traffic Survey, November 2016.

4. Local light vehicular (passenger) traffic from crossing existing bridge & leading to Margao & vice versa is more than 15000 PCU/day (calculated based on turning movement survey). Rehabilitation of existing Zuari Bridge at Borim has been carried out by the NH PWD Goa recently. If it is presumed that this bridge will serve the light vehicular for another next 15 years, then this light vehicular traffic will prefer use of existing Zuari Bridge. **In such case, initial traffic on proposed Zuari Bridge may remain 29025 – 15000 = 14025 PCU/ day**. Considering this, 4 lane divided carriageway will be sufficient till next 15 years.

5. The Grade separation is not required at any of the junctions on Project Highway as per turning movement survey. But existing NH project road intersects with newly declared NH at Bythakol junction, Grade Separator is proposed at this junction.

6. O-D Survey carried out at Ch. 6/900 along project corridor shows that most of the traffic on the project corridor is of local nature i.e. interstate traffic. Due to absence of missing link between Loutolim and Verna, the commercial traffic leading to Verna Industrial Estate / Port etc. are being used longer route via Arlem bypass. After completion of the proposed (new) Bridge across River Zuari on NH-17 B, there will be substantial saving in time, fuel & cost in transportation of commercial vehicles.

Chapter – 6

TRAFFIC FORECAST

6.0 TRAFFIC FORECAST

6.1 Approach:

Long term forecasting of traffic on the project road during the time horizon of the study is required for design of highway and assessing the economic and financial viability of the proposed investment. To establish future traffic growth rates, following approaches have been explored;

i) Past trend in traffic growth on project road
ii) Growth of registered motor vehicles
iii) Transport demand elasticity approach (As per IRC:108-2015)

The transport demand elasticity method is a proven technique worldwide and is also the preferred technique in India. We have made efforts to build time series past traffic data for the project road from the available data. Similarly, time series past data on population, State Income (NSDP) and Per Capita Income for Goa state has been developed. The projected growth rates worked out for major vehicles groups such as Cars, Buses, 2 Wheelers, and Trucks are used for "Traffic Forecast".

6.2 Past Trend in Traffic Growth on Project Road.

Traffic growth on a road facility is generally estimated on the basis of historical trends. Accordingly, consultants tried to collect the past traffic data from PWD, Goa. The traffic data for project roads is available for last one year only. As such, in absence of past traffic data, the past trend in traffic growth rate cannot be worked out.

6.3 Growth rates based on vehicle registration.

An alternative approach is to explore the registered motor vehicles growth in the influence area and assume a growth rate equal to the average growth rate of vehicles registration. Such assumption may not be correct, unless the area of influence is well defined and the general development pattern of influence area remains the same. However, this would be an alternative approach in the absence of any additional information or past traffic data on the project road. It is observed that major passenger as well as commercial traffic is destined / originating within Goa state and thus there is strong influence of number of registered vehicles in Goa on traffic on the project road. The growth rates for various categories of the vehicles for the year 2009-10 to year 2013-14 in Goa state are presented in the following Table.

Table - 6.1
Growth rates of vehicles registered in Goa State

Year	Two Wheeler	Three Wheeler	Car	Bus	Goods Vehicle	Tractor & Others
2009-10	-	-	-	-	-	-
2010-11	8.4 %	2.9 %	11.7 %	6.8 %	9.6 %	12.8 %
2011-12	9.2 %	2.1 %	11.1 %	6.0 %	10.3 %	7.8 %
2012-13	8.5 %	2.6 %	10.0 %	4.7 %	4.5 %	5.2 %
2013-14	7.9 %	3.3 %	8.1 %	9.7 %	2.6 %	4.4 %
Average	**8.5 %**	**2.7 %**	**10.2 %**	**6.8 %**	**6.7 %**	**7.5 %**

Source: Motor Transport statistics of Goa

It can be observed from the above table, during the above 5 years, average growth rate for Cars is 10.20%. The high growth rate more than 10% may not sustain in future. Therefore, other rational approaches are to be explored in order to derive realistic growth rates.

6.4 Transport Demand Elasticity Approach.

The exercise of traffic growth rate estimation has been carried out by using the elasticity approach as per IRC: 108-2015. The elasticity model relates traffic growth to changes in related economic parameters. Elasticity in the present context is defined as the ratio of percentage change in traffic to the percentage change in socio-economic parameters. The regression equation to express dependent variable in terms of one more independent variable is developed. The preferred dependent variable would have been past traffic on the project road. However, due to non availability of past traffic data on project roads, number of registered motor vehicles in influence area (Goa state) is taken as dependent variable, the independent variables are socio-economic parameters. The choice of independent variable depends upon vehicles type under consideration. It is logical to relate growth in Cars and Two Wheelers with NSDP and Per Capita Income, Buses with NSDP and population and commercial vehicle growth with NSDP, industrial and agriculture output. The analysis of O-D survey data along the project road indicates a strong influence of Goa State in major traffic generation of passenger as well as commercial traffic on the project road either originating from or destined to various parts of Goa. As traffic contribution is mainly from Goa State, the transport demand elasticity's have been developed with respect to economic indicators of Goa. The methodology involved fitting log-log

regression equations to the time series data. NSDP, Population and Per Capita Income in Goa are considered as independent variables for passenger and commercial vehicles. Elasticity values for registered motor vehicles with respect of NSDP, Population and Per Capita Income are worked out.

The projected growth rates worked out for major vehicle groups such as Car, Bus, Two Wheelers and Trucks were further moderated to detailed vehicle categories considering The likely future shift among the vehicle categories. The probable structural shift and Modal choice of vehicle ownership from 2 axle trucks to multi axle vehicles and 2-3 Wheeler market to Cars have been taken into account while moderating the elasticity values. This is considered necessary as the purchasing power increases; there will be a shift from low cost vehicle to high speed, more expensive and better comfortable vehicles. Further, with the road improvement and realisation of economics of scale, goods operators will tend to transfer from 2 axle trucks to multi axle vehicles. These market driven forces have been realistically considered in the traffic forecast.

6.4.1 Past Trend in Growth of Economy.

The average growth rate per annum of NSDP for Goa State is 16.60%. The NSDP for Goa State is given in following table.

Table - 6.2
NSDP for Goa State

Year	NSDP for Goa State (in Lacs)	% Growth
2004-05	1099900	
2005-06	1248800	13.54%
2006-07	1439400	15.26%
2007-08	1704500	18.42%
2008-09	2214900	29.94%
2009-10	2522400	13.88%
2010-11	2938700	16.50%
2011-12	3806100	29.52%
2012-13	3703500	-2.70%
2013-14	4256400	14.93%
Average	**-**	**16.60%**

Table - 6.3
Economic Indicators for Goa State

Year	Population	PCI (Rs.)	NSDP (Rs. In lacs)
2004-05	1391349	76968	1099900
2005-06	1402402	84721	1248800
2006-07	1413543	94882	1439400
2007-08	1424773	108708	1704500
2008-09	1436092	135966	2214900
2009-10	1447501	149164	2522400
2010-11	1459000	168024	2938700
2011-12	1470591	211570	3806100
2012-13	1482274	200514	3703500
2013-14	1494049	224138	4256400

6.5 Per Capita Income

The data related to Per Capita Income for Goa State is collected for duration of 10 years as given below.

Table - 6.4
Per Capita Income of Goa State

Year	Per capita State Income (Rs.)	% Growth
2004-05	76968	
2005-06	84721	10.07
2006-07	94882	11.99
2007-08	108708	14.57
2008-09	135966	25.07
2009-10	149164	9.71
2010-11	168024	12.64
2011-12	211570	25.92
2012-13	200514	-5.23
2013-14	224138	11.78
	Average	**12.95**

6.6 Past Trend in Growth in Population

Total population of Goa as per census of year 2011 is 14.59 lacs. It constitutes 0.12% of India's population. The growth of total population of India and that of Goa State for a period of 10 years intervals is as shown in table below.

Table - 6.5
Population Growth

Year	India		Goa	
	Population in lacs	**% growth for 10 years**	**Population in lacs**	**% growth for 10 years**
1961	4392.00	-	5.90	-
1971	5481.60	24.81%	7.95	34.75%
1981	6833.30	24.66%	10.08	26.79%
1991	8335.30	21.98%	11.70	16.07%
2001	10290.00	23.45%	13.48	15.21%
2011	12102.00	17.61%	14.59	8.23%
Average for 10 years interval		**22.50%**	**-**	**20.21%**
Average per year		**2.25%**	**-**	**2.02%**

6.7 Elasticity Values

Elasticity value is the factor by which social-economic growth rate is multiplied to get the traffic growth rate. Traffic is directly linked to the economic growth such as per Capita Income, Population, and NSDP/GSDP. Considering time series data on category wise registered vehicles and economic variables, by regression analysis values are estimated for each class of vehicles and given table below.

Table - 6.6

Future Growth of Elasticity values

Sr. No	Vehicle Type	Elasticity Values											
		Pessimistic Approach				Normal Approach				Optimistic Approach			
		2017-21	2022-26	2027-31	Beyond 2031	2017-21	2022-26	2027-31	Beyond 2031	2017-21	2022-26	2027-31	Beyond 2031
1	**2 Wheeler**	0.60	0.54	0.49	0.44	0.71	0.64	0.57	0.52	0.82	0.73	0.66	0.60
2	**Car**	0.73	0.65	0.59	0.53	0.85	0.77	0.69	0.62	0.98	0.88	0.80	0.72
3	**Bus**	6.77	6.09	5.48	4.93	7.96	7.16	6.45	5.80	9.16	8.24	7.42	6.67
4	**Truck**	0.52	0.47	0.42	0.38	0.61	0.55	0.50	0.45	0.70	0.63	0.57	0.51

6.8 Future Economic Growth

Any agenda for future growth of the state economy has to take into account past trends and future prospects. The growth prospect for the state have been developed taking into consideration the past performance of the state economy and economic growth envisaged for the future. The pace with which the regional economies grow with the envisaged growth of the state is a major contributing factor in growth of traffic. The growth of NSDP of Goa from 2004-05 to 2013-14 has been 16.0% considering future target of NSDP a growth of 14.0%, 14.70%, 13.90% and 12.50% is assumed for the four periods. The population growth rate of 1.03% to 0.83% has been assumed. The growth of PCI has been taken as 12.0% to 10.77%.

Table - 6.7
Future Growth of Economic Indicators

Sr. No	Vehicle Type	Economic Indicators											
		Pessimistic Approach				Normal Approach				Optimistic Approach			
		2017-21	2022-26	2027-31	Beyond 2031	2017-21	2022-26	2027-31	Beyond 2031	2017-21	2022-26	2027-31	Beyond 2031
1	2 Wheeler (PCI)	10.20	10.71	10.17	9.16	12.00	12.60	11.97	10.77	13.80	14.49	13.77	12.39
2	Car (PCI)	10.20	10.71	10.17	9.16	12.00	12.60	11.97	10.77	13.80	14.49	13.77	12.39
3	Buses (POP)	0.87	0.87	0.78	0.71	1.03	1.03	0.92	0.83	1.18	1.18	1.06	0.95
4	Truck (NSDP)	11.90	12.50	11.87	10.68	14.00	14.70	13.97	12.57	16.10	16.91	16.06	14.45

The estimated traffic growth rates are arrived by multiplying elasticity values and growth rates in economic indicators.

6.9 Traffic Growth Rates

Vehicles registration data represents all vehicles registered in the state but does not indicate actual number of vehicles plying on the road owing to vehicles taken off the road due lack of fitness certificates. Hence, elasticity values based on registration data are usually higher than those based on actual traffic. Hence, there is need to moderate values obtained from registration data. In order to arrive at realistic future elasticity's for the project road, various factors relating to vehicle technology changes besides character of traffic and travel pattern in the project road are to be considered.

- High elasticity of cars being witnessed now is because of large demand facilitated by financing schemes and loans. Factors like growth of household incomes (particularly in urban areas), reduction in the prices of entry-level cars, growth of the used car market, changes in life style, growing personal incomes, desire to own a vehicle facilitated by availability of loans/financing schemes on easy terms, etc. have all contributed to the rapid growth in ownership of cars. However, such trend would slow down and elasticity can be expected to decline. In view of this, elasticity values obtained by using registration data have been moderated for future years.

- Over the years, there is a change in passenger movement with more and more persons shifting towards personalized modes. Moreover, buses are usually plying on fixed pre-decided routes and thus elasticity values for buses have been considered accordingly.

- With the changing freight vehicle mix in favour of LCV for short distance traffic and 3-axle/MAV for long-distance traffic, higher elasticity values for these have been considered as compared to 2-axle trucks. Considering the ongoing technical advancements in automobile industry, some of the standard two axle trucks would gradually be replaced by three axle truck and MAVs, leading to reduction in number of trucks. Considering the economic indicators of Goa, the projected elasticity values for various vehicle types are presented, which have been used to estimate the growth rates of each vehicle type.

  Based on elasticity values and the projected economic/ demographic indicators, the future average annual compound traffic growth rates by vehicle type for the different approaches i.e. pessimistic, normal and optimistic approach are as given below.

Table - 6.8

Traffic Growth rates for various approaches

Sr. No	Vehicle Type	Projected Annual Traffic Growth Rates											
		Pessimistic Approach				Normal Approach				Optimistic Approach			
		2016-21	2022-26	2027-31	Beyond 2031	2016-21	2022-26	2027-31	Beyond 2031	2016-21	2022-26	2027-31	Beyond 2031
1	**2 Wheeler (PCI)**	6.0	4.8	3.8	3.4	7.0	5.60	4.5	4.0	8.1	6.4	5.2	4.6
2	**Car (PCI)**	6.4	5.1	4.3	3.4	7.5	6.0	5.0	4.0	8.6	6.9	5.8	4.6
3	**Buses (POP)**	3.4	3.1	2.7	2.6	4.0	3.6	3.2	3.0	4.6	4.1	3.7	3.5
4	**Truck (NSDP)**	4.3	3.8	3.4	3.0	5.0	4.50	4.0	3.5	5.8	5.2	4.6	4.0

6.10 Induced Traffic on Project Road

When the project road is improved, it will enable much lower travel time and transportation cost and improved riding comfort. This would attract traffic from surrounding road network of the project road. In this case, the present condition of road in terms of riding quality is satisfactory. As such, after improvement of the project road, it is presumed that there will be no increase in traffic volume on Project roads and the traffic will play in the same manner as that plying presently.

6.11 Diverted Traffic from Project road.

Presently, commercial heavy vehicles are not allowed on existing Zuari Bridge at Cortalim along Panvel - Mangalore National Highway 17, so vehicles coming from Panaji, Konkan, Mumbai and leading to Verna IDC, Marmagoa port, Vasco Airport, Madgaon and vice versa are diverted on project route NH17-B via Ponda-Borim-Arlem Bypass-Verna IDC. As construction of new bridge across Zuari River on Panvel to Manglore road (NH-17) is in progress which will open for traffic before completion of this project. So, this traffic i.e. 4965 PCU/Day will get diverted in future.

6.12 Projected Traffic

The following tables give the projected traffic on the project road based on the normal and most realistic approach.

Table - 6.9

Traffic Projection at Ch. 8/550

Year	Two Wheeler	Auto Rickshaw	Car/Vans/Jeeps/Taxi	6 Seater	Mini Bus	Govt. Bus	Pvt. Bus	Goods Auto	LCV	2-Axle Truck	3-Axle Truck	Multi Axle Truck	Const. Equipments	Govt. Vehicles	Ambulance	Fire Fighting	Agri. Tractor with trailer	Agri. Tractor without trailer	Cycle	Cycle Rickshaw	Animal cart	Hand Cart	Total Vehicles per day	Total PCU per Day
2016-17	**13027**	**4**	**10986**	**347**	**87**	**160**	**529**	**0**	**856**	**1770**	**297**	**224**	**5**	**0**	**0**	**0**	**4**	**1**	**14**	**0**	**0**	**0**	**28311**	**29036**
2017-18	13939	5	11810	354	91	167	551	0	899	1859	312	236	6	0	0	0	5	2	15	0	0	0	**30251**	**30881**
2018-19	14915	6	12696	362	95	174	574	0	944	1952	328	248	7	0	0	0	6	3	16	0	0	0	**32326**	**32843**
2019-20	15960	7	13649	370	99	181	597	0	992	2050	345	261	8	0	0	0	7	4	17	0	0	0	**34547**	**34936**
2020-21	17078	8	14673	378	103	189	621	0	1042	2153	363	275	9	0	0	0	8	5	18	0	0	0	**36923**	**37169**
2021-22	18274	9	15774	386	108	197	646	0	1095	2261	382	289	10	0	0	0	9	6	19	0	0	0	**39465**	**39546**
2022-23	19298	10	16721	408	112	205	670	0	1145	2363	400	303	11	0	0	0	10	7	21	0	0	0	**41684**	**41667**
2023-24	20379	11	17725	431	117	213	695	0	1197	2470	418	317	12	0	0	0	11	8	23	0	0	0	**44027**	**43896**
2024-25	21521	12	18789	456	122	221	721	0	1251	2582	437	332	13	0	0	0	12	9	25	0	0	0	**46503**	**46248**
2025-26	22727	13	19917	482	127	229	747	0	1308	2699	457	347	14	0	0	0	13	10	27	0	0	0	**49117**	**48721**
2026-27	24000	14	21113	509	132	238	774	0	1367	2821	478	363	15	0	0	0	14	11	29	0	0	0	**51878**	**51330**
2027-28	25080	15	22169	538	137	246	799	0	1422	2934	498	378	16	0	0	0	15	12	31	0	0	0	**54290**	**53653**
2028-29	26209	16	23278	569	142	254	825	0	1479	3052	518	394	17	0	0	0	16	13	33	0	0	0	**56815**	**56081**
2029-30	27389	17	24442	601	147	263	852	0	1539	3175	539	410	18	0	0	0	17	14	35	0	0	0	**59458**	**58620**
2030-31	28622	18	25665	635	152	272	880	0	1601	3302	561	427	20	0	0	0	18	15	37	0	0	0	**62225**	**61279**
2031-32	29910	19	26949	671	157	281	909	0	1666	3435	584	445	22	0	0	0	20	16	40	0	0	0	**65124**	**64067**
2032-33	31107	20	28027	709	162	290	937	0	1725	3556	605	461	24	0	0	0	22	17	43	0	0	0	**67705**	**66540**
2033-34	32352	21	29149	749	167	299	966	0	1786	3681	627	478	26	0	0	0	24	18	46	0	0	0	**70389**	**69110**

Year	Two Wheeler	Auto Rickshaw	Car/Vans/Jeeps/Taxi	6 Seater	Mini Bus	Govt. Bus	Pvt. Bus	Goods Auto	LCV	2-Axle Truck	3-Axle Truck	Multi Axle Truck	Const. Equipments	Govt. Vehicles	Ambulance	Fire Fighting	Agri. Tractor with trailer	Agri. Tractor without trailer	Cycle	Cycle Rickshaw	Animal cart	Hand Cart	Total Vehicles per day	Total PCU per Day
2034-35	33647	22	30315	791	173	308	995	0	1849	3810	649	495	28	0	0	0	26	20	49	0	0	0	**73177**	**71769**
2035-36	34993	23	31528	836	179	318	1025	0	1914	3944	672	513	30	0	0	0	28	22	52	0	0	0	**76077**	**74537**
2036-37	36393	24	32790	883	185	328	1056	0	1981	4083	696	531	32	0	0	0	30	24	55	0	0	0	**79091**	**77408**
2037-38	37849	25	34102	933	191	338	1088	0	2051	4226	721	550	34	0	0	0	32	26	59	0	0	0	**82225**	**80389**
2038-39	39363	26	35467	986	197	349	1121	0	2123	4374	747	570	36	0	0	0	34	28	63	0	0	0	**85484**	**83488**
2039-40	40938	27	36886	1042	203	360	1155	0	2198	4528	774	590	39	0	0	0	36	30	67	0	0	0	**88873**	**86709**
2040-41	42576	28	38362	1101	210	371	1190	0	2275	4687	802	611	42	0	0	0	39	32	71	0	0	0	**92397**	**90057**
2041-42	44280	29	39897	1163	217	383	1226	0	2355	4852	831	633	45	0	0	0	42	34	75	0	0	0	**96062**	**93538**
2042-43	46052	30	41493	1229	224	395	1263	0	2438	5022	861	656	48	0	0	0	45	36	80	0	0	0	**99872**	**97150**
2043-44	47895	31	43153	1298	231	407	1301	0	2524	5198	892	679	51	0	0	0	48	39	85	0	0	0	**103832**	**100896**
2044-45	49811	32	44880	1371	238	420	1341	0	2613	5380	924	703	54	0	0	0	51	42	90	0	0	0	**107950**	**104790**
2045-46	51804	33	46676	1448	246	433	1382	0	2705	5569	957	728	58	0	0	0	54	45	96	0	0	0	**112234**	**108840**

The above projected traffic is based on present traffic volume (after deduction of diverted traffic). However, as explained in Chapter 5, Sr. No. 5.11, Local light vehicular (passenger) traffic from crossing existing bridge & leading to Margao & vice versa is more than 15000 PCU/day (calculated based on turning movement survey). Rehabilitation of existing Zuari Bridge at Borim has been carried out by the NH PWD Goa recently. If it is presumed that this bridge will serve the light vehicular for another next 15 years, then this light vehicular traffic will prefer use of existing Zuari Bridge. In such case, initial traffic on proposed Zuari Bridge may remain 29025 – 15000 = 14025 PCU/ day. Considering this, 4 lane divided carriageway will be sufficient till next 15 years.

Chapter – 7

IMPROVEMENT PROPOSAL & DESIGN

7.0 IMPROVEMENT PROPOSAL AND DESIGN

7.1 General:

The Project road is a section of NH-17B (NH-566). NH-17B which is declared as National Highway in July 1999 originates from intersection with NH-4A at Farmagudi (Ponda), proceeding via. Borim, Loutulim, Verna & terminating at Marmagoa port. There is missing link of this NH between village Loutulim & Verna Industrial Estate.

The Project road under consideration is located between Km. 3/860 to Km. 11/860 of NH-17B i.e. 8 Km. The project corridor located in two districts South Goa & North Goa out of which majority length passes through North Goa district.

- At present, improvement of section of NH-17B (NH-566) from Farmagudi to Davli Bypass junction i.e. stretch before start of project road under consideration (km. 0/00 to Km. 3/860) to 4 lane divided carriageway is in progress.
- Also, construction of 4 lane divided carriageway road from Loutolim to Verna (Missing link) i.e. stretch is in progress.
- Existing bridge across River Zuari at Borim was constructed in 1986. Now, typical problems manifested in the balance cantilever prestressed span of the existing bridge.
- Hence, it is decided to construct a new bridge across River Zuari at Borim including approaches with minimum 4 lane divided carriageway configuration.
- Accordingly, after study of various alternative alignments, it is proposed to construct a new high level bridge across River Zuari at a distance of about 1700m at D/s side of existing bridge.
- In the above mentioned proposal, approaches involving realignment/ new alignment are proposed.
- The detailed improvement proposal is discussed in this chapter.

7.2 Design Standards:

The standards prescribed in IRC / MoRT&H / BIS are adopted in general. Where Indian standards are silent or where required under TOR, the applicable sections of AASHTO / BS / ASTM are adopted for design.

Considering the physical condition and cost effectiveness, the improvement proposals are conceived and developed under following standards.

i) The minimum desirable standards, which could be adopted as a rule.

ii) The absolute minimum standards, which could be accepted for difficult stretches where application of the minimum desirable standards, would lead to exorbitant costs.

Accordingly, design standards for geometric elements have been proposed under "minimum desirable" and "absolute minimum" categories. These proposed standards are consistent with and fall within the parameters recommended in the IRC:SP-73-2015. The proposal is finalized in accordance with IRC:SP:84-2014 manual. The deviations which are inevitable due to various constraints the same will be given separately in contract document (Schedule – D).

As far as possible, first preference is given to adopt desirable design speed for design of geometrics. Where desirable design speed is not possible to accommodate the proposed corridor in the available/ existing ROW, second preference is given to minimum design speed as specified above. Where, both desirable as well as minimum design speed specified in manual is not possible to accommodate the corridor in the available/ existing ROW, third preference is given for the lesser design speed.

Table No. 9.1 gives the design standards proposed to be adopted for the Project highway.

Table 7.1

Design standards

Sr. No.	Element	Proposed Design Standards		Reference to IRC
		Desirable/ Ruling	Minimum	
1.	**Design speed (km/hour)**			
	Plain and rolling terrain	100	80	IRC:SP:84 -2014
2.	**Sight Distance (m)**			
	Design speed 100 km/hr.	360 m	180 m	IRC:SP:84 -2014
	Design speed 80 km/hr.	260 m	130 m	
3.	**Horizontal alignment**			
	• Minimum radius of curve			IRC:SP:84 -2014
	• Plain & rolling terrain	400m	250m	
	• Super elevation	For road:- i) Limited to 7%, if radius of curve is less than desirable minimum and		IRC:SP:84 -2014

Sr. No.	Element	Proposed Design Standards		Reference to IRC
		Desirable/ Ruling	**Minimum**	
		shall be limited to 5% if radius of curve is more than desirable minimum. ii) For structures - 4% (Maximum)		
	• Radii beyond which no super elevation is required Speed 100 km/hr Speed 80 km/hr	 1800 m 1100 m		 IRC:SP:84 -2014 IRC: 38-1988
4.	**Vertical Alignment**			
	• **Gradient**			
	Plain and Rolling	2.5%	3.3%	IRC:SP:84 -2014
	Mountainous	5.0%	6.0%	
	• **Vertical curves**			IRC:SP-23
	Summit curve	**Minimum length**		
	Speed 100 km/hr	135 x A	73.6 x A	
	Speed 80 km/hr	60 x A	32.6 x A	
	Speed 65 km/hr	33.8 X A	18.4 X A	
	Speed 60 km/hr	26.7 X A	14.5 X A	
	Speed 50 km/hr	15.0 X A	8.2 X A	
	Speed 40 km/hr	8.4 X A	4.6 X A	
	Valley curve			
	Speed 100 km/hr	-	41.5 x A	
	Speed 80 km/hr	-	25.3 x A	
	Speed 65 km/hr	-	17.4 x A	
	Speed 60 km/hr	-	15.0 x A	
	Speed 50 km/hr	-	10.0 X A	
	Speed 40 km/hr	-	6.6 X A	
	A = Algebraic difference in grades expressed in percentage.			
5.	**Cross–sectional elements**	**For 2 Lane road**	**4 Lane road**	

Sr. No.	Element	Proposed Design Standards		Reference to IRC
		Desirable/ Ruling	**Minimum**	
	• Carriageway • Paved Shoulder (on both side) • Paved area (in built-up section)	7.0 m 1.5 m 2 x 1.0m	2 x 7.0 m 1.5 m ---	IRC:SP-73 & IRC:SP-84
	Cross–sectional elements	**For 2 Lane road**	**4 Lane road**	
	• Earthen Shoulder (on both sides) • Median (Raised)	2.0 m ---	2.00 2.5m (Built-up area)	
	• Total formation width	14.0 m	26.00 m	
	• **Camber** Main carriageway Paved shoulders Earthen shoulder	 Min. 2.5 % for BT road Min. 2.0 % for CC road Same as per pavement 3.0% or 0.5 % steeper than slope of paved shoulder.		
	• **Side slope for Fill**			
	• Fill section	2H:1V		
	• **Cut portion**			
	• Soil	2H:1V		
	• Soft disintegrated rock	1H:2V		
	• Hard rock	1H:4V to near vertical		
6.	**Intersections**	As per manual & standard drawings of MoRT&H		IRC:SP-41 and Type designs of junctions prepared by MoRTH

7.2.1 Design of structures:

It shall be ensured that the superstructure and substructure proposed for new bridges are made aesthetically pleasing. The form selected shall be innovative and cost effective. Design of proposed structures and preparation of their General Arrangement Drawing (GAD's) shall be as per provisions contained in the following IRC Codes.

Table 7.2

Standard Specifications and Codes of Practice for Road Bridges

IRC: 5-2015	Standard Specifications and Code of Practice for Road Bridges. Section-I - General Features of Design.
IRC: 6-2014	Standard Specifications and Code of Practice of Road Bridges. Section – II - Loads and Stresses
IRC: 112-2011	Code of Practice for Concrete Bridges.
IRC:22-2015	Composite construction for road bridges. (Section VI – Composite Construction)
IRC: 78-2014	Standard Specifications and Code of Practice for Road Bridges. Section – IV - Foundations and Substructure.
IRC: 83-2015	Standard Specifications and Code of Practice for Road Bridges, Section-IX - Bearings Part – I - Metallic Bearings.
IRC: 83-2015	Standard Specifications and Code of Practice for Road Bridges, Section-IX-Bearings Part – II – Elastomeric Bearings.
IRC: 83-2002	Standard Specifications and Code of Practice for Road Bridges, Section-IX-Bearings Part – III – POT, POT cum PTFE, PIN and Metallic Bearings.
IRC: SP-37-2010	Evaluation of load carrying capacity of bridges.
IRC:40-2002	Standard Specifications and Code of Practice for Road Bridges, Section IV – Brick, Stone and Block Masonry (Second Revision)

IRC-54-1974	Lateral and Vertical Clearances at Underpasses for Vehicular Traffic.
IRC:89-1997	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)
IRC:SP:18-1978	Manual for Highway Bridge Maintenance Inspection
IRC:SP:40-1993	Guidelines on Techniques for Strengthening and Rehabilitation of Bridges
IRC:SP:51-2015	Guidelines for Load Testing of Bridges (First Revision)
IRC:SP:64-2005	Guidelines for the Analysis and Design of Cast-in-Place Voided Slab Superstructure
IRC:SP:65-2005	Guidelines for Design and Construction of Segmental Bridges
IRC:SP:66-2005	Guidelines for Design of Continuous Bridges
IRC:SP:67-2005	Guidelines for Use of External and Unbonded Prestressing Tendons in Bridge Structures
IRC:SP:69-2011	Guidelines & Specifications for Expansion Joints (First Revision)
IRC:SP:71-2006	Guidelines for Design and Construction of Pretensioned Girder of Bridges
IRC:SP-90-2010	Manual for Grade Separators and Elevated Structures
IRC:SP-102-2014	Guidelines for Design and Construction of Reinforced Soil Walls

Apart from this, other relevant National and International codes for good engineering practice shall also be followed.

Typical cross sections of structures proposed to be followed have been presented in a separate volume i.e. "Volume of Drawings" in GAD of corresponding structure.

7.2.2 Pavement Design:

a) The pavement design for new construction/ reconstruction/ widening of road as per IRC: 37- 2012 is done and as given below;

Table 7.3
Calculation of MSA

Description	**Stretch**		
	Dhavli Bypass junction to Loutolim		
Traffic – A	**Ponda to Margao**	**Margao to Ponda**	**Higher Traffic in one direction adopted for design**
Buses	425	351	425
LCV	495	361	495
2 Axle	1510	1406	1510
3 Axle	267	222	267
Multi axle	195	174	195
Total Commercial Traffic (CVPD)	**2892**	**2514**	**2892**
Traffic growth rate – r			
Buses	4.5 %		
LCV	16.5%		
2 Axle	7.2%		
3 Axle	7.2%		
Multi axle	7.2%		
Construction Period	**2 Years**		
Initial Traffic (CVPD)			
Lane distribution – factor - d	0.75		
Design Period	15 years		
VDF (F)	**Ponda to Margao**	**Margao to Ponda**	**Adopted for Design**
Buses	1.64	1.30	1.64
LCV	0.25	0.18	0.25
2 axle	3.18	1.17	3.18
3 axle	1.70	4.05	4.05
Multi axle	3.09	2.47	3.09
Cumulative Standard Axles	**58.92 MSA**	**say**	**60 MSA**

$$\text{Cumulative standard Axles MSA} = \frac{365[(1+r)^n - 1] \times d \times F \times A}{r \times 1000000}$$

The C.B.R of borrow material is more than 8% & C.B.R. of existing subgrade (which is proposed to retain) observed as 8% and onwards. Hence, the value of CBR for design of crust is considered as 8%.

- As per traffic survey, the cumulative number of standard axles (MSA) for project highway works out to 58.92 MSA (Maximum).
- As per IRC:SP:73-2015 Manual, minimum traffic of 20 MSA shall be taken if actual traffic is less than 20 MSA.
- Since, projected traffic in the project corridor is 58.92 MSA, it is proposed to adopt traffic of 60 MSA for pavement design..

Crust required as per IRC-37 for C.B.R of 8% and traffic of 60 MSA calculated as per Plate No. 6 of IRC:37 – 2012 is given in Table 9.4

Table 7.4 a

Crust for Road - Flexible Pavement
Main Carriageway & Slip Road

Crust Component	**Crust Thickness**
Bituminous concrete (BC)	40 mm
Dense Bituminous Macadam (DBM)	105 mm
Wet Mix Macadam (WMM)	250 mm
Granular Sub-base (GSB)	200 mm
Total	**595 mm**

Table 7.4 b

Crust for Road - Flexible Pavement
Service Road – for 10 MSA traffic as per manual

Crust Component	**Crust Thickness**
Bituminous concrete (BC)	40 mm
Dense Bituminous Macadam (DBM)	60 mm
Wet Mix Macadam (WMM)	250 mm
Granular Sub-base (GSB)	200 mm
Total	**550 mm**

b) The crust required for cement concrete pavement for 30 years design life is determined as per IRC:58 - 2015 and is as given below;

Table 7.5

Crust for Cement Concrete Road

Crust Component	Crust Thickness
Pavement Quality Concrete (PQC)	300 mm
Dry Lean Concrete (DLC)	150 mm
Granular Sub-base (GSB)	200 mm

7.2.3 Type of Pavement:

For the stretch under consideration, it is recommended to adopt flexible pavement considering the followings;

i) The adjoining stretches before start of project corridor and after end of project corridor, work of 4 laning with flexible pavement is under progress.

ii) There is high embankment in the approaches of the proposed bridge & there is water logged area involving clay soil.

7.3 Proposal for New Major Bridge Across River Zuari:-

7.3.1 The major component of this project is proposed major bridge across River Zuari in Lieu of existing major Bridge. Various alternative alignments were studied for the proposed bridge and the same are explained in Chapter- 3. Among these, alternative – 7 alignment i.e. alignment at 1700m D/s side from existing bridge is approved by the Client/ Employer. Also, it was decided to propose an iconic bridge at this location. There is navigation of barges in this channel of Zuari River for transportation of Iron Ore from Sanvordem Jetties to Marmagao Port.

7.3.2 Alternatives studied for type of Bridge:-

Three different alternatives for type of superstructure were studied as follows;

- Bridge involving Cable Stayed span with steel superstructure (for navigational span)

- Bridge involving Cable Stayed span with pre-cast PSC Segmental Box Girder superstructure (for navigational span)
- Bridge involving Balance Cantilever Box Girder

Among these alternatives, Cable Stayed Bridge involving pre-cast PSC Segmental Box Girder was recommended by the consultants considering the following points;

i) Since, tourism is a backbone of Economy of Goa; an aesthetically pleasant structure will be highly appreciated at this location. Cable Stayed Bridge with pre-cast PSC segmental box girder will be more aesthetically pleasant structure among these alternatives.

ii) This alternative will be economical as compared to alternative – 1.

iii) Faster construction is possible as compared to balance cantilever structure.

iv) For costal/ marine environment, concrete segment structure will be more durable than steel structure in view of corrosion.

As per recommendations of the consultants, approval is given by the client vide their letter no. F8024/PWD/WDXV/(NH)/ASW/2017-18/464 dated 17th Jan. 2018.

7.3.3 Salient Features of the Proposed Bridge Across River Zuari at Ch. 8/330

For the proposed bridge across River Zuari, 6 lane divided carriageway bridge is proposed. Cross sectional details as per IRC: SP: 84 - 2014, Fig. No. 7.3 i.e. cross sectional of bridge at deck level with footpath of 3 +3 =6 lane standards is adopted. **For General Arrangement Drawing (GAD) of the proposed bridge across River Zuari refer drawing no. 869 – ZB- GAD -001 (R0).** The salient features of the proposed bridge are as follows;

Table 7.6

Total Length	:	905.00 m
Total Width	:	2 x 16.00 m = 32.00 m
Cross Sectional Configuration	:	
Width of carriageway	:	2 x 12.00 m = 24.00 m
Width of crash barrier including shy line	:	2 x 2 x 1.00 m = 4.00 m

Width of footpath	:	2 x 1.50 m = 3.00 m
Width of Railing	:	2 x 0.50 m = 1.00 m
Type of Foundation	:	R.C.C. cast-in-situ bored piles 1500mm dia.
Type of Substructure	:	R.C.C. Pylon – for cable stayed span R.C.C. Pier & pier cap – for viaduct
Type of Superstructure	:	PSC pre-cast Segmental Box Girder
Span Arrangement	:	(1 x 150 m) + (2 x 75 m) + (11 x 55 m)
Obligatory Spans	:	
Navigational Span	:	150m pier c/c (for clear navigational channel of 90 m) in cable stayed with 75 m back spans on either side.
Vertical Clearance for Navigational Span	:	a) 14.00 m between H.T.L. & Lowest soffit of superstructure (as per guidelines received from of Captain of Ports) b) 5.5 m at A1-P1 span – for cross road
Margao down ramp	:	Down Ramp at Loutulim end for traffic leading to Margao Total width - 14.00 m Carriageway – 10.00 m Footpath – 1.50 m Crash barrier + shy line = 2 x 1 m = 2m Railing = 0.5 m

7.4 Proposal for highway including approaches of proposed Zuari bridge:-

7.4.1 Lane configuration for highway:-

- As explained in Chapter 5, present traffic (A.A.D.T.) is 33990 PCU/day.
- Actual traffic after deduction of diverted traffic (A.A.D.T.) will be 29050.
- As per IRC:SP:84 – 2014, Clause No. 2.19 – Warrants for Six-Laning, the project highway shall be widened to 6 laning when total traffic including the traffic on service roads, if any, reaches the design service volume corresponding to Level of services 'C' i.e. 60000 PCU.

- As explained in Table No. 6.9 of chapter 6 of this report, the design service volume will reach up to 60000 PCU in the year 2029-30.
- Also, local light vehicular (passenger) traffic from crossing existing bridge & leading to Margao & vice versa is more than 15000 PCU/day (calculated based on turning movement survey). Rehabilitation of existing Zuari Bridge at Borim has been carried out by the NH PWD Goa recently. If it is presumed that this bridge will serve the light vehicular for another next 15 years, then this light vehicular traffic will prefer use of existing Zuari Bridge. In such case, initial traffic on proposed Zuari Bridge may remain 29025 – 15000 = 14025 PCU/ day. Considering this, 4 lane divided carriageway will be sufficient till next 15 years.
- **Considering the above mentioned traffic scenario, it is proposed to develop the highway stretch under consideration to 4 lane divided carriageway road with paved shoulder configuration as per IRC:SP:84-2014 manual**.
- Other than project highway, down ramp for Bythakol to Margao traffic and one way road for Margao to Bythakol traffic is proposed. For these stretches, 2 lane with paved shoulder configuration road is proposed as per IRC:SP:73 – 2015 manual.

7.4.2 Proposed Cross Sections:

As explained above, it is proposed to upgrade the project stretch as 4 lane divided carriageway road with paved shoulder configuration.

The type cross sections for proposed improvement of highway are prepared as per IRC: SP:84-2014 manual. For stretches other than project highway, typical cross sections are prepared as per IRC:SP:73 – 2015.

Table 7.7
Type Cross sections as per configuration of road

TCS-A	Typical cross section for 4 lane divided carriageway road with paved shoulders, 2 lane one way flyover approach & one side service road configuration (in built-up area)
TCS-B	Typical cross section for 4 lane divided carriageway road with paved shoulders configuration in Open country.
TCS-C	Typical cross section for 4 lane divided carriageway road with paved shoulders configuration & centrally located approach of 6 lane grade separator in Open country.
TCS-D	Typical cross section involving centrally located 6 lane divided carriageway

	with paved shoulder configuration grade separator and slip roads on either side
TCS-E	Typical cross section for 2 lane carriageway road with paved shoulder configuration in Open country.

The proposed cross section as per configuration for various stretches is given below;

Table 7.8
Stretches & Corresponding Type Cross sections as per configuration of road

Design Chainage		Design Length (Km)	TCS adopted	
From 'Km'	To 'Km'			
Project Highway				
3+870	4+318	0.448	TCS – A	4 lane road in Built up section
4+318	5+196	0.878	TCS – B	4 lane road in open country
5+196	5+494	0.298	TCS – C	4 lane road + approach of 6 lane grade separator
5+494	6+210	0.716	TCS - B	4 lane road in open country
6+210	7+214	1.004	TCS -D	6 lane grade separator + slip roads
7+214	7+904	0.690	TCS - B	4 lane road in open country
7+904	8+808	0.904		Proposed 6 Lane River Bridge
8+808	9+020	0.212	TCS - B	4 lane road in open country
9+020	9+599	0.579	TCS -D	6 lane grade separator + slip roads
Margao Down Ramp				
0+165	0+839	0.674	TCS - E	2 lane road with paved shoulder
One way road for Margao to Bythakol Traffic				
0+000	0+331	0.331	TCS - E	2 lane road with paved shoulder

7.4.2 Improvement of Geometry:

The scope of work consist of proposal of new high level bridge across River Zuari including it approaches involving realignment as per site condition and improvement of highway stretch between existing Km. 3/860 to Km. 11/860. The details of proposed widening, realignment/ new alignment are as below;

Table 7.9

Design Chainage (Km)		Side of improvement	Design Length (m)	Improvement Proposed
From	To			
3+870	4+318	LHS	448	Eccentric widening
4+318	5+196	RHS	878	Curve Improvement
5+196	6+485	RHS	1289	New alignment
6+485	6+765	LHS	280	New alignment
6+765	9+599	RHS	2834	New alignment

Proposed ROW:-

In general, realignment/ new alignment is proposed for the stretch under consideration except initial length of about 500m. The width of the proposed ROW is as under;

Design Chainage		Proposed ROW 'm'	Remark
From 'Km'	To 'Km'		
For Project Highway			
3+870	4+318	45.00	Built-up section
4+318	9+599	60.00	
For Ramps/ Arms other than project highway			
0+000	0+340	26.50	Ponda side flyover approach
0+000	0+839	30.00	Margao down ramp
0+000	0+331	30.00 (existing ROW)	At grade road for Margaon to Bythakol
0+160	0+617	Total area in clover loop	Loutolim Down Ramp

Note:- From design Ch. 4570 to 5100, additional width of ROW beyond 60m ROW is proposed since there is deep cutting more than 15m depth is involved.

7.4.3 Geometric Design:

- **Design Speed:-** As per IRC:SP:84 – 2014 manual, ruling design speed shall be 100 Km/Hr. and minimum design speed shall be 80 Km/hr. The horizontal alignment is designed for design speed of 80 Km/Hr from Km. 3+860 to Km. 5+196 and 100 Km/Hr. from Km. 5+196 to Km. 9+599. There are some restrictions due to site conditions such as due to which the vertical profile is designed for design speed of 80 Km/hr. Thus design speed adopted for the project highway is 80 Km/Hr.

  For stretches other than project highway the following design speed is adopted;

  - ✓ For Margao down ramp - 60 Km/Hr.
  - ✓ For Margao to Bythakol road - 60 Km/Hr.
  - ✓ For flyover at Dhavli junction - 50 Km/Hr.
  - ✓ For flyover at Bythakol junction - 50 Km/Hr.
  - ✓ For Loutulim Up & Down Ramp - 40 Km/Hr.

- **Horizontal Alignment:-** As per IRC:SP:84 – 2014 manual, desirable minimum radius shall be 400 m and absolute minimum radius shall be 250 m. For the project highway, the horizontal alignment with minimum radius of 250 m is designed from Km. 3+860 to Km. 5+196 and 400m from Km. 5+196 to Km. 9+599. For various arms, up/ down ramps/ clover leaf etc. radius less than 250m is adopted.

- **Vertical Profile:**- As per IRC:SP:84 – 2014 manual, ruling gradient & Limiting gradient shall be 2.5% & 3.3% respectively. In general vertical profile with longitudinal gradient between 2.5% to 3.3% is provided for the project highway. Only, from Km. 4+625 to 5+115, vertical gradient of 5% is adopted due to involvement of deep cutting. There is hillock portion in this stretch. The stretch wise longitudinal gradient adopted for the project highway are as follows;

Table 7.10

Design Ch.		Proposed Longitudinal Gradient (Max.)	Remarks
From 'Km'	To 'Km'		
3+870	4+340	2.98 %	Built up area
4+340	4+625	3.3 %	Hillock portion
4+625	5+115	5.0 %	Hillock portion
5+115	5+275	0.0 %	Bythakol junction

5+275	5+680	2.5%	Hillock portion
5+680	6+283	3.08%	Hillock portion
6+283	6+900	0.03 %	Durbhat Flyover viaduct
6+900	7+172	3.3 %	Durbhat Flyover approach
7+172	7+432	0.0 %	Slip road Merging/ demerging portion
7+432	7+655	3.3 %	Approach before hillock
7+655	7+940	0.0 %	Hillock portion
7+940	8+910	2.5 %	Approaches of proposed Zuari Bridge
8+910	9+180	0.0 %	Slip road Merging/ demerging portion
9+180	9+599	3.3 %	Approaches of proposed missing link

For the stretches other than project highway following maximum gradients are adopted;

- ✓ For Margao down ramp - 2.5 %
- ✓ For Margao to Bythakol road - 1.16 %
- ✓ For flyover at Dhavli junction - 3.3 %
- ✓ For flyover at Bythakol junction - 3.3% & 5.56 %
- ✓ For Loutulim Up Ramp - 4.0 %
- ✓ For Loutulim Down Ramp - 3.3 %

For flyover at Bythakol junction, steep gradient of 5.56 % beyond end of flyover is provided to match with the gradient of existing road.

7.5 Improvement of Junctions / Grade Separators

The details of major/ important junctions located in the project corridor are given in table below;

Table 7.11

Major/ Important Junctions on Project Road

Sr. No.	Existing Chainage	Location / Identification	Type	Remark
1	3/860	Dhavli	Y	Rotary junction (road leading to Ponda city)

2	5/200	Bythakol	Y	Rotary junction SH - bypass to Ponda city
3	8/200	Shiroda	Y	Rotary junction SH-6 – road leading to Shiroda
4	9/520	Margao	T	SH-5 road leading to Margao

- The proposed alignment is away from the existing Shiroda junction and Margao/ Vasco junction. Hence, no improvement is proposed for these junctions.

- **Dhavali Junction:-** Dhavli bypass junction is not a major junction but it is an important junction of town road leading to Ponda. As per directions of the client, to segregate the local traffic and highway traffic, one way flyover along the road leading to Ponda town is proposed at this junction.
  For GAD of Flyover at Dhavli junction refer drawing No. 869-ZUA-GAD-DHA-FLY-001(R0).

- **Bythakol Junction:-** As per turning movement survey, grade separator is not justified at Bythakol junction. But this is a major junction of newly declared National Highway with the project highway. Thus a grade separator at this junction is proposed as per guidelines given in the IRC:SP: 84-2015 manual. There is movement of commercial vehicles in Amigos to Loutulim/ Verna and vice versa direction. Hence, 6 lane divided carriageway flyover along the Bythakol – Amigos road is proposed. **For GAD of Flyover at Bythakol junction, refer drawing No. 869-ZUA-GAD-BYT-FLY-001 (R0).**

- Durbhat Junction:- It is a minor intersection of village road with the project highway. The proposed new alignment of project highway intersects existing stretch of the highway at 2 locations near Durbhat junction. Hence, flyover at this location is proposed to segregate local traffic as well as to provide conflict free access to local traffic on project highway. 6 lane divided carriageway flyover as per IRC:SP:84-2014 manual is proposed at this location. **For GAD of Durbhat Flyover, refer drawing no. 869-ZUA-GAD-DUR-FLY-001 (R0).**

7.6 Proposal for Bridges, Culverts and Other Structures:

Based on the condition survey of the bridges and CD Structures, proposed alignment, recommendations for the (existing) structures include widening, rehabilitation/repair, new construction for existing bridges & other CD structures.

For Bridges and Structures the main recommendations can be categorized as stated below:

1. Widening of Bridges for 2 / 4 /6 lane carriageway.

2. Repair and Rehabilitation of existing bridges and structures.

3. Widening of culverts to 2 / 4 /6 lane carriageway.

4. Reconstruction of bridges / culverts.

The category wise detailed statement of improvement of structures in various sections is given below.

7.6.1 Major Bridges

As explained above at Sr. No. 8.3.3, major bridge across River Zuari at Borim is proposed at design Ch. 8+330 in lieu of existing Zuari Bridge. The salient features are also explained above. At the end of the project corridor, for approach leading to missing link viaduct is proposed between Ch. 9+290 and 9+599.

Table 7.12

Improvement Proposed for Major Bridges

Design Chainage	Proposed Bridge Details		Remarks
	Width	Span	
8+330	**2 x 16m= 32m**	(1 x 150 m) + (2 x 75 m) + (11 x 55 m)	Zuari Bridge New Construction
9+445	**2 x 23 = 46 m** **2 x 14.50 = 29 m**	4 x 27.5 m 6 x 27.5 m	Viaduct in missing link approach

7.6.2 Minor Bridges:

The details of improvement scheme for minor bridges such as widening, reconstruction and new construction

Table 7.13

Improvement Proposed for Minor Bridges

Structure	Proposed Chainage	Existing Width	Existing Span Arrangement	Proposed Width	Proposed Span Arrangement	Improvement Proposal
Main Alignment (Project Highway)						
Minor Bridges						
MNB-01	7+555	-	-	2x16 (Skew 19^0)	1 x 10.0m	New Construction
MNB-02	9+050	-	-	44.3 (Skew 29^0)	2 x 15.00m	New Construction
Ramps/ Arms :- for Down Ramp to Margao						
MNB-03	0+600	-	-	26 (Skew 40^0)	2 x 15.00m	New Construction

7.6.3 Culverts

In general realignment/ new alignment is proposed in entire length of the project highway except initial 500m length. Hence, there are majority new culverts are proposed as per topography and site condition. For improvement of existing culverts following consideration has been made.

a) Pipe culverts having diameter of Pipe less than to 0.9m are considered for reconstruction with Pipe of 1.20 m dia.

b) Culverts requiring reconstruction on account of the vertical profile of proposed road not matching with existing road or deck level of the culvert due to geometric improvement.

c) Culverts where bedding underneath the pipe has been washed away due to storm water action. Now water flows underneath the pipe until water level increase above inlet level.

d) Culverts whose pipe / box / slab or its abutment are damaged.

e) Culverts where the proposed centerline of the Project Highway falls outside of the existing carriageway because of improvement of geometrics.

f) Culverts of inadequate width will be widened to roadway width.

g) Existing NP-2 class pipes will be replaced by NP-4 class pipes.

The proposed scheme for culverts is given in following table;

Table No. 7.14

Improvement Proposed for Pipe culverts

Structure	Proposed Chainage	Existing Width	Existing Span Arrangement	Proposed Width	Proposed Span Arrangement	Improvement Proposal
Main Alignment (Project Highway)						
PC-1	0+200	9.85	-	22.50	1 x 1.20m	Re-Construction
PC-2	4+380	13.50 (Skew-12^0)	2 x 1.200m	26.00 (Skew 12^0)	2 x 1.20m	Widening
PC-3	4+720	-	-	26.00	1 x 1.20m	New Construction
PC-4	4+800	-	-	26.00	1 x 1.20m	New Construction
PC-5	4+895	-	-	26.00	1 x 1.20m	New Construction
PC-6	5+110	-	-	26.00	1 x 1.20m	New Construction
PC-7	5+290	-	-	47.00	1 x 1.20m	New Construction
PC-8	5+850	-	-	26.00	1 x 1.20m	New Construction
PC-9	6+390	-	-	32.00	1 x 1.20m	New Construction
PC-10	7+150	-	-	51.00	1 x 1.20m	New Construction
Ramps/ Arms						
Down Ramp to Loutolim from Missing Link						
PC-13	0+600	-	-	10.00	1 x 1.20m	New Construction
PC-12	0+275	-	-	12.00	1 x 1.20m	New Construction
Up Ramp to Missing Link						
PC-11	0+030	-	-		1 x 1.20m	Included in existing ongoing proposal
PC-12	0+430	-	-		1 x 1.20m	Included in existing ongoing proposal

Table No. 7.15

Improvement Proposed for slab/ box culverts

Structure	Proposed Chainage	Existing Width	Existing Span Arrangement	Proposed Width	Proposed Span Arrangement	Improvement Proposal
Main Alignment						
SC-1	3+870	35.70	1 x 0.800m	63.00	1 x 2.00m	Re-Construction
SC-2	4+105	8.50 (Skew-15^0)	1 x 2.200m	42 (Skew 15^0)	1 x 2.50m	Re-Construction
SC-3	5+200	64.00	1 x 1.200m	50.00	1 x 2.00m	Re-Construction
SC-4	5+440	-	-	47.00	1 x 2.0m	New Construction
SC-5	5+940	-	-	26.00	1 x 3.00m	New Construction
SC-6	6+580	-	-	10.50 (Skew 36^0)	1 x 6.0m	New Construction
SC-7	6+600	10 (Skew-7^0)	2 x 0.500m	14.0 (Skew 7^0)	1 x 2.0m	Re-Construction
SC-8	6+625	14 (Skew-9^0)	1 x 1.000m	14.0 (Skew 9^0)	1 x 2.0m	Re-Construction
SC-9	6+700	16 (Skew-23^0)	2 x 0.500m	14.0 (Skew 23^0)	1 x 2.0m	Re-Construction
SC-10	6+775	8.50	1 x 6.000m	20.00	1 x 6.0m	Widening
SC-11	6+825	-	-	10.50	1 x 6.0m	New Construction
Down Ramp to Margao						
SC-17	0+250	-	-	26.00	1 x 3.00m	New Construction
SC-18	0+380	-	-	26.00	1 x 3.00m	New Construction
Road for Margaon to Bythakol traffic						
SC-15	0+095	-	-	12.00	1 x 6.0m	New Construction
SC-16	0+215	-	-	12.00	1 x 2.0m	New Construction
Loutulim Up Ramp to Missing Link						
SC-12	0+050	-	-		1 x 6.0m	Included in existing ongoing proposal
SC-13	0+150	-	-		1 x 2.0m	
SC-14	0+190	-	-		1 x 6.0m	
SC-15	0+250	-	-		1 x 6.0m	
SC-16	0+370	-	-		1 x 2.0m	

7.7 Provision of new underpasses / over pass

7.7.1 Vehicular Overpass

The project highway passes through hillock portion near Bythakol junction. Between the new alignment from Bythakol junction and Durbhat, the proposed road will be in cutting portion. Plotting of land with kachha road is observed in this portion at Ch. 5+690. To provide access to the RHS area, 2 lane vehicular over pass is proposed at Ch. 5+690. Vertical clearance of min. 5.5m below his vehicular overpass is maintained. The proposed vehicular overpass consists of 2 spans of 22.5m each considering the future widening of project highway.

7.8 Provision of Retaining wall

Provision of retaining walls has been made in the proposal to retain the bank slope within the ROW.

7.9 Drainage Design

7.9.1 Hydrological Design Methodology:

Methodology for hydrological design is adopted as per IRC:SP-13 and IRC:5. For major streams catchment area are calculated from Toposheets. L-Section and cross sections of stream shall be taken as per guidelines given in IRC:SP-13 and IRC-5. The HFL are ascertained from flood marks / local enquiry. Discharges are calculated as per empirical formula as well as per Manning's formula. Both the discharges are tallied and HFL decided. Based on the final HFL further hydraulic calculations such as design discharge % obstruction and afflux, scour depth etc. are prepared. For the proposed Bridge across Zuari River, separate hydraulic design report is submitted.

7.9.2 Study of available data

Following data is collected and reviewed.

(1) Collection of Toposheets – for calculating catchments area.

(2) Details of structures with span arrangement.

(3) Geotechnical data is not available.

(4) Rainfall data for 15 years for PIA will be obtained from Water Resources Department of Govt. of Maharashtra.

7.9.3 Design calculations for Storm water

The maximum rainfall in one day during last 15 years in the PIA is considered for storm water calculations.

Step (i) Calculation of one hour rainfall:

From maximum rainfall in 24 hours one hour rainfall will be decided by formula.

$$I_o = \left[\frac{F}{T} \quad \frac{T+1}{t+1} \right]$$

where

F = Total rainfall in cm

T = Total time (24 hr.)

t = 1 hr.

I_o = One hr. rainfall in cm

Step (ii) – Time of concentration:

$$t_c = \left[0.87 \times \frac{L}{H} \right]^{3.0385}$$

where

t_c = Time of concentration in hour.

L = Distance from Critical point to the structure in km.

H = Fall in level from critical point to structure in m

L & H to be found from Toposheets.

Step (iii) Design Intensity:

$$Ic = I_o \left[\frac{2}{tc + 1} \right]$$

where

Ic = Design Intensity in cm/hour

Step (iv) Calculation of runoff:

$Q = 0.028\ P\ A\ Ic\ m^3/Sec$

where

P=Co-efficient of run off for the catchments characteristics

A = Catchment area in Sqm.

7.9.4 Hydraulic design and resizing of existing culverts

The waterway requirement and hydraulic design calculations are done as per procedure given in preceding paras. The required waterways are verified with existing waterway. Resizing of structures is done if existing waterway is inadequate. The required waterway is provided after investigation and Hydraulic calculations.

7.9.5 Treatment for scour and other protection methods :

The aprons along with toe wall and detached type cut off wall are considered for culverts as a protection measure against scour. For major and minor bridges the founding level of the proposed structures are considered below the scour level.

7.9.6 Design of road side drain:

Design of road side drains are done as per IRC. The water from road and adjacent area shall be intercepted and carried though road side drains to natural outfall. Road side drain shall be designed as per IRC:SP-42 and IRC:SP-50. Longitudinal slope shall not be less than 0.2% for lined drain and 0.3% for unlined drains. The design shall be based on principle of flow in open channel. Where due to site constraints the gradients are restricted for the longitudinal drains. In open country, open earthen drains are proposed and in built-up areas RCC covered drains are proposed. For the stretches in deep cutting portion R.C.C. open drains are proposed.

7.10 Design of Road markings, signs and other safety devices:

7.10.1 Road Makings:

The road makings are considered as per IRC:35 with hot applied thermoplastic paint for better visibility and longer service life. Lane markings are necessary for regulating traffic into proper lanes and to curb the meandering tendency of the drivers, thereby promoting safety. No overtaking zones are to be marked where sight distance is restricted. Edge makings are necessary to indicate the carriageway edges of road to delineate the limits upto which drivers can safely venture. For safety of pedestrians in built-up areas or at the location of bus stops, zebra crossing is necessary. The road markings are also necessary at bus bays, truck parking, Junctions and accordingly provisions are made in the proposal. The road signs are also very important for diversion of traffic during construction.

7.10.2 Sign & other safety devices.

To ensure long term road safety on the highways the suitable engineering measures such as Traffic Control Devices, Road Safety devices and Road side furniture comprising of road signs, road markings, object markers, hazard markers, studs, delineators, attenuators, safety barriers, pedestrian guard rails, boundary stones, km stones etc., are considered essential for improving road safety leading to reduction of accidents.

The traffic signs are one of the most important traffic control devices. On a highway it is necessary to give information / warning of the road ahead to the driver so as to control the vehicle. Traffic signs are very important from this point of view.

Road signs are of 3 types:-

- Mandatory / Regulatory sign
- Cautionary / warning sign
- Informatory sign

The signs are to be provided as per guide lines given in IRC-67- (Latest). Following table gives the list of signs proposed on the Project Highway. Apart from road signs other safety devices such as delineator, guard rails etc are proposed as a safety measures. A list of other safety devices proposed is given in a table below.

Table no. 7.16

List of signs

Sr. No.	Type of Road signs	Where to be provided
1.	Direction & place identification signs	
	(i) Advance direction/destination sign	Every 5 km. and before entering town
	(ii) Direction sign	Before junction
	(iii) Reassurance sign	Every 5 km.
	(iv)Place identification sign	Before town / village
	(v) Truck lay bye / Bus bay / Bus shelter	Before truck lay bye / Bus bay / bus shelter
2.	Stop and give way sign	
	(i) Stop sign	Junction and toll booth
	(ii) Give way	Junction

Table No. 7.17

List of other safety devices

Sr. No.	Type of safety Device	Where to be provided
i.	Retro reflective delineators	At shoulder location as per IRC:SP:84 -2014
ii.	Guard Rail	In between footpath and main carriageway for built-up areas & in median of road in built-up areas.
iii.	Metal Beam Crash barrier	Embankments with height 3m or more, along curves having radii up to 450m
iv.	Barricading	During construction
v.	Road Studs	On edge line and center line of pavement.

Pedestrian Facilities:

For pedestrians, footpaths are proposed in the built-up areas with pedestrian guard rails. Also sign boards, zebra crossings are considered in the provision. The locations of footpath and railings are as given below;

Table No. 7.18
Locations of proposed footpath/ Railing

Sr. No.	Built-up stretches	Design Chainage (km)		Side	Length of stretch in 'm'
		From	To		
1	Near Dhavli junction	3+870	4+318	Both side	448

Street Lighting:

Provision of street lighting is made at important built-up stretches. The locations of proposed street lighting are as follows;

Table No. 7.19
Locations of proposed Street Lighting

Sr. No.	Built-up stretches	Design Chainage (km)		Side	Length of stretch in 'm'
		From	To		
1	Near Dhavli junction	3+870	4+318	Both side	448

7.11 Clearances Required:

a) Environmental Clearance: - Since the length of the project highway is less than 100 Km & width of additional proposed ROW is less than 60m, Environmental clearance is not required.

b) Forest Clearance: - Since, there is no acquisition forest land involved in this project, forest clearance is not required.

c) CRZ clearance: - Since, River Zuari is tidal river and there is mangroves at the bank of river, CRZ clearance is required. Accordingly, drawing showing proposed Bridge alignment has been submitted to concern department. A site visit was also held by the concern officers to inspect the proposed location of the bridge. Further, delineation of CRZ line is awaited from this department.

d) Utility Shifting:- There are existing utilities such as over head / underground electrical lines, high tension tower line and underground water supply lines which needs to be shifted. Site visits of utility owner department were held and the proposal of shifting these utilities submitted. Cost estimates for shifting of these utilities are awaited from these utility owner departments.

e) Tree cutting permission:- The proposed alignment of the project highway is passing through hillock portion in majority length. The affected trees within the corridor are being identified. The proposal will be submitted to the forest department for obtaining tree cutting permission.

7.12 Issues specific to the project:

i) Mainly, the project consist of new 6 lane high level bridge across River Zuari involving Cable Stayed Bridge portion for navigational span and PSC pre-cast segmental box girder superstructure for remaining viaduct.

ii) The project involved construction of 4 lane divided carriageway road from Dhavli junction to Loutolim including various grade separators, up and down ramps as discussed in this chapter.

iii) At Loutolim end the work of missing link is in progress. This work involves 4 lane divided carriageway road, vehicular subway at Loutolim end across Cortalim road and approaches in REW from subway to Loutolim having height up to 17m. Since, it is proposed to connect the proposed alignment (approach of proposed Zuari

Bridge) directly to missing link near subway. Due to this, during construction of proposed approach of Zuari bridge, the approach in RES involved in missing link project needs to be dismantled. This issue was brought to notice in various reports submitted as well as during meetings.

Chapter – 8

BLOCK COST ESTIMATE

8.0 BLOCK COST ESTIMATE:

8.1 General:

Detailed cost estimate covering all aspects and provisions will be made after receipt of approval to the GAD of the proposed Zuari Bridge and improvement proposal of highway including other provisions such as grade separators, culverts etc. In this chapter, block cost estimate for various provisions proposed in this project is prepared based on the unit rates as per current similar projects.

8.2 Block Cost Estimate:

Block cost estimate of the project is derived as follows;

A) Civil Cost:-

- Cost of 4/6 lane divided carriageway road – rate per Km basis
- Cost of River Bridge – rate per Sqm basis
  - i) For navigational span & back span
  - ii) For 55m spans -
- Cost of grade separators – rate per Sqm basis
  - i) Cost for viaduct portion
  - ii) Cost for solid approaches
- Cost of Minor Bridges – rate per Sqm basis
- Cost of C.D. works – cost per no. basis
- Misc. - % basis

B) Other Charges:-

- Agency Charges = 3% of Civil cost
- Supervision Charges = 3% of Civil cost
- QC Charges = 0.25% of Civil cost
- Road Safety Charges = 0.25% of Civil cost
- Maintenance Charges = 5% of Civil cost
- Price Escalation for 2 Years = 10% of Civil cost

C) Non Civil Cost:-

- Utility Relocation = 1% of Civil cost
- Land Acquisition = as per ready reckoner rates of Govt.
- Rehabilitation and Re-settlement = 1% of Civil cost
- Environmental Impact Mitigation Measures = 0.25% of Civil Cost

Quantities of Road Work

Description	No.	L	Qty.	Unit
4 Lane Road	1	3.23	**3.23**	**Km**
2 Lane road (slip/ service road)				
Ponda town slip road	1	0.40	0.40	
Service road Ch. 3/870 to 4/300	1	0.43	0.43	
Slip road at Durbhat	2	1.00	2.00	
Margaon down arm	1	0.68	0.68	
road for Margaon to Bythakol traffic	1	0.88	0.88	
Loutolim down arm	1	0.13	0.13	
			4.52	**Km**
5.5m slip/ service road				
Ponda town side slip road	1	0.40	0.40	
Slip road along Bythakol to Amigos road	2	0.25	0.50	
			0.90	**Km**

Quantities of Bridge/ Flyover/VUP Work

Description	No.	L	W	Qty.	Unit
River Bridge - Cable Stayed Portion					
Navigational span & Back span	1	300	32	**9600**	**Sqm**
River Bridge – balance portion viaduct					
Viaduct of River Bridge 55m spans	1	605	32	19360	
55m spans - For Margaon Arm	1	220	12	2640	
				22000	**Sqm**
Flyover Viaduct					
Dhavli Flyover	1	70	8.5	595	
Bythakol Flyover	1	60	24	1440	
Durbhat Flyover	2	366	14.5	10614	
Missing Link Approach Viaduct	2	275	14.5	7975	
Loutulim Up Ramp	1	175	8.5	1487.5	
Loutulim Down Ramp	1	250	8.5	2125	
				24236.5	**Sqm**
Flyover RES/ Solid Approach					
Dhavli Flyover	1	478	8.5	4063	
Bythakol Flyover	1	297	24	7128	
Durbhat Flyover	1	630	32	20160	
Missing Link Approach solid ramp	1	226	32	7232	

Description	No.	L	W	Qty.	Unit
for Loutolim up arm	1	115	8.5	977.5	
for Loutolim down arm	1	210	8.5	1785	
				41345.5	**Sqm**

Cost of Major Components of the Project

Description	Unit	Qty.	Unit Rate in Lacs	Cost in Lacs
A) River Bridge				
Navigational span & Back span	Sqm	9600	1.50	14400
Viaduct of 55m spans	Sqm	22000	0.75	16500
Total Cost of A)				**30900**
B) Flyover/ VUP				
Flyover Viaduct	Sqm	24236.50	0.45	10906
Total Cost of B)				**10906**
C) Reinforced Earth Work/ Solid Approaches				
Flyover RES Approach	Sqm	41345.5	0.20	8269
Total Cost of C)				**8269**
D) Road Work				
4 Lane Road	Km	3.23	1500	4845
2 Lane road (slip/ service road)	Km	4.52	500	2260
5.5m slip/ service road	Km	0.90	300	270
Total Cost of D)				**7375**
E) Minor Bridges, VOP, Culverts				
3 Nos.	Sqm	2960	0.90	2664
VOP	Sqm	383	0.30	115
Slab Culverts - 15 Nos.	No.	15	60	900
Pipe Culverts - 12 Nos.	No.	12	20	240
Total Cost of E)				**3919**

APPROXIMATE COST OF LAND ACQUISITION								
FOR THE PROPOSED BRIDGE ACROSS ZUARI AT BORIM INCLUDING APPROACHES & ROAD WORK								
VILLAGE	**TALUKA**	**BASE RATE Rs/Sqm**	**AREA REQUIRED in Sqm.**	**COST in cr. AS PER BASE RATE**	**Multiplying factor over cost as per base rate**	**Net Cost of L.A. in Cr.**		
1	**2**	**3**	**4**	**5**	**6**	**7**		
QUEULA	PONDA	1000	54150	5.415	5	27.075		
BORIM	PONDA	1000	201680	20.168	5	100.840		
LOUTULIM	SALCETE	2500	109380	27.345	5	136.725		
			365210	**52.928**		**264.640**		
			35.52 Hect.		**Say**	**265.00**	**Cr.**	
					i.e. Approximate cost of Land Acquisition = Rs.	**265.00**	**Cr.**	

Note:-

i) The base rate of lands are taken from Official Gazette of Govt. of Goa dated 3rd Jan. 2013.

Following factors are applied to the base rate as per LA Act - Right to fair compensation & transparency in Land Acquisition, Rehabilitation & Resettlement Act, 2013.

a) Multiplying factor for Rural area 1.5 to 2 = Here 2 factor is considered b) Soletium charge = 100 % i.e. (2 factor)

c) Factor for misc. administrative charges = 1

Thus total factor applied over base rate of land is = 2 + 2 +1 = 5

SUMMARY OF PROJECT COST

Sr. No.	Description		Cost	
A	River Bridge	Rs.	30900	
B	Flyover/ VUP	Rs.	10906	
C	RES for Flyover/ VUP etc.	Rs.	8269	
D	Road Work	Rs.	7375	
E	Minor Bridges, VOP, Culverts etc.	Rs.	3919	
F	**Total Cost A+B+C+D+E = F**	**Rs.**	**61369**	**Lacs**
G	**Total Cost A+B+C+D+ E = F**	**Rs.**	**613.69**	**Cr.**
	Drainage & Protection @ 5% of G	Rs.	30.68	Cr.
	Miscellaneous Items @ 1% of G	Rs.	6.14	Cr.
H	**Total Civil Cost = H =**	**Rs.**	**650.51**	**Cr.**
	Add for Contingencies at 2.80 %	Rs.	18.21	Cr.
I	**TOTAL CIVIL COST including Contingencies (I) =**	**Rs.**	**668.72**	**Cr.**
J	Agency Charges 3% = H	Rs.	20.06	Cr.
K	Supervision Charges 3% = I	Rs.	20.06	Cr.
L	QC Charges 0.25% = J	Rs.	1.67	Cr.
M	Road Safety Charges 0.25% = K	Rs.	1.67	Cr.
N	Maintenance Charges 5% = L	Rs.	33.44	Cr.
O	Price Escalation for 2 Years 10%= M	Rs.	66.87	Cr.
P	**Total Cost = I+J+K+L+M+N+O = P**	**Rs.**	**812.49**	**Cr.**
Q	**Non Civil Works**			
1	Utility Relocation 1%@ H	Rs.	8.12	Cr.
2	Land Acquisition	Rs.	265.00	Cr.
3	Rehabilitation and Re-settlement 1%@ H	Rs.	8.12	Cr.
4	Environmental Impact Mitigation Measures 0.25%@ H	Rs.	2.03	Cr.
Q	**Sub Total (Q)**	**Rs.**	**283.27**	**Cr.**
R	**Total Project Cost = P + Q**	**Rs.**	**1095.76**	**Cr.**