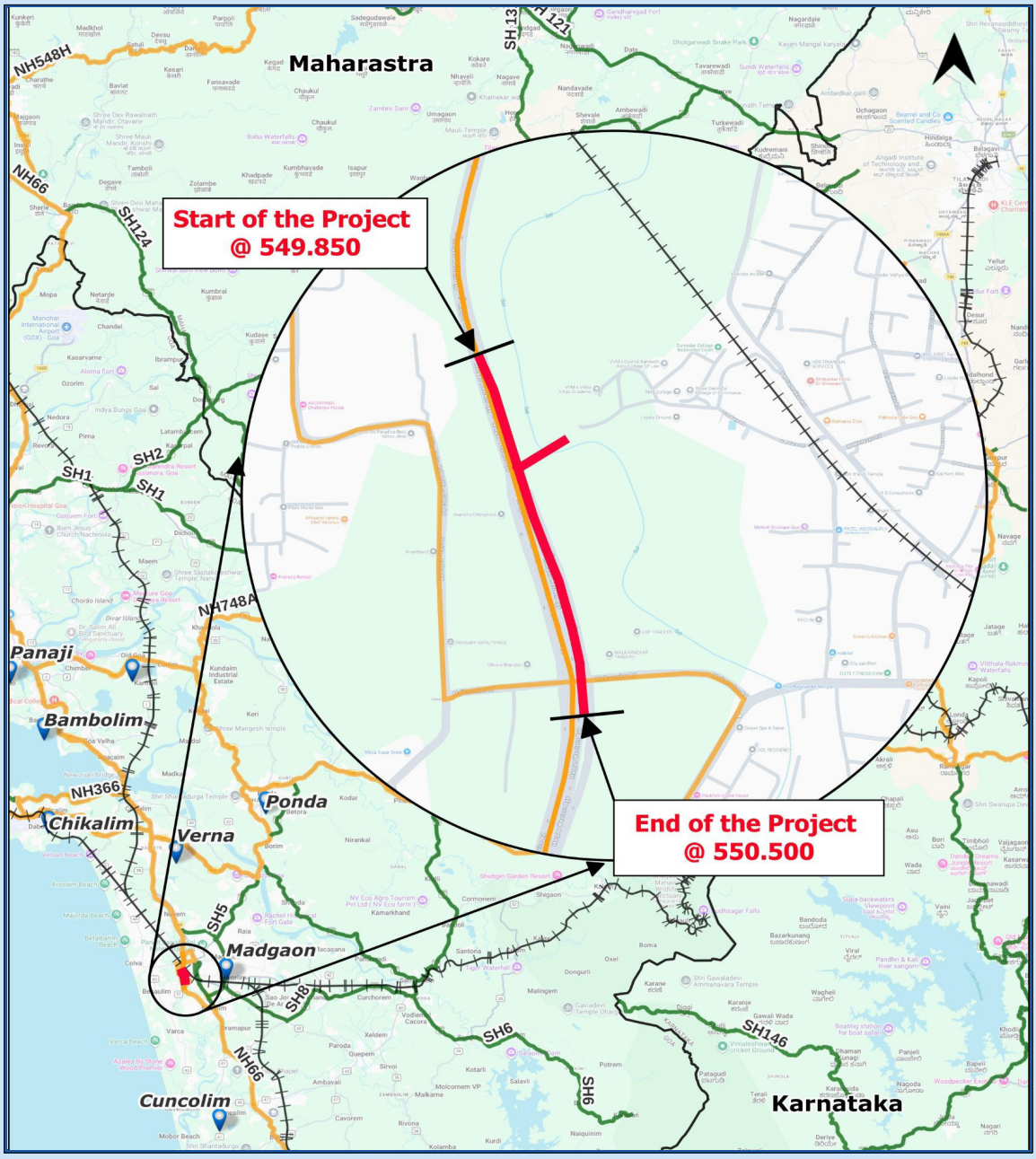
# GOVERNMENT OF GOA

## PUBLIC WORKS DEPARTMENT (NATIONAL HIGHWAYS)

**Construction of service road and improvement of Khareband junction with road safety measures from Km 549.850 to Km 550.500 on Margao bypass section of NH-66.**




## MAIN REPORT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# 1 . INTRODUCTION

## 1.1 General

The Government of India has envisaged to create a world-class infrastructure facility, to boost the economic development in the country and also to minimize the number of accidents/fatalities, for which Ministry of Road Transport and Highways (MoRTH) plays a key role. MoRTH has been entrusted to implement various developmental projects of National Highways in order to ensure safer and faster movement of the Vehicles. As part of this endeavor, MoRTH executes the works through the Public Works Department (PWD) in the state of Goa. Public Works Department (NH), Goa has taken up developement of road network in the state of Goa

Public Works Department (PWD) of Goa has appointed M/s Aarvee Engineering Consultants Ltd (Formerly M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd., Hyderabad) to provide consultancy services for DPR for the above road section.

## 1.2 Project Background

The length of National Highways in the state is around 280 Km. There are 6 National Highways running length and breadth of Goa state viz., NH-66, NH-748, NH-366, NH-566, NH-166S and NH-748AA.

***Table 1.1: Details of Existing Alignment of the Road part in the State of Goa***

| S.No | NH | <2L | 2L | 2L+PS | 4L | Total Length in Km |
|---|---|---|---|---|---|---|
| 1 | 66 | 0 | 53.26 | 0 | 70.62 | 123.88 |
| 2 | 748 | 0 | 52.2 | 0 | 16.88 | 69.08 |
| 3 | 366 | 0 | 6 | 10 | 0 | 16 |
| 4 | 566 | 0 | 8 | 0 | 29.5 | 37.5 |
| 5 | 748AA | 27 | 0 | 0 | 0 | 27 |
| 6 | 166S | 0 | 0 | 0 | 6.58 | 6.58 |
| **Total Length in Km** | | | | | | **280.04** |

Instant proposal is to widen&construct the service road between Km 549.850 to Km 550.450 & propose a new cross road for the traffic travelling to and fro from Margao city. This cross road connects the proposed ROB at Comba and NH-66. Margao city is one of the most important urban centers in the State of Goa. It functions as the commercial, cultural, and administrative hub of South Goa. The city accommodates important government offices, educational

institutions, healthcare facilities, markets, and commercial establishments, serving the needs of both the local population and residents of surrounding towns and villages. Margao is a major transit point for passenger and goods movement due to the presence of Margao Railway Station, one of the busiest railway stations in Goa, providing connectivity to major cities across India. The city also plays a significant role in tourism, acting as a gateway to popular beaches and heritage locations in South Goa. Owing to these factors, Margao attracts substantial daily commuter traffic, freight movement, and tourist inflow, making efficient transportation infrastructure essential for its sustained growth.

In addition, Margao accommodates several prominent educational institutions, including schools, colleges, and professional institutes. A large number of students and staff from surrounding towns and villages commute daily to the city to access these institutions, further contributing to regular traffic demand on the city road network.

Margao city is well connected through a network of National Highways, State Highways, Major District Roads, and urban roads, facilitating intra-city and inter-city movement. The road network caters to diverse traffic including local commuters, inter-district traffic, tourist vehicles, and heavy commercial vehicles. The existing road system provides connectivity between residential areas, commercial centers, industrial zones, bus terminals, railway station, and nearby villages. However, rapid urbanization, increase in vehicular ownership, and growing economic activities have resulted in congestion at key junctions and arterial roads, especially during peak hours. The existing urban road infrastructure is under increasing stress, highlighting the need for capacity augmentation and improved access management.

In recent years, there has been a substantial increase in traffic volume due to population growth, expansion of urban limits, increased tourism, and rising commercial activities. The existing access points between Margao city, NH-66, and adjoining villages are limited and, in several locations, inadequate to handle present and projected traffic demand. Considering future traffic growth, it is imperative to develop additional service road connecting Margao city to NH-66(Existing Service road) and providing safe and efficient connectivity to villages located on either side of the highway. The construction of such service road would:

- Reduce congestion on existing city roads and junctions
- Improve travel time and traffic distribution
- Enhance road safety by minimizing conflict points

- Provide direct and reliable access to NH-66 from Margao city.
- Support balanced urban and regional development

This stretch on NH-66 starts at Km 549.850 and Ends at Km 550.450 having a length of 0.600 Km. The length of proposed service road is 0.600 and the cross road is 0.092 Km.

**Based on traffic assessment, the projected traffic demand on the proposed access road is estimated at 11,827 PCU, catering to traffic from Margao City and adjoining villages.**

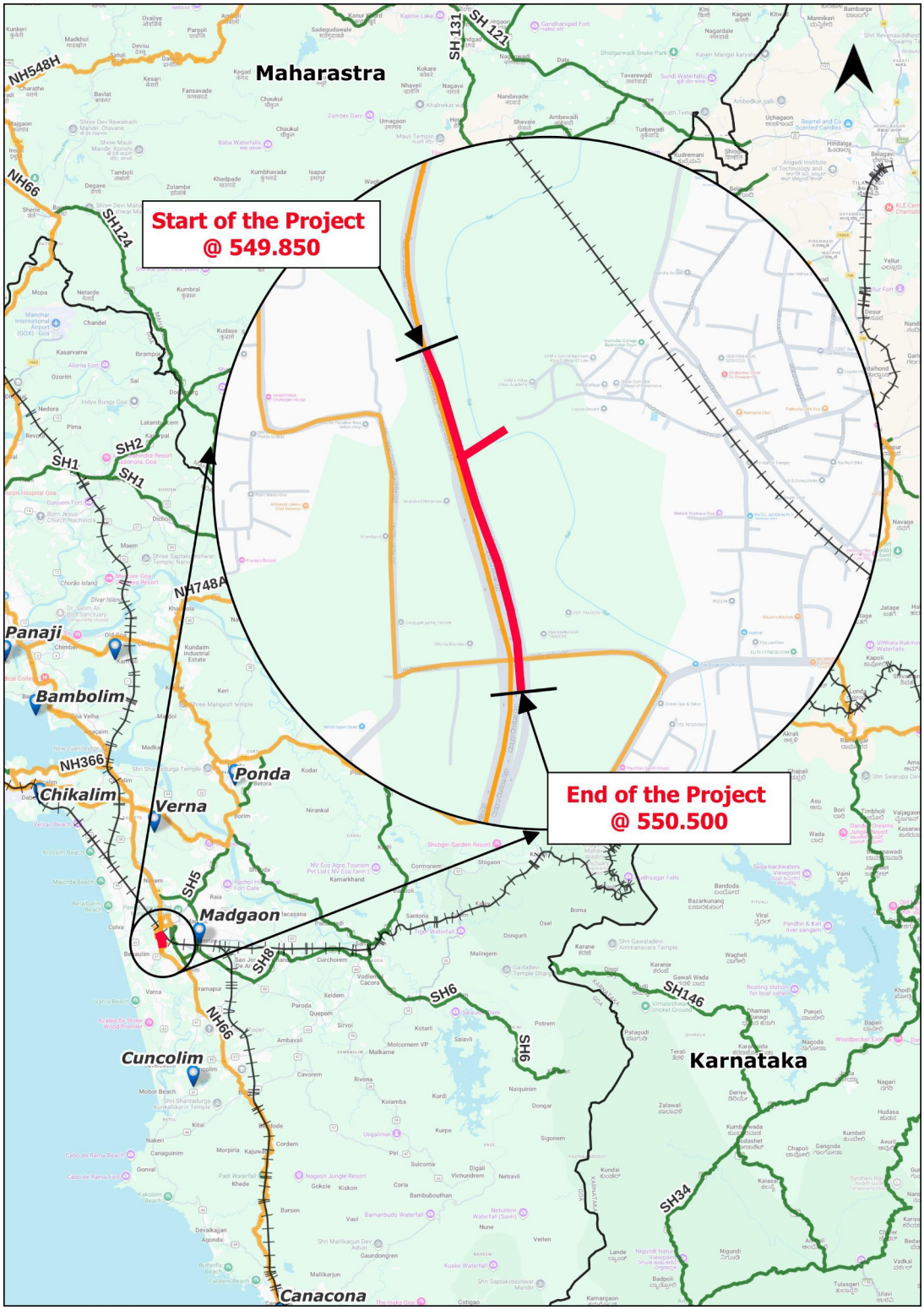



*Figure 1.1: Location Map of the Project*

### 1.3 Existing Road Condition

PWD (NH) entrusted M/s Aarvee Engineering Consultants Ltd. (formerly M/s Aarvee Associates Architects Engineers and Consultants) to study the feasibility of constructing the service/access road for the Margao city local traffic and also to develope the Junction at Khareband VUP. NH-66 is passing parallel to the Margao city, but are having very few access roads to Margao city traffic. There has been a substantial increase in traffic volume in the recent years due to population growth, expansion of urban limits, increased tourism, and rising commercial activities. The existing access points between Margao city, NH-66, and adjoining villages are limited and, in several locations, inadequate to handle present and projected traffic demand. Considering future traffic growth, it is imperative to develop additional service road/access road connecting Margao city to NH-66(Service road) and providing safe and efficient connectivity to villages located on either side of the highway.

### 1.4 Objectives

The main objective of the consultancy services is to undertake feasibility studies for the project highway for the purpose of firming up the Authority requirements in respect of development and construction of service road and safety measures between Km 549.850 to Km 550.500 and improvement of junction at Khareband VUP

The objective of the consultancy services also includes:

1. Enhanced safety and level of service for the road users;
2. Superior operation and maintenance enabling enhanced operational efficiency of the Project Highway;
3. Minimal adverse impact on the local population and road users due to road construction;
4. Minimal adverse impact on environment;
5. Minimal acquisition of land;

# 2.1 Traffic Analysis & Forecasting

## 2.1.1 General

An accurate estimate of the traffic that is likely to use the Project road is very important as it forms the basic input in planning, design, operation and financing. A thorough knowledge of the travel characteristics of the traffic likely to use the Project road as well as other major roads in the influence area of the study corridor is essential for future traffic estimation. The estimation of revenue through toll collection is important to assess the financial viability of the project and to finalize the financial covenants for the concession agreement. Thus accurate assessment of the existing traffic and forecasting attains utmost importance in the projects taken up under BOT/EPC basis. Hence, detailed traffic surveys are carried out to assess the baseline traffic characteristics on the project road. This Chapter deals with the traffic studies undertaken and the analysis thereafter.

## 2.1.2 Project Location

The instant Project location is between Km 549.850 and Km 550.500 on Margao Western bypass of NH-66 in South Goa district. Instant stretch is to be developed with proposed service road for the Margao city connecting to NH-66 existing service road.

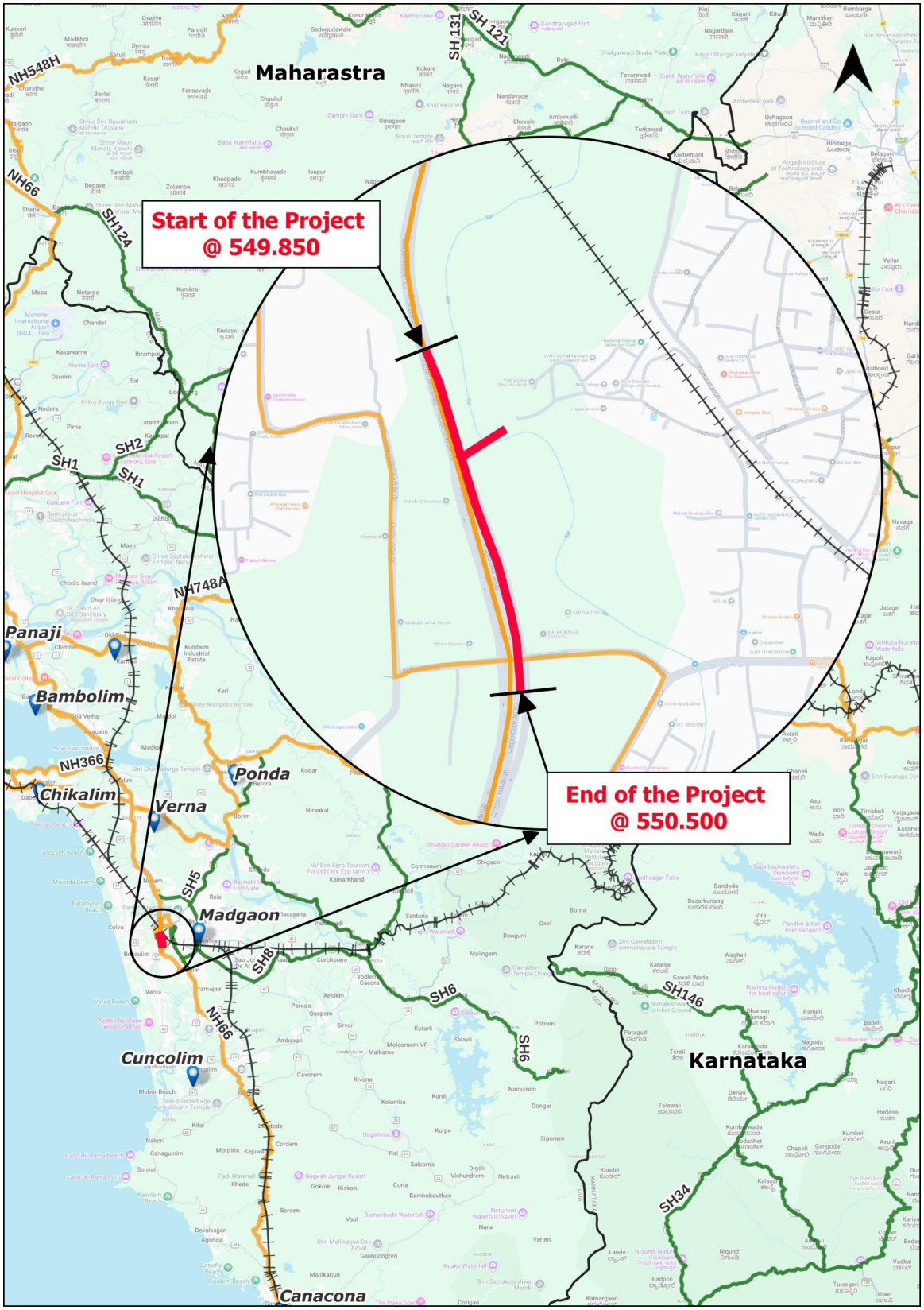



**Fig. – 2.1: Index Map of Project Stretch**

## 2.2 Traffic Surveys Planning & Schedule

### 2.2.1 Traffic Surveys and Collection of Data

The road network has been thoroughly studied during the reconnaissance stage. In order to assess the traffic pattern and volume, the Consultants have carried out classified traffic volume count survey at Km 546.720 on Madgaon Bypass on NH-66. Further, to assess the traffic on internal roads the traffic data has been obtained from PWD.

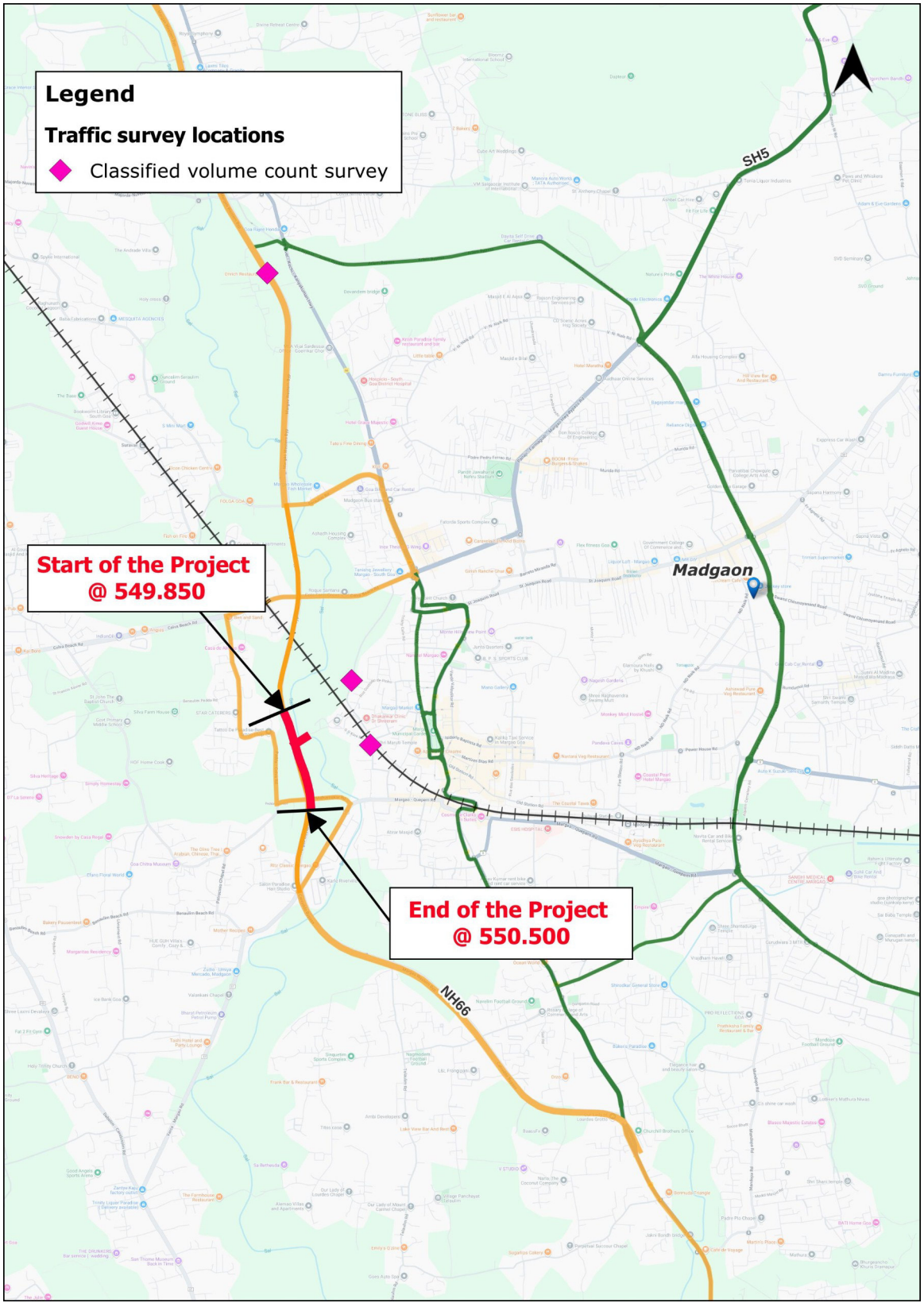



**Fig.– 2.2: Map showing Traffic Survey Locations**

### 2.2.2 Schedule of Traffic Surveys

A detailed schedule of all traffic surveys conducted along the project stretch are listed and presented below.

**Table – 2.1: Traffic Surveys Schedule**

| S. No. | Type of Survey | Location | Date of Survey | Duration of Survey |
|---|---|---|---|---|
| 1 | Classified Traffic Volume Count | Gorroti (Km. 546.720) | 15-07-2024 | 24 hours |

### 2.2.3 Objectives of Traffic Surveys

The primary objective of these traffic studies is:

- To determine characteristics of traffic movement and to establish base year traffic demand
- To determine the travel pattern of goods and passenger vehicles
- For capacity assessment
- To determine the percentage of cross road traffic at road intersections as a guide to the intensity of vehicle – vehicle conflict
- To determine vehicle damage factor
- Input in toll revenue calculations.

### 2.2.4 Methodology of Traffic Surveys

- Cameras were installed at strategic locations at the location. The station is managed by a supervisor.
- Continuous 24-hour Turning Movement count survey was conducted. The survey was conducted in accordance with the guidelines provided by IRC: 9. The vehicles are broadly classified into motorized passenger vehicles, motorized goods vehicles and non-motorized vehicles. These groupings have further been sub-divided to reflect the present day traffic pattern more realistically.

## 2.3 Traffic Volume Surveys and Analysis

### 2.3.1 Data Collection

The data collected from primary and secondary sources are recorded in Excel sheets, compiled, checked and corrected before further proceeding for analysis. Traffic data analysis has been carried out, to understand traffic characteristics and travel pattern in the study area and to provide basic input for pavement design.

### 2.3.2 Traffic Volume Count

The analysis has been carried out to derive:

- Weekly Traffic Summary
- Average Daily Traffic (ADT) of fast and slow moving vehicles
- Average Daily Variation and Average Hourly Variation
- Annual Average Daily Traffic (AADT) after seasonal correction
- AADT Modal split

### 2.3.3 Average Daily Traffic

The classified traffic volume count data collected is analyzed to assess the traffic intensity along the project corridors. The Average Daily Traffic (ADT in number of vehicles) for the traffic surveys at the survey location with salient findings as shown in Table 4.2.

**Table – 2.2: Average Daily Traffic**

| Mode | Km. 546.720 |
|---|---|
| Two Wheelers | 8902 |
| Three Wheelers | 46 |
| Car / Jeep / Van | 8772 |
| Car Yellow board | 683 |
| Tata Magic | 337 |
| RTC Bus | 140 |
| Private Bus | 55 |
| School/College bus | 69 |
| Mini Bus | 10 |

| Mode | | Km. 546.720 |
|---|---|---|
| 2 Axle | | 51 |
| 3 Axle | | 11 |
| M Axle | | 4 |
| HEM | | 5 |
| LCV/LGV | | 199 |
| Mini LCV | | 714 |
| Three Wheeler goods | | 4 |
| Tractor | | 3 |
| Tractor with trailer/ others | | 0 |
| Non-Motorized Vehicles | | 22 |
| Govt. Exempted Vehicles | | 31 |
| Tollable Traffic (vehicles) | | 11050 |
| Tollable Traffic (PCU's) | | 11750 |
| Total Vehicles | Motorized | 20036 |
| | Non-Motorized | 22 |
| | Total Traffic | 20058 |
| Total PCUs | Motorized | 16300 |
| | Non-Motorized | 16 |
| | Total Traffic | 16316 |

### 2.3.4 Seasonal Variation factor (SVF)

The Average Daily Traffic (ADT) has to be adjusted for the seasonal variation along the project stretch. The seasonal variation factor is normally estimated using the past fuel sales data collected from the existing petrol bunks along the project stretch. The Diesel and Petrol sales data collected from petrol bunks along NH-66 for the past one year is analyzed for the monthly variation in the sales of fuel.

**Table – 2.3: Seasonal variation for Petrol & Diesel vehicles on NH-66**

| Month | MS (kl) | HSD (kl) |
|---|---|---|
| Jan | 317 | 437 |
| Feb | 282 | 463 |
| Mar | 280 | 439 |
| Apr | 260 | 444 |
| May | 270 | 469 |
| Jun | 252 | 471 |
| Jul | 244 | 433 |
| Aug | 262 | 430 |
| Sep | 255 | 419 |
| Oct | 293 | 439 |
| Nov | 302 | 442 |
| Dec | 362 | 526 |
| **Average** | **1.15** | **1.04** |

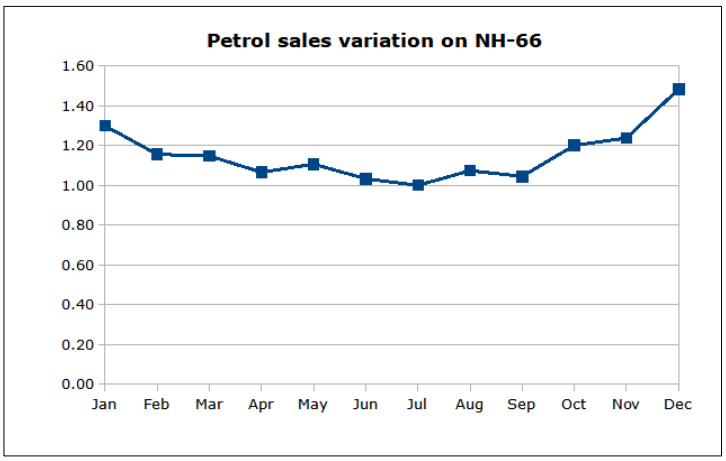



**Figure – 2.3: Petrol Sales Variation**

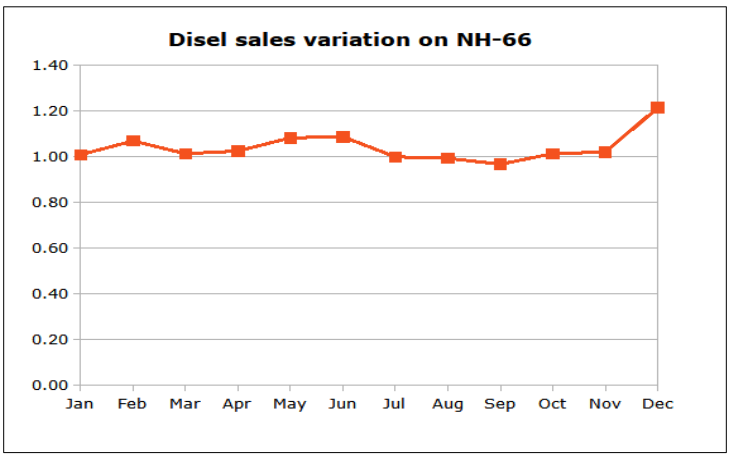



**Figure – 2.4: Diesel Sales Variation**

The traffic volume surveys are conducted in the month of July, 2024. From the analyzed fuel sales data, the seasonal variation factors have been considered as shown below Table-4.4 for AADT calculations.

**Table – 2.4: Seasonal Variation Factors(SVF)**

| S. No. | Section | Petrol | Diesel |
|---|---|---|---|
| 1 | Margao city (NH-66) | 1.10 | 1.04 |

### 2.3.5 Annual Average Daily Traffic (AADT)

The Annual Average Daily Traffic (AADT in no of vehicles) at the survey locations is obtained by multiplying the Average Daily Traffic (ADT) with the seasonal correction factor. The AADT of vehicles for the year 2024 at the survey location of traffic volume count survey along the Project corridor is presented below.

**Table – 2.5: Annual Average Daily Traffic (AADT)**

| Mode | Km. 546.720 |
|---|---|
| Two Wheelers | 9792 |
| Three Wheelers | 48 |
| Car / Jeep / Van | 9393 |
| Car Yellow board | 731 |
| Tata Magic | 361 |
| RTC Bus | 146 |
| Private Bus | 57 |
| School/College bus | 72 |
| Mini Bus | 10 |
| 2 Axle | 53 |
| 3 Axle | 11 |
| M Axle | 4 |
| HEM | 5 |
| LCV/LGV | 207 |
| Mini LCV | 744 |
| Three Wheeler goods | 4 |
| Tractor | 3 |
| Tractor with trailer/others | 0 |

| Mode | | Km. 546.720 |
|---|---|---|
| Non-Motorized Vehicles | | 22 |
| Govt. Exempted Vehicles | | 33 |
| Tollable Traffic (vehicles) | | 11795 |
| Tollable Traffic (PCU's) | | 21697 |
| Total Vehicles | Motorized | 21675 |
| | Non-Motorized | 22 |
| | Total Traffic | 21697 |
| Total PCUs | Motorized | 17524 |
| | Non-Motorized | 16 |
| | Total Traffic | 17540 |

### 2.3.6 AADT Modal Split

- Car (White board) Traffic is about 44.95%, Goods contribute 4.76%. Two wheeler constitute 45.13% in the total traffic along the corridor as shown in Figure – 4.5.
- The share of non motorized vehicles is negligible.

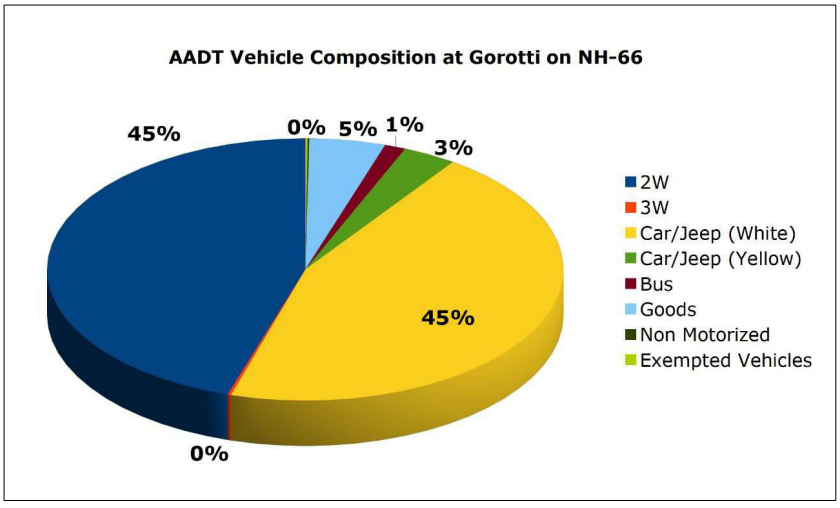



**Figure – 2.5: AADT Modal Split at Gorroti (Km. 546.720)**

### 2.3.7 Total and Tollable Traffic

The share of tollable traffic as a percentage of AADT, for the project section varies as shown below in Figure – 4.6.

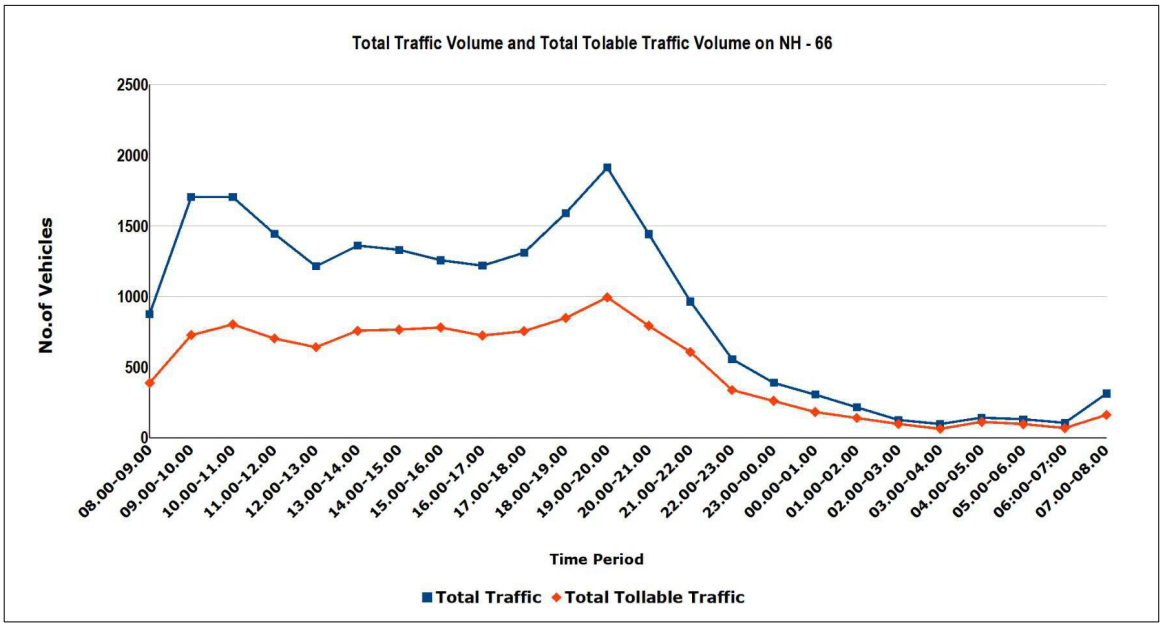



**Figure – 2.6: Total traffic & Tollable traffic volume for Gorotti at Km. 546.720**

### 2.3.8 Peak Hour Traffic

The peak hour factor is defined as the traffic volume during peak hour expressed as a percentage of AADT. The peak hour volume is taken as the highest hourly volume based on actual traffic counts. The maximum possible value for the peak hour factor is 1.00, which occurs when the volume in each interval is constant. The peak hour factor calculated for both the sections at the traffic count locations are given in Table – 4.6. The peak hour factors indicate fairly uniform distribution of the traffic volume during the day.

**Table –2.6: Peak Hour Factor (PHF)**

| S. No. | Volume Count Location | Peak Hour | Peak Hour Volume | AADT | Peak Hour Factor |
|---|---|---|---|---|---|
| 1 | Gorroti at Km.546.720 | 18:45 – 19:45 | 1427 | 17540 | 8.14% |

### 2.3.9 Traffic Assessment

- A traffic assessment was carried out for the instant construction stretch considering traffic on NH-66 and Access road to Margao city. For the design year, it is assumed that 10% of the existing traffic on NH-66 will pass through instant project stretch owing to improved connectivity and travel conditions. The base-year traffic volumes were converted to PCU and reassigned, and the resulting link volumes were evaluated against their respective capacities to determine volume–capacity ratios and level of service. The analysis indicates that, under this 10% diversion scenario, instant stretch with added diverted traffic operate within acceptable capacity and safety limits, subject to implementation of appropriate traffic management and signage measures.

- The instant project stretch has been carried out by considering diversion of additional traffic from the approach arms towards the project corridor. For the analysis scenario, it is assumed that 50% of the traffic on V N Sarmalkar road and 30% of the traffic on G R Kare road will be diverted to the instant project stretch due to improved connectivity and route choice. The base traffic volumes on each arm were converted to PCU and reassigned to the respective diverted movements, and the resulting turning volumes on the project corridor were evaluated against the available carriageway capacity to determine volume–capacity ratios and level of service, the stretch operates within acceptable capacity and safety limits, subject to provision of appropriate traffic management measures, channelization and regulatory signage.

- The local traffic assessment for the instant project stretch has been conducted following new construction to evaluate access and capacity impacts. Local traffic volumes were classified by vehicle type and converted to PCU for analysis against IRC capacity standards. Final, traffic adopted for instant project stretch as follows.

**Table –2.7: Adopted traffic volumes along instant project stretch (in 2024)**

| Year | 2W | 3W | Cars | BUS | M. Bus | 2 Axle | 3 Axle | M Axle | LGV/ LCV | M. LCV | Tractors | Total volume | Total volume (PCU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10% of NH-66 | 980 | 5 | 1049 | 22 | 8 | 6 | 2 | 1 | 21 | 75 | 1 | 2170 | 1760 |
| 50% of V N Sarmalkar road | 3952 | 0 | 216 | 11 | 4 | 30 | 11 | 7 | 925 | 1756 | 0 | 6912 | 5529 |
| 30% of G R Kare road | 2375 | 0 | 112 | 6 | 2 | 27 | 10 | 3 | 756 | 1924 | 0 | 5215 | 4503 |
| **Total** | **7307** | **5** | **1377** | **39** | **14** | **63** | **23** | **11** | **1702** | **3755** | **1** | **14297** | **11792** |

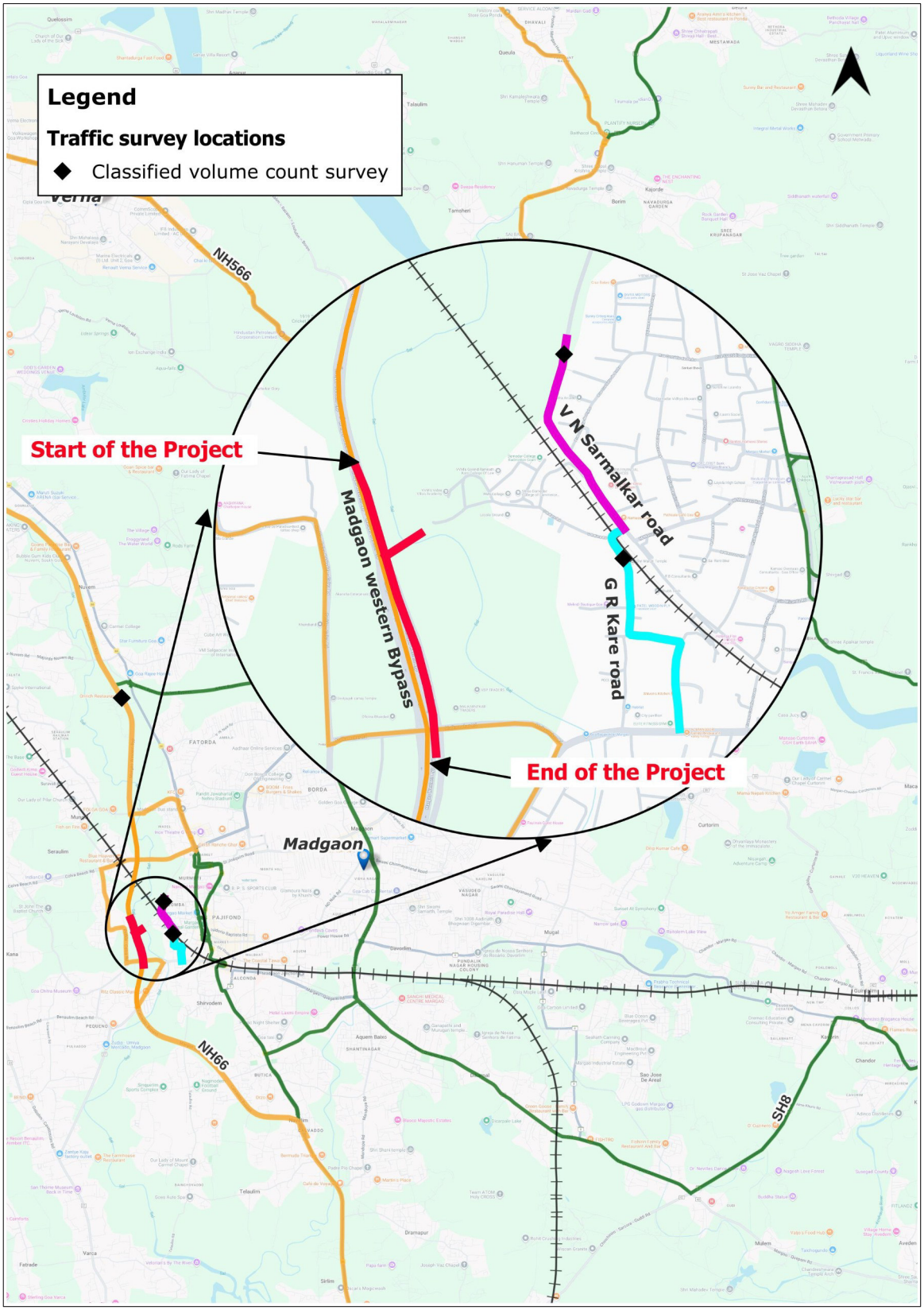



**Fig.– 2.7: Map showing Traffic Assessment plan**

## 2.4 Traffic Forecast

### 2.4.1 Methodology

The past motor vehicle registration data at the state level provides a valuable indication regarding the trends in the traffic growth and presents a dependable tool for estimating future growth rates in different categories of vehicles.

A more rational method will be to establish a relationship between the socio-economic variables such as Population, Net State Domestic Product (NSDP) and Per-Capita Income (PCI) on the one hand and the past registration data of different categories of vehicles on the other to determine the elasticity of transport demand with respect to different categories of vehicles. According to IRC: 108 - 1996, an econometric model could be derived in the form

$$\text{Log e } P = A0 + A1 \text{ Log e } (E.I)$$

Where:

P = number of vehicles of any particular category;

E.I = Economic Indicator such as NSDP, Per-capita income or Population;

A0 = Constant;

A1 = Regression coefficient (Elasticity value).

Based on future economic growth prospects in terms of income growth, per-capita growth and population growth, the future traffic growth rate by vehicle type are estimated by suitably adjusting the elasticity values.

### 2.4.2 Secondary Data Collection

The analyzed traffic data from the primary surveys and processed data from secondary sources pertaining to the project stretch together provide basic input for design, future projection of traffic. It is observed from the number plate data, that Goa state registered vehicles constitute majority of the vehicles, following secondary information like statistical data, economic indicators and vehicle registration data (past traffic data) of Goa has been collected as shown below.

**Table –2.8: Vehicle registration & Economic Indicators of Goa**

| Sl. No. | Year | Vehicle Registration statistics | | | | | Economic Indicators | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cars/ Jeeps | Trucks | 2 Wheel-ers | Buses | 3 Wheel-ers | GSDP (Rs in Crs) | PCI (Rs) | Pop (in 00's) | NSDP (Rs in Crs) |
| 1 | 2006 | 99548 | 32524 | 408269 | 6376 | 3569 | 15042 | 86257 | 1403107 | 13085 |
| 2 | 2007 | 109945 | 32762 | 436662 | 6770 | 3622 | 15875 | 87085 | 1414194 | 13655 |
| 3 | 2008 | 121490 | 32969 | 467827 | 7644 | 3675 | 17466 | 90409 | 1425282 | 14728 |
| 4 | 2009 | 133717 | 33587 | 502042 | 8332 | 3728 | 19248 | 95320 | 1436370 | 16119 |
| 5 | 2010 | 149869 | 34771 | 541934 | 8907 | 3782 | 22499 | 110306 | 1447457 | 19293 |
| 6 | 2011 | 167544 | 37730 | 589377 | 9513 | 3835 | 27045 | 129397 | 1458545 | 23279 |
| **Average Yearly Growth Rate %** | | **10.98** | **3.05** | **7.62** | **8.36** | **1.45** | **12.57** | **8.65** | **0.78** | **12.4** |

*Note: GSDP – Gross State Domestic Product, NSDP–Net State Domestic Product, PCI- Per Capita Income, Pop- Population*

### 2.4.3 Traffic Growth Rate

The most important parameter, on which the future forecast of traffic depends, is the Growth rate. However, for a small stretch where most of the traffic neither originates nor ends within the stretch, growth potential of the origin and destination (Zone of Influence) need to be assessed to arrive at the growth potential of the stretch. It is ideal to identify future growth potential of each zone for goods and passenger movements and for each category of vehicles separately.

### 2.4.4 Estimation of Growth Rates

To arrive at a realistic and rational assessment of growth factor, efforts have been made to collect various secondary data and statistical information.

The growth factor derived from past traffic data on the stretch supplemented by registration trend and the statistical parameters would have been the ideal method. However, due to irregular, erratic and insufficient past traffic data available, the derivation of elasticity and growth factors was based on registration data of vehicles and the economic parameters.

The growth trend has been derived for the following categories of vehicles:

Pv = Passenger Vehicles (Car, jeep, Taxi, Van, etc.)
T = Trucks (Mini LCV, LCV, 2 Axle, 3 Axle and M Axle)

B = Bus, Mini Bus

The following steps have been adopted to derive the elasticity and growth factors

- Growth rate of registered vehicles in zone of influence is found out.
- Growth rates of NSDP/GSDP, Per Capita Income and population are obtained.
- For passenger vehicles and buses, number of registered vehicles has been regressed with population data of the state.
- For trucks, number of registered trucks has been regressed with NSDP of the state for intra-state movement and GDP for inter-state movement.
- Mean value of average growth rate of registered vehicles and the growth rate obtained by regression analysis for all categories have been found out at state level for trucks.
- For passenger vehicles and buses, the mean growth rate of registered vehicular growth rate and that from regression analysis have been adopted.

The elasticity analysis is presented below.

**Table – 2.9 : Elasticity Analysis**

| S. No | Mode | Economic Indicator | Goa | |
|---|---|---|---|---|
| | | | Elasticity Value | $R^2$ Value |
| 1 | Cars/Jeep | PCI | 1.14 | 0.88 |
| 2 | Trucks | NSDP | 0.25 | 0.94 |
| 3 | 2 Wheelers | PCI | 0.81 | 0.89 |
| 4 | Buses | Population | 10.73 | 0.99 |

The projected growth rates for different category of vehicles for revenue calculations are presented below.

**Table – 2.10 : Projected Growth Rates**

| S. No. | Period | 2 Wheeler | 3 Wheeler | Cars/ Jeeps | Buses | Trucks | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2 Axle | 3 Axle | M Axle | LCV and Mini LCV |
| 1 | Up to 2027 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| 2 | 2028 -2032 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| 3 | Beyond 2032 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |

## 2.5 Traffic Projections

### 2.5.1 Traffic projections

The project corridor is a grade separated structure and projection of traffic is important for knowing the Total Traffic in the coming years. The traffic growth is influenced by several factors such as state economy, agricultural production, industrial production etc. The traffic on the project corridor has been projected with growth rates. Traffic projections summary has been furnished below**.**

**Table – 2.11: Traffic Projections Along the Main Road on Gorroti (Km. 546.720)**

| Year | 2W | 3W | Cars | BUS | M. Bus | 2 Axle | 3 Axle | M Axle | LGV/ LCV | M. LCV | Tract-ors | Total volume (nos.) | Total volume (PCU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2024 | 9792 | 48 | 10124 | 351 | 10 | 53 | 11 | 4 | 207 | 744 | 0 | 21661 | 17580 |
| 2029 | 12498 | 61 | 12921 | 448 | 13 | 68 | 15 | 5 | 265 | 949 | 0 | 27645 | 22438 |
| 2034 | 15950 | 78 | 16491 | 572 | 17 | 87 | 19 | 7 | 338 | 1211 | 0 | 35283 | 28637 |
| 2039 | 20357 | 100 | 21048 | 1172 | 22 | 110 | 24 | 9 | 431 | 1546 | 0 | 45031 | 36548 |
| 2044 | 25982 | 127 | 26863 | 1496 | 28 | 141 | 30 | 11 | 550 | 1973 | 0 | 57472 | 46646 |
| 2049 | 33160 | 162 | 34284 | 1910 | 35 | 180 | 39 | 14 | 702 | 2518 | 0 | 73351 | 59533 |
| 2054 | 42321 | 207 | 43757 | 2437 | 45 | 230 | 50 | 18 | 896 | 3214 | 0 | 93616 | 75981 |

### 2.5.2 Capacity and Level of Service

The Capacity of a facility is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of the lane or roadway during a given time period under prevailing roadway, traffic and control conditions. By comparing the present traffic volume with the capacity of existing highways, their adequacy or deficiency can be assessed. Improvements and changes in the geometric features, junction features, traffic control devices and traffic management measures can be planned if capacity studies are considered.

The Highway Capacity Manual has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating conditions and traffic volumes. It is defined as a qualitative measure describing the operational conditions within a traffic stream and their perception by motorists. The level of service for urban and suburban roads can be related to the flow conditions, aver-

age overall travel speed, load factor at intersections, peak hour factor and service volume to capacity ratio. National and State Highways in rural areas are normally designed for LOS B giving a design service volume of 40000 PCUs per day for 4 lane divided carriageway and 57000 PCUs per day for 6 lane divided carriageway. The LOS and capacity analysis for the proposed project stretch are presented in Table – 4.15

**Table – 2.12: Capacity Analysis with total traffic on Project stretch**

| Year | 2W | 3W | Car / Jeep | Car / Jeep (YB) | Tata Magic | RTC Bus | Private Bus | School | Mini Bus | 2 Axle | 3 Axle | Multi Axle | Over sized | LGV/ LCV | Mini LCV | Tractor | Tractor with trailer/ Others | Cycle | Cycle Rickshaw | Animal Drawn | Total Vehicles | Total PCUs | Recommendation based on V/C ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCU's | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 3.00 | 3.00 | 3.00 | 1.50 | 3.00 | 3.00 | 4.50 | 4.50 | 1.50 | 1.00 | 1.50 | 4.50 | 0.50 | 2.00 | 8.00 | | | |
| **2024** | 7307 | 5 | 1277 | 100 | 36 | 20 | 9 | 10 | 14 | 63 | 23 | 10 | 1 | 1702 | 3755 | 1 | 0 | 0 | 0 | 0 | 14333 | 11827 | 2 Lane Divided with Paved Shoulder |
| **2025** | **7672** | **5** | **1341** | **105** | **38** | **21** | **9** | **11** | **15** | **66** | **24** | **11** | **1** | **1787** | **3943** | **1** | **0** | **0** | **0** | **0** | 15050 | 12418 | 2 Lane Divided with Paved Shoulder |
| **2026** | 8056 | 6 | 1408 | 110 | 40 | 22 | 10 | 11 | 15 | 69 | 25 | 11 | 1 | 1876 | 4140 | 1 | 0 | 0 | 0 | 0 | 15802 | 13039 | 2 Lane Divided with Paved Shoulder |
| **2027** | 8459 | 6 | 1478 | 116 | 42 | 23 | 10 | 12 | 16 | 73 | 27 | 12 | 1 | 1970 | 4347 | 1 | 0 | 0 | 0 | 0 | 16592 | 13691 | 2 Lane Divided with Paved Shoulder |
| **2028** | 8882 | 6 | 1552 | 122 | 44 | 24 | 11 | 12 | 17 | 77 | 28 | 12 | 1 | 2069 | 4564 | 1 | 0 | 0 | 0 | 0 | 17422 | 14375 | 2 Lane Divided with Paved Shoulder |
| **2029** | 9326 | 6 | 1630 | 128 | 46 | 26 | 11 | 13 | 18 | 80 | 29 | 13 | 1 | 2172 | 4792 | 1 | 0 | 0 | 0 | 0 | 18293 | 15094 | 2 Lane Divided with Paved Shoulder |
| **2030** | 9792 | 7 | 1711 | 134 | 48 | 27 | 12 | 13 | 19 | 84 | 31 | 13 | 1 | 2281 | 5032 | 1 | 0 | 0 | 0 | 0 | 19208 | 15849 | 2 Lane Divided with Paved Shoulder |
| **2031** | 10282 | 7 | 1797 | 141 | 51 | 28 | 13 | 14 | 20 | 89 | 32 | 14 | 1 | 2395 | 5284 | 1 | 0 | 0 | 0 | 0 | 20168 | 16641 | 2 Lane Divided with Paved Shoulder |
| **2032** | 10796 | 7 | 1887 | 148 | 53 | 30 | 13 | 15 | 21 | 93 | 34 | 15 | 1 | 2515 | 5548 | 1 | 0 | 0 | 0 | 0 | 21176 | 17473 | 2 Lane Divided with Paved Shoulder |
| **2033** | 11336 | 8 | 1981 | 155 | 56 | 31 | 14 | 16 | 22 | 98 | 36 | 16 | 2 | 2640 | 5825 | 2 | 0 | 0 | 0 | 0 | 22235 | 18347 | 4 Lane Divided |
| **2034** | 11902 | 8 | 2080 | 163 | 59 | 33 | 15 | 16 | 23 | 103 | 37 | 16 | 2 | 2772 | 6116 | 2 | 0 | 0 | 0 | 0 | 23347 | 19264 | 4 Lane Divided |
| **2035** | 12497 | 9 | 2184 | 171 | 62 | 34 | 15 | 17 | 24 | 108 | 39 | 17 | 2 | 2911 | 6422 | 2 | 0 | 0 | 0 | 0 | 24514 | 20227 | 6 Lane Divided |
| **2036** | 13122 | 9 | 2293 | 180 | 65 | 36 | 16 | 18 | 25 | 113 | 41 | 18 | 2 | 3057 | 6743 | 2 | 0 | 0 | 0 | 0 | 25740 | 21239 | 6 Lane Divided |
| **2037** | 13778 | 9 | 2408 | 189 | 68 | 38 | 17 | 19 | 26 | 119 | 43 | 19 | 2 | 3209 | 7081 | 2 | 0 | 0 | 0 | 0 | 27027 | 22301 | 6 Lane Divided |
| **2038** | 14467 | 10 | 2528 | 198 | 71 | 40 | 18 | 20 | 28 | 125 | 46 | 20 | 2 | 3370 | 7435 | 2 | 0 | 0 | 0 | 0 | 28378 | 23416 | 6 Lane Divided |
| **2039** | 15191 | 10 | 2655 | 208 | 75 | 42 | 19 | 21 | 29 | 131 | 48 | 21 | 2 | 3538 | 7806 | 2 | 0 | 0 | 0 | 0 | 29797 | 24586 | 6 Lane Divided |
| **2040** | 15950 | 11 | 2788 | 218 | 79 | 44 | 20 | 22 | 31 | 138 | 50 | 22 | 2 | 3715 | 8197 | 2 | 0 | 0 | 0 | 0 | 31287 | 25816 | 6 Lane Divided |
| **2041** | 16748 | 11 | 2927 | 229 | 83 | 46 | 21 | 23 | 32 | 144 | 53 | 23 | 2 | 3901 | 8607 | 2 | 0 | 0 | 0 | 0 | 32851 | 27107 | 6 Lane Divided |
| **2042** | 17585 | 12 | 3073 | 241 | 87 | 48 | 22 | 24 | 34 | 152 | 55 | 24 | 2 | 4096 | 9037 | 2 | 0 | 0 | 0 | 0 | 34494 | 28462 | 6 Lane Divided |
| **2043** | 18464 | 13 | 3227 | 253 | 91 | 51 | 23 | 25 | 35 | 159 | 58 | 25 | 3 | 4301 | 9489 | 3 | 0 | 0 | 0 | 0 | 36219 | 29885 | 6 Lane Divided |
| **2044** | 19388 | 13 | 3388 | 265 | 96 | 53 | 24 | 27 | 37 | 167 | 61 | 27 | 3 | 4516 | 9963 | 3 | 0 | 0 | 0 | 0 | 38030 | 31379 | 6 Lane Divided |
| **2045** | 20357 | 14 | 3558 | 279 | 100 | 56 | 25 | 28 | 39 | 176 | 64 | 28 | 3 | 4742 | 10461 | 3 | 0 | 0 | 0 | 0 | 39931 | 32948 | 6 Lane Divided |
| **2046** | 21375 | 15 | 3736 | 293 | 105 | 59 | 26 | 29 | 41 | 184 | 67 | 29 | 3 | 4979 | 10984 | 3 | 0 | 0 | 0 | 0 | 41928 | 34596 | 6 Lane Divided |
| **2047** | 22444 | 15 | 3922 | 307 | 111 | 61 | 28 | 31 | 43 | 194 | 71 | 31 | 3 | 5228 | 11534 | 3 | 0 | 0 | 0 | 0 | 44024 | 36325 | 6 Lane Divided |
| **2048** | 23566 | 16 | 4118 | 323 | 116 | 65 | 29 | 32 | 45 | 203 | 74 | 32 | 3 | 5489 | 12110 | 3 | 0 | 0 | 0 | 0 | 46225 | 38142 | 6 Lane Divided |
| **2049** | 24744 | 17 | 4324 | 339 | 122 | 68 | 30 | 34 | 47 | 213 | 78 | 34 | 3 | 5764 | 12716 | 3 | 0 | 0 | 0 | 0 | 48537 | 40049 | 6 Lane Divided |
| **2050** | 25981 | 18 | 4541 | 356 | 128 | 71 | 32 | 36 | 50 | 224 | 82 | 36 | 4 | 6052 | 13352 | 4 | 0 | 0 | 0 | 0 | 50963 | 42051 | 6 Lane Divided |

| Year | 2W | 3W | Car / Jeep | Car / Jeep (YB) | Tata Magic | RTC Bus | Private Bus | School | Mini Bus | 2 Axle | 3 Axle | Multi Axle | Over sized | LGV/ LCV | Mini LCV | Tractor | Tractor with trailer/ Others | Cycle | Cycle Rickshaw | Animal Drawn | Total Vehicles | Total PCUs | Recommendation based on V/C ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCU's | 0.50 | 1.00 | 1.00 | 1.00 | 1.00 | 3.00 | 3.00 | 3.00 | 1.50 | 3.00 | 3.00 | 4.50 | 4.50 | 1.50 | 1.00 | 1.50 | 4.50 | 0.50 | 2.00 | 8.00 | | | |
| **2051** | 27280 | 19 | 4768 | 373 | 134 | 75 | 34 | 37 | 52 | 235 | 86 | 37 | 4 | 6354 | 14019 | 4 | 0 | 0 | 0 | 0 | 53512 | 44154 | 6 Lane Divided |
| **2052** | 28644 | 20 | 5006 | 392 | 141 | 78 | 35 | 39 | 55 | 247 | 90 | 39 | 4 | 6672 | 14720 | 4 | 0 | 0 | 0 | 0 | 56187 | 46361 | 6 Lane Divided |
| **2053** | 30077 | 21 | 5256 | 412 | 148 | 82 | 37 | 41 | 58 | 259 | 95 | 41 | 4 | 7006 | 15456 | 4 | 0 | 0 | 0 | 0 | 58997 | 48679 | 6 Lane Divided |
| **2054** | 31580 | 22 | 5519 | 432 | 156 | 86 | 39 | 43 | 61 | 272 | 99 | 43 | 4 | 7356 | 16229 | 4 | 0 | 0 | 0 | 0 | 61946 | 51113 | 6 Lane Divided |
| **2055** | 33159 | 23 | 5795 | 454 | 163 | 91 | 41 | 45 | 64 | 286 | 104 | 45 | 5 | 7724 | 17040 | 5 | 0 | 0 | 0 | 0 | 65044 | 53669 | 6 Lane Divided |

# 3.0 Pavement Design Report

## 3.1 Introduction

The Government of India has envisaged to create a world-class infrastructure facility, to boost the economic development in the country and also to minimize the number of accidents/fatalities, for which Ministry of Road Transport and Highways (MoRTH) plays a key role. MoRTH has been entrusted to implement various developmental projects of National Highways in order to ensure safer and faster movement of the Vehicles. As part of this endeavor, MoRTH executes the works through the Public Works Department (PWD) in the state of Goa. Public Works Department (NH), Goa has taken up developement of road network in the state of Goa

Public Works Department (PWD) of Goa has appointed M/s Aarvee Engineering Consultants Ltd (Formerly M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd., Hyderabad) to provide consultancy services for DPR for the above road section.

The consultants have carried out the traffic surveys to assess the traffic pattern and volume of traffic. Pavement design has been carried out based on the output of Traffic surveys conducted at the junction locations.

## 3.2 Pavement Design Objective

The Objective is to determine the total thickness of the pavement structure as well as thickness of individual structural layer components. Design strength of pavement must be adequate to support the projected traffic loading throughout the design period.

## 3.3 Design Guidelines

**Design Life**: "Flexible pavements are designed in accordance with IRC:37 and rigid pavement are designed in accordance with the method prescribed in IRC:58

- Clause 4.3.1 of IRC:38-2018, states: "A design period of 20 years may be adopted for the structural design of pavements for National Highways, State Highways and Urban Roads"
- Clause 5.4 of IRC:58-2015, states: Cement concrete pavements may be designed to have a life span of 30 years or more.
- Clause 5.7.4 of IRC: 58-2015, states: A subbase of Dry Lean Concrete (DLC) having a 7-day average compressive strength of 7 MPa determined as per IRC:SP:49 over GSB is recommended for highways. Minimum recommended thickness of DLC for major highways is **150 mm**. The DLC shall extend beyond the PQC by 0.5 m on either side.

- Clause 5.7.5 of IRC:58-2015, states: A de-bonding interlayer of polythene sheet white or transparent having a minimum thickness of 125 micron is recommended as per the current practice in India

### 3.4 Design CBR

The CBR of borrow material varies between 6% and 14%. Considering the fact that the contractor executing the works may opt for alternative sources than studied herein, an average value of 10% is adopted in the pavement design.

### 3.5 Traffic Volume Count Surveys

Since the proposed road is a brownfield corridor, traffic volume count surveys were conducted at the junction locations. The Consultant have carried out Classified Traffic Volume Count survey near Gorotti at Km. 546.720 on NH-66, round the clock for 24 hours at the location. Axle load survey conducted at the survey locations to assess the load characteristics of commercial vehicles. Accordingly the commercial traffic is estimated using the fraction of the vehicle movement between the influential zones applied to the Annual average daily traffic data. Only the commercial vehicles are to be converted into standard axles for the purpose of pavement design. Detailed analysis has been presented in Traffic Report.

**Table-3.1: AADT for the survey location near Gorotti (Km. 546.720)**

| Mode | Gorroti (Km. 546.720) |
|---|---|
| Two Wheelers | 9792 |
| Three Wheelers | 48 |
| Car / Jeep / Van | 9393 |
| Car Yellow board | 731 |
| Tata Magic | 361 |
| RTC Bus | 146 |
| Private Bus | 57 |
| School/College bus | 72 |
| Mini Bus | 10 |
| 2 Axle | 53 |
| 3 Axle | 11 |
| M Axle | 4 |
| HEM | 5 |
| LCV/LGV | 207 |
| Mini LCV | 744 |

| Mode | | Gorroti (Km. 546.720) |
|---|---|---|
| Three Wheeler goods | | 4 |
| Tractor | | 3 |
| Tractor with trailer/others | | 0 |
| Non-Motorized Vehicles | | 22 |
| Govt. Exempted Vehicles | | 33 |
| Tollable Traffic (vehicles) | | 11795 |
| Tollable Traffic (PCU's) | | 21697 |
| Total Vehicles | Motorized | 21675 |
| | Non-Motorized | 22 |
| | Total Traffic | 21697 |
| Total PCUs | Motorized | 17524 |
| | Non-Motorized | 16 |
| | Total Traffic | 17540 |

### 3.6 Traffic Growth Rates

Past trends in the growth rates along the proposed project corridor provide a valuable information to the likely future traffic. But in most cases, the past traffic data from statistical department is inconsistent and cannot be taken as a basis for future traffic growth rate. Alternatively the motor vehicle registration data at the state level during the recent past provides more consistent information regarding the trends in traffic growth and thus presents a better tool for estimating future growth rates of different categories of vehicles. A more rational method is to establish a relationship between the socio - economic variables such as population, Net State Domestic Product and Per-capita income on one hand and the past registration data of different categories of vehicles on the other to determine the Elasticity of Transport Demand with respect to different categories of vehicles. The detailed calculations of growth rates are given in traffic report. The computed traffic growth rates are given in the below Table-5.2.

**Table-3.2: Actual growth rates in percentages**

| Traffic Growth Rates (%) | BUS | LCVs | 2-Axle Trucks | 3-Axle Trucks |
|---|---|---|---|---|
| Up to 2024 | 5.0 % | 5.0 % | 5.0 % | 5.0 % |
| 2024-2029 | 5.0 % | 5.0 % | 5.0 % | 5.0 % |
| 2029–2034 | 5.0 % | 5.0 % | 5.0 % | 5.0 % |
| 2034 – 2039 | 5.0 % | 5.0 % | 5.0 % | 5.0 % |
| Beyond 2039 | 5.0 % | 5.0 % | 5.0 % | 5.0 % |

### 3.7 Axle Load Surveys

The Vehicle Damage Factor (VDF) is an index characterizing the traffic loading for a highway and is defined as a multiplier for converting the number of commercial vehicles of different axle loads to Standard Axle Loads (SAL). Equivalency factor (EF) is normally worked out by using the Fourth Power Rule derived by AASHTO. However, CRRI has suggested a factor of 4.5 for developing countries. In the present study, the Fourth Power Rule given by AASHTO has been adopted. With the help of equivalency factors and frequency distribution of axle loads, Equivalent Axle Loads (EAL) are computed. The standard axle loads and the legal axle loads considered while calculating the equivalency factors for various axles are furnished below.

**Table-3.3: Standard & legal Axle loads**

| S.No | Type of Axle | Standard Axle Load (Tonnes) | Legal Axle Load (Tonnes) | Reference |
|---|---|---|---|---|
| 1 | Single Axle (1$^{le}$ wheel) | 6.60 | 6.60 | IRC-3 |
| 2 | Single Axle (2$^{al}$ wheel) | 8.16 | 10.20 | IRC-37/IRC-3 |
| 3 | Tandem Axle | 15.09 | 19.00 | IRC-37/IRC-3 |

VDF depends on the composition of commercial traffic, the load carried and the actual sample collected. The following table gives the VDF's adopted in design.

**Table-3.4: Vehicle Damage Factor (VDF) adopted**

| Mode | Adopted VDF |
|---|---|
| LCV | 0.74 |
| 2A | 3.78 |
| 3A | 4.53 |
| MA | 5.39 |

### 3.8 Million Standard Axles (MSA)

Design traffic in terms of Million Standard Axles (MSA) is determined at location, where both volume count and axle load surveys were conducted.

The traffic loading in terms of the cumulative number of standard axles for the design period is computed using the following relationship.

$N = 365 * [(1+r)^n - 1] * A * D * L * F / r$

Where,

N: The cumulative number of standard axles to be catered for in the design in terms of MSA.

A: Initial traffic in the year of completion of construction in terms of the number of commercial vehicles per day

L: Lane Distribution Factor

D: Directional Distribution Factor

n: Design Life in years

r: Annual Growth rate of commercial vehicles (5 %).

F: Vehicle Damage Factor

### 3.9 Pavement Investigations

The design consultants have undertaken the following pavement investigations to assess the condition of the existing pavement along with the quality of the materials that have been incorporated in construction. Pavement has been investigated subjectively as well as objectively at suitable interval where necessary, for its structural and functional performance. Following investigations were carried out for the project stretch.

- Condition survey by visual inspection
- Test Pit investigations
- Geotechnical investigation of subgrade
- Benkelman Beam Deflection Test

### 3.10 Preliminary Design of Flexible Pavement

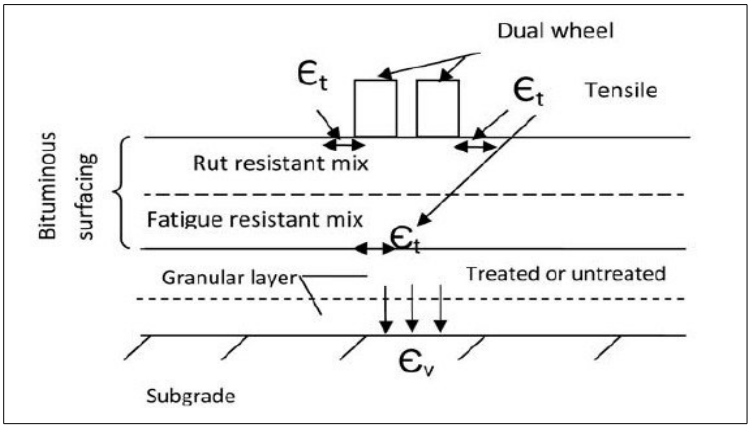
#### 3.10.1 General

The flexible pavement is modeled as an elastic multi layer structure. Stresses and strains at critical locations are computed using linear layered elastic model. The stress – strain analysis software IIT-PAVE has been used for the computation of stress and strain in flexible pavements as mentioned below

- Horizontal Tensile Strain at bottom of bituminous layer, which can cause fatigue failure of bituminous layer.

- Vertical Compressive Strain at the top of subgrade, which can cause rutting failure of pavement layers.
- Horizontal Tensile Strain at bottom of Cement treated base, which can cause fatigue failure of cement treated layer.

The flexible pavement has low flexural strength and hence layers reflect the deformation of the lower layers/sub-grade on to the surface layer after the withdrawal of wheel load. To control the deflections in the sub-grade so that no permanent deflections results the pavement thickness is so designed that the stresses on the subgrade soil are kept within its bearing power. Loading of bituminous pavement requires the stiffest layers to be placed at the surface with successive weaker layers down to subgrade. For the purpose of structural design, only the number of commercial vehicles of laden weight of 3 tonnes or more and their axle loading will be considered.




### 3.10.2 Fatigue Model

Due to repetition of loads, tensile strain develops cracks at the bottom of bituminous layers which is a problem for long term serviceability. The phenomenon is called fatigue of the bituminous layer and the number of load repetitions in terms of standard axles that causes fatigue denotes the life of the pavement. Two fatigue equations are considered, one in which the computed strains corresponds to 80% reliability level and the other corresponding to 90% reliability level.

The 80% reliability equation is used for the pavement where VG30 grade bitumen is used and 90% reliability equation is used for the pavement where VG40 grade bitumen is used. The two equations for the conventional bituminous mixes designed by Marshall method are given below.

$$N_f = 2.21 \times 10^{-4} \times (1/E_t)^{3.89} \times (1/M_R)^{0.854} \text{ ---------1 (80\% Reliability)}$$

$$N_f = 0.711 \times 10^{-4} \times (1/E_t)^{3.89} \times (1/M_R)^{0.854} \text{ --------2 (90\% Reliability)}$$

$N_f$ = Fatigue life in number of standard axles

$E_t$ = Maximum tensile strain at the bottom of Bituminous layer.

$M_R$ = Resilient Modulus of the Bituminous layer

The ***equation 2*** is modified by considering 90% reliability with air voids around 3% and the volume of bitumen about 13%.

### 3.10.3 Rutting Model

Rutting is the permanent deformation in pavement usually occurring longitudinally along the wheel path. The rutting may partly be caused by deformation in the subgrade and other non-bituminous layers which would reflect to the overlying layers to take a deformed shape. The 80% reliability equation is used for the pavement where VG30 grade bitumen is used and 90% reliability equation is used for the pavement where VG40 grade bitumen is used. The rutting model considers the vertical strain in subgrade and the two equations are given below by considering 80% & 90% reliability.

$$N = 4.1656 \times 10^{-8} \times (1/E_v)^{4.5337} \text{ ------3 (80\% Reliability)}$$

$$N = 1.41 \times 10^{-8} \times (1/E_v)^{4.5337} \text{ ---------4 (90\% Reliability)}$$

N = Number of cumulative standard axles to produce 20 mm rutting.

$E_v$ = Maximum Vertical subgrade strain (micro strain)

### 3.10.4 Pavement Layers

In accordance with IRC:37-2018 for the following base and sub-base options are available.

- Granular base and sub-base.
- Cementitious bases and sub-bases with a crack relief layer of aggregate inter-layer below bituminous surfacing.
- Cementitious bases and sub-bases with SAMI in between bituminous surfacing and the contentious base layer for retarding the reflection cracks into the bituminous layer.
- Cemented base and granular sub base with crack relief inter-layer of aggregate above Cemented base.
- Bituminous surfacing over treated RAP and cemented sub base.

Stage construction is not permitted when we are using cemented base and sub-bases according to the guidelines of the code as it may lead to cracking of the stabilized layer leading to failure of the pavement. Hence, the consultants adopting Granular Base & Granular Sub-base for main carriageway pavement with stage construction.

#### 3.10.4.1 Sub-base layer:

The sub-base layer serves three functions like to protect the sub-grade from over stressing, to provide a platform for the construction traffic and to serve as drainage and filter layer. Material passing through 0.425 mm (425 micron), LL & PI shall not more than 25 and 6 %. Material shall have a minimum 10% fines when tested in compliance with BS:812. The wa-

ter absorption value (as per IS 2386) of the coarse aggregate shall be less than 2%, if not soundness test shall be carried out as per IS 383. 100% sample should pass through 75mm sieve and only 3-10% sample should pass through 0.075mm sieve for all the three grades. When coarse graded sub base is used as a drainage layer, Los Angeles abrasion value should be less than 40, so that there is no crushing during the rolling and the permeability is retained. The sub-base should be composed of two layers, the lower layer forms the separation/filter layer to prevent intrusion of subgrade soil into the pavement and upper layer forms the drainage layer to drain away any water that may enter through surface cracks.

**Strength Parameter:** Resilient Modulus ($M_{Rgsb}$)

$M_{Rgsb}$= 0.2 X $h^{(0.45)}$ X $M_{R\ subgrade}$, where h is thickness of subbase layer in mm.

$M_R$ value of subbase is dependent on $M_R$ value of subgrade since weaker subgrade does not permit higher modulus of the upper layer because of deformation under loads.

$M_{R\ subgrade}$ = 10 X CBR if Subgrade CBR is <=5

$M_{R\ subgrade}$ = 17.6 X $(CBR)^{0.64}$ if Subgrade CBR is >5

### 3.10.4.2 Base layer:

Base layer consists of WMM, WBM, Crusher run macadam, reclaimed concrete etc. Relevant specifications of IRC/MORTH are to be adopted for the construction.

*Strength Parameter*: Resilient Modulus ($M_{R\ granular}$)

When both sub-base and base layers are made up of unbound granular layers, the composite resilient modulus of the granular subbase and base are as follows:

$M_{R\ granular}$= 0.2 X $h^{0.45}$ X $M_{R\ subgrade}$,

where h is combined thickness of subbase and base layers in mm.

### 3.10.4.3 Bituminous layers (Binder and Surface)

Binder layer consists of DBM and BM are to be adopted for construction. It acts like a load distribution and supporting layer.

**Strength Parameter:** Resilient Modulus ($M_{RBC/DBM}$)

The strength of bituminous mix based on extensive laboratory testing of Resilient Modulus Test. Based on the study data of India, IRC:37-2018 recommended resilient modulus for different mix types and temperatures are given below.

**Table-3.5: Resilient Modulus of Bituminous Mixes, Mpa**

| Mix Type | Temperature °C | | | | |
|---|---|---|---|---|---|
| | 20 | 25 | 30 | 35 | 40 |
| BC and DBM for VG10 bitumen | 2300 | 2000 | 1450 | 1000 | 800 |
| BC and DBM for VG30 bitumen | 3500 | 3000 | 2500 | 2000 | 1250 |

| Mix Type | Temperature °C | | | | |
|---|---|---|---|---|---|
| | 20 | 25 | 30 | 35 | 40 |
| BC and DBM for VG40 bitumen | 6000 | 5000 | 4000 | 3000 | 2000 |
| BC with Modified bitumen (IRC:SP:13) | 5700 | 3800 | 2400 | 1650 | 1300 |
| BM with VG10 bitumen | - | - | - | 500 | - |
| BM with VG30 bitumen | - | - | - | 700 | - |
| RAP treated with 4% bitumen | - | - | - | 800 | - |

### 3.10.5 Flexible pavement design

Design of flexible pavement is carried out in accordance with IRC:37-2018 for Granular base and sub-base. The standard designs given in plate-6, 14 and 22 of clause 12.1, 12.2 & 12.2 of IRC:37-2018 specify the minimum thickness and specifications of various component layers for different options for the given traffic in terms of cumulative standard axles and the 10% sub-grade CBR. Cumulative standard axles calculated for the 20 year design life for leg wise is given in the Table-5.7.

**Table-3.6: Million standard axles for developmental traffic**

| Section | Cumulative MSA | Design MSA |
|---|---|---|
| Service road & Cross road | 13 | 20 |

Anticipating heavy commercial traffic movement on the proposed highway due to the future developments flexible pavement is adopted for **20 MSA**. Along with the flexible pavement composition with conventional layers option, layer composition with alternate materials have been considered and given in the following tables:

**Table-3.7: Conventional Pavement Composition (Option-1)**

| Section | Eff. CBR (%) | MSA for 20 yrs design life | Bitumen Grade | Crust Composition (mm) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | BC | DBM | WMM | GSB | Total |
| Service road & Cross road | 10 | 20 | VG-40 | 40 | 70 | 250 | 200 | **560** |

**Table-3.8: Composition details Bituminous pavement with Cemented base and sub base with Crack Relief Interlayer of aggregate (Option-2)**

| Section | Eff. CBR (%) | MSA for 20 yrs design life | Bitumen Grade | Crust Composition (mm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | BC | DBM | AIL | CTB | CTSB | Total |
| Service road & Cross road | 10 | 20 | VG-40 | 50 | - | 100 | 110 | 200 | **460** |

**Table-3.9: Composition details Bituminous pavement with Cemented base and Granular Sub base with AIL (Option-3)**

| Section | Eff. CBR (%) | MSA for 20 yrs design life | Bitumen Grade | Crust Composition (mm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | BC | DBM | AIL | CTB | GSB | Total |
| Service road & Cross road | 10 | 20 | VG-40 | 30 | 50 | 100 | 155 | 200 | **535** |

**Table-3.10: Composition details Bituminous pavement with Cemented base and Cemented Sub base with SAMI Layer (Option-4)**

| Section | Eff. CBR (%) | MSA for 20 yrs design life | Bitumen Grade | Crust Composition (mm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | BC | DBM | SAMI | CTB | CTSB | Total |
| Service road & Cross road | 10 | 20 | VG-40 | 30 | 50 | SAMI | 150 | 200 | **430** |

### 3.11 Recommended Pavement Option

Considering the use of the alternate materials in the composition of flexible pavement, due to the lack in the significant practical experience while adopting the mix design and performance after laying, flexible pavement option with the Granular sub base and Wet Mix Macadam is adopted for flexible pavement.

**Recommended option: Flexible Pavement with Wet Mix Macadam (WMM) and Granular sub-base (GSB).**

**Table-3.11: Recommended Pavement Composition (BT, WMM & GSB)**

| Section | Eff. CBR (%) | MSA for 20 yrs design life | Bitumen Grade | Crust Composition (mm) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | BC | DBM | WMM | GSB | Total |
| Service road & Cross road | 10 | 20 | VG-40 | 40 | 70 | 250 | 200 | **560** |

# 4. COST ESTIMATE

## 4.1 Introduction

The Government of India has envisaged to create a world-class infrastructure facility, to boost the economic development in the country and also to minimize the number of accidents/fatalities, for which Ministry of Road Transport and Highways (MoRTH) plays a key role. MoRTH has been entrusted to implement various developmental projects of National Highways in order to ensure safer and faster movement of the Vehicles. As part of this endeavor, MoRTH executes the works through the Public Works Department (PWD) in the state of Goa. Public Works Department (NH), Goa has taken up developement of road network in the state of Goa

Public Works Department (PWD) of Goa has appointed M/s Aarvee Engineering Consultants Ltd (Formerly M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd., Hyderabad) to provide consultancy services for DPR for the above road section.

## 4.2 Location of the Project

The instant Project location is between Km 549.850 and Km 550.500 on Margao Western bypass of NH-66 in South Goa district. Instant stretch is to be developed with proposed service road for the Margao city connecting to NH-66 existing service road.

## 4.3 Objectives

The main objective of the consultancy services is to undertake feasibility studies for the project highway for the purpose of firming up the Authority requirements in respect of development and construction of service road and safety measures between Km 549.850 to Km 550.500 and improvement of junction at Khareband VUP

The objective of the consultancy services also includes:

1. Enhanced safety and level of service for the road users;
2. Superior operation and maintenance enabling enhanced operational efficiency of the Project Highway;
3. Minimal adverse impact on the local population and road users due to road construction;
4. Minimal adverse impact on environment;
5. Minimal acquisition of land;

## 4.4 Rate Analysis

The Unit rates of all items of construction work have been analyzed as per the guidelines given in Standard Data Book of MORT&H. The rates of materials are obtained from the SSR of Goa(2023-24) and corrigendum issued by Govt of Goa from time to time. Market rates are adopted for items for which the rates are not available in SSR. The location of material quarries like gravel, sand, crushed aggregate are obtained from the material investigations. The leads of different materials are obtained by drawing the lead chart. In respect of hourly hire and operating cost of various road construction machinery and equipment, rates given in MORT&H Standard Data Book and SSR are considered. For machinery and equipment not covered by these two, the prevailing market rates are considered and the labour rates are taken from SSR.

The details of Rate Analysis carried out for the project corridor is given in Rate Analysis chapter.

## 4.5 Cost Estimates

The Cost Estimates are calculated based on the estimated quantities for each item wise with respect to the analysis Rates arrived as per the guidelines given in Standard Data Book of MORT&H & from the SSR of Goa.

# 5. Project Proposals

## 5.1 General

The Government of India has envisaged to create a world-class infrastructure facility, to boost the economic development in the country and also to minimize the number of accidents/fatalities, for which Ministry of Road Transport and Highways (MoRTH) plays a key role. MoRTH has been entrusted to implement various developmental projects of National Highways in order to ensure safer and faster movement of the Vehicles. As part of this endeavor, MoRTH executes the works through the Public Works Department (PWD) in the state of Goa. Public Works Department (NH), Goa has taken up development of road network in the state of Goa

Public Works Department (PWD) of Goa has appointed M/s Aarvee Engineering Consultants Ltd (Formerly M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd., Hyderabad) to provide consultancy services for DPR for the above road section.

Instant stretch is to provide the service road for the traffic travelling to and fro from Margao city. Margao city is one of the most important urban centers in the State of Goa. It functions as the commercial, cultural, and administrative hub of South Goa. The city accommodates important government offices, educational institutions, healthcare facilities, markets, and commercial establishments, serving the needs of both the local population and residents of surrounding towns and villages. Margao is a major transit point for passenger and goods movement due to the presence of Margao Railway Station, one of the busiest railway stations in Goa, providing connectivity to major cities across India. The city also plays a significant role in tourism, acting as a gateway to popular beaches and heritage locations in South Goa. Owing to these factors, Margao attracts substantial daily commuter traffic, freight movement, and tourist inflow, making efficient transportation infrastructure essential for its sustained growth.

In addition, Margao accommodates several prominent educational institutions, including schools, colleges, and professional institutes. A large number of students and staff from surrounding towns and villages commute daily to the city to access these institutions, further contributing to regular traffic demand on the city road network.

Margao city is well connected through a network of National Highways, State Highways, Major District Roads, and urban roads, facilitating intra-city and inter-city movement. The road network caters to diverse traffic including local commuters, inter-district traffic, tourist vehicles, and heavy commercial vehicles. The existing road system provides connectivity between residential areas, commercial centers, industrial zones, bus terminals, railway station, and nearby villages. However, rapid urbanization, increase in vehicular ownership, and growing economic activities have resulted in congestion at key junctions and arterial roads, especially during peak hours. The existing urban road infrastructure is under increasing stress, highlighting the need for capacity augmentation and improved access management.

In recent years, there has been a substantial increase in traffic volume due to population growth, expansion of urban limits, increased tourism, and rising commercial activities. The existing access points between Margao city, NH-66, and adjoining villages are limited and, in several locations, inadequate to handle present and projected traffic demand. Considering future traffic growth, it is imperative to develop additional service road connecting Margao city to NH-66(Existing Service road) and providing safe and efficient connectivity to villages located on either side of the highway. The construction of such service road would:

- Reduce congestion on existing city roads and junctions
- Improve travel time and traffic distribution
- Enhance road safety by minimizing conflict points
- Provide direct and reliable access to NH-66 from Margao city.

- Support balanced urban and regional development

Keeping in view of the above, following are the provisions considered in the estimate:

| Sr. No | Stretch | Provisions |
|---|---|---|
| 1. | Service road | • Widening of existing service road to two lane with paved shoulder from km. 549.850 to Km. 550.450 on Margao Western bypass of NH-66 for a length of 0.600 Km<br>• Construction of two lane road from Vidya Vikas Mandal to Service road on NH-66 for a length of 0.092Km<br>• Construction of Footpath along with paver blocks and provision of railing in a length of 0.492 Km(on LHS).<br>• Improvement of Junctions<br>• Provision of footpath for a length of 310 m at cross roads as part of junction development.<br>• Mural painting for the Vehicular Underpass at Khareband and Varca.<br>• Painting of RE wall for the Vehicular Underpass at Khareband and Varca.<br>• Dismantling of existing toe/retaining walls and construction of new toe/retaining walls at junction locations for junction improvement.<br>• Provision of Retaining wall with crash barrier for a length of 0.686 Km including both sides.<br>• Dismantling & reconstruction of Retaining wall with crash barrier for a length of 0.065 Km as a part of junction improvement at Khareband VUP.<br>• Provision of Highway lighting<br>• Provision of Thrie Metal beam crash barrier for a length of 1.2 |

Km in the Main Carriageway median

- Provision of double faced Thrie beam crash barrier in the separator for a length of 0.185 Km
- Cleaning/removal of vegetation/soil in existing drain and culverts
- Road furniture & Traffic calming measures including sign boards, pavement markings, road studs, Zebra Crossing, Solar Blinkers, Convex mirrors, Reflective Stickers, flexible median markers and Crash barrier indicators.
- Shifting of Utilities
- Provision of Cross Drainage Structures:

| S.No | Proposed type | Proposed span arrangement (m) | Proposed culvert type |
|---|---|---|---|
| 1 | PSC-I Girder (Km 0.046 on Cross road) | 1 x 30.0 | New construction |
| 2 | Box MIB (Km 550.000 on SR) | 1 x 3.0 + 1 x 6.0 + 1 x 3.0 | Retained |
| 3 | Box MIB (Km 550.174 on SR) | 1 x 3.0 + 1 x 6.0 + 1 x 3.0 | Retained and Widening |
| 4 | Box MIB (Km 550.369 on SR) | 1 x 3.0 + 1 x 6.0 + 1 x 3.0 | Retained and Widening |

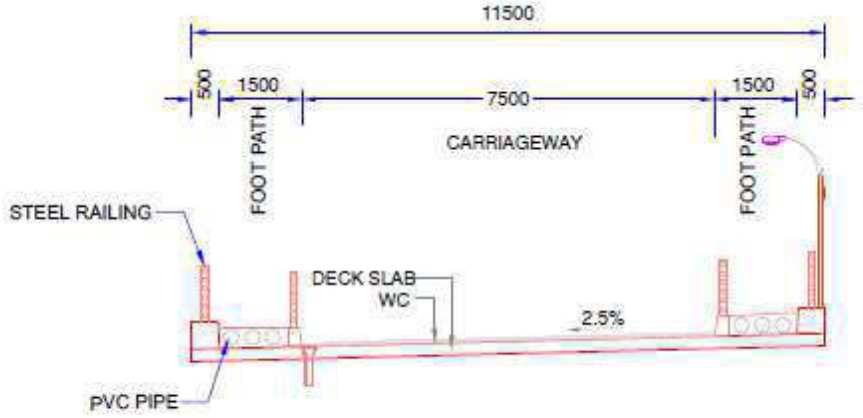
## 5.1 Typical Cross Sections

Following TCS schedule and drawings has been followed for the instant stretches:

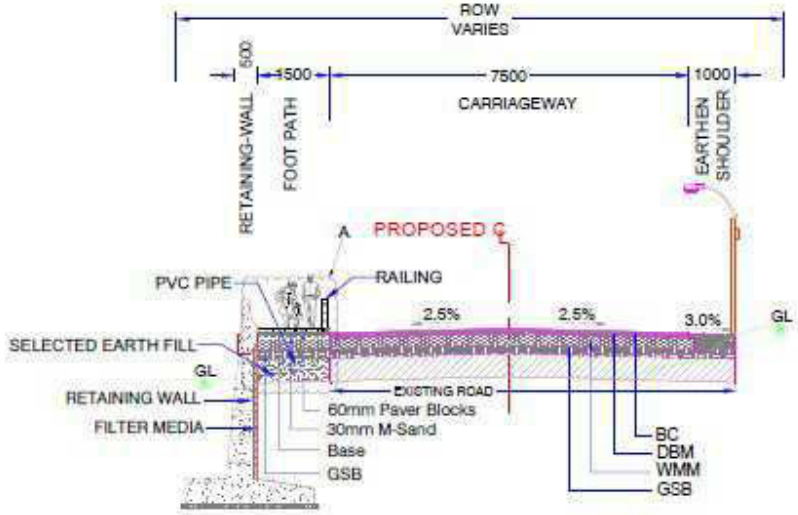
***Table 1: TCS Schedule***

| Cross road | | | | | |
|---|---|---|---|---|---|
| **Chainage (m)** | | **Length (m)** | **PROW** | **Type** | **TCS Description** |
| **From** | **To** | | | | |
| 0 | 31 | 31 | 10.5 | IB | 2 lane road |
| 31 | 61 | 30 | 11.5 | IA | Minor Bridge |
| 61 | 92 | 31 | 11.5 | IC | 2 lane road with retaining wall on both sides |
| **Total** | | **92** | | | |
| **Service road** | | | | | |
| **Chainage (m)** | | **Length (m)** | **PROW** | **Type** | **TCS Description** |
| **From** | **To** | | | | |
| 549850 | 549925 | 75 | 60 | IIA | Existing 4 lane with 2 lane service road (Diverging portion) |
| 549925 | 550050 | 125 | 60 | IIB | Existing 4 lane with 2 lane service road |
| 550050 | 550450 | 400 | 60 | IIC | Existing 4 lane with 2 lane service road (Widening) |
| **Total** | | **600** | | | |

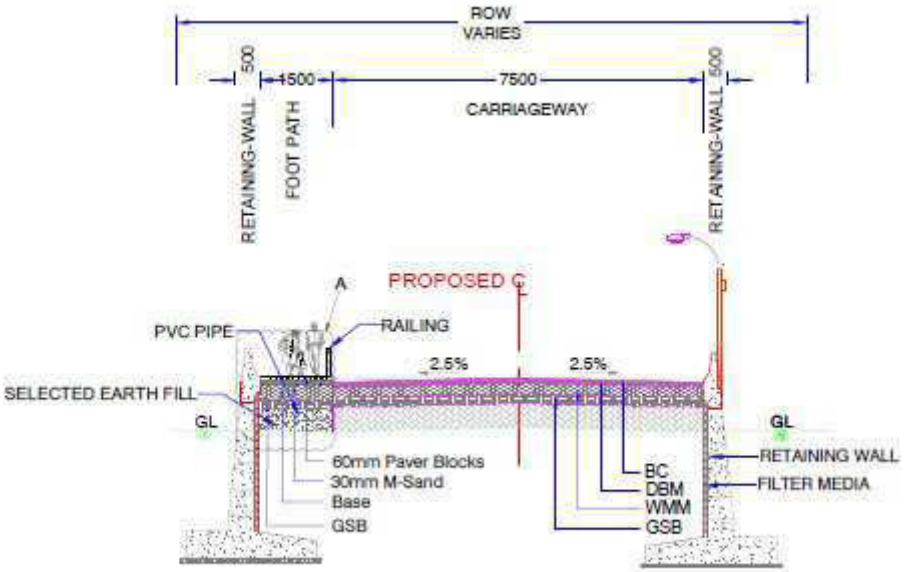
## Typical Cross Sections



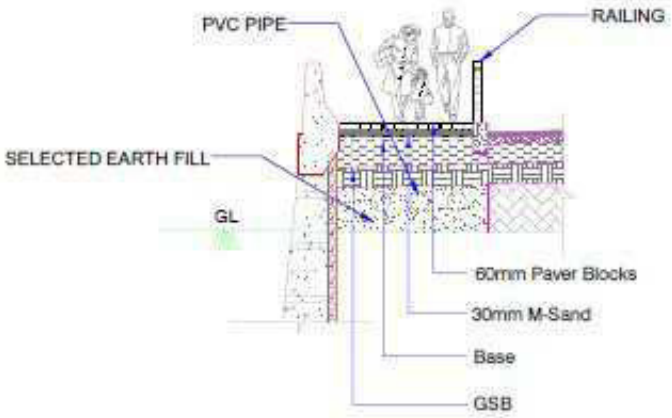

TCS I(A): TYPICAL CROSS SECTION FOR 2 LANE MINOR BRIDGE WITH FOOTPATH ON BOTH SIDES



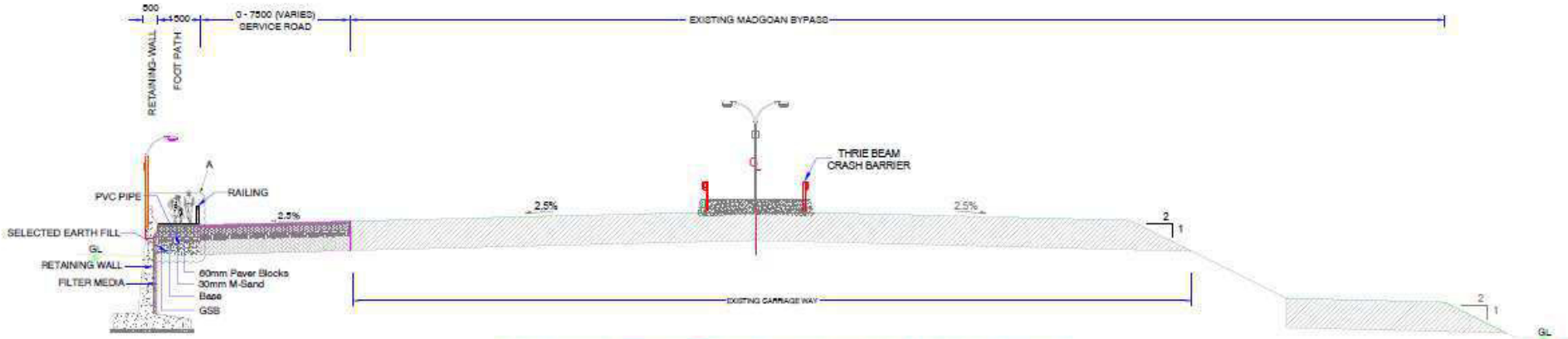

TCS I(B) : 2-LANE ROAD (LHS RETAINING WALL)



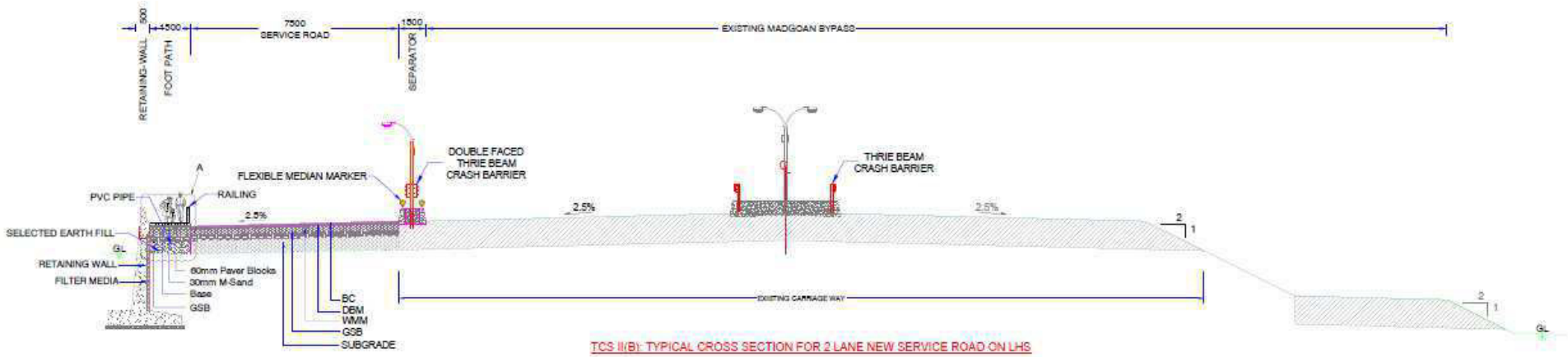

TCS I(C) : 2-LANE ROAD (BOTH SIDES RETAINING WALL)




DETAIL 'A'




TCS II(A): TYPICAL CROSS SECTION FOR 2 LANE NEW SERVICE ROAD ON LHS (DECELERATION)




TCS II(B): TYPICAL CROSS SECTION FOR 2 LANE NEW SERVICE ROAD ON LHS