GOVERNMENT OF GOA

PUBLIC WORKS DEPARTMENT (NATIONAL HIGHWAYS)

Construction of Cattle Underpass near Moita at Km. 528.915 and Construction of Service road between Km. 527.425 to Km. 529.695 on NH-66 in the state of Goa.









MAIN REPORT

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Table of Contents

1.0		Introduction	Page.no
	1.1	General	1-1
	1.2	Project background	1-2
	1.3	Existing Road Condition	1-5
	1.4	Importance Of Road Safety Audit	1-5
	1.5	Objective	1-6
	1.6	Scope	1-6
	1.7	Purpose of existing stage safety audit	1-7
2.0		**Road Safety Audit and Methodology**	
	2.1	Introduction	2-1
	2.2	References of Standards, Specifications and Guidelines	2-4
	2.3	Methodology	2-6
	2.4	Safety audit report	2-7
	2.5	The Checklists	2-8
3.0		**Design Standards**	
	3.1	Road Safety Audit	3-1
	3.2	Importance of Road Safety Audit	3-1
	3.3	Different stages of road safety	3-2
	3.4	Specifications of Road furniture items	3-3
	3.5	Road Studs	3-16
	3.6	Roadside and median safety barriers	3-16
	3.7	Specifications of Traffic calming measures	3-17
	3.8	Measures to control traffic speed	3-26
	3.9	Pedestrian safety measures	3-27
	3.10	Parking Facilities	3-28
	3.11	Safety features at school zones and bus stops	3-29
	3.12	Safety features at Curve locations	3-29
	3.13	Road Studs	3-29
	3.14	Safety features at overtaking zones	3-32
	3.15	Safety features at pedestrian crossings	3-32
	3.16	Pedestrian Level of Service	3-33
	3.17	Footpath	3-34
	3.18	Footpath Design	3-34
	3.19	Shading on pedestrian facilities	3-37
	3.20	Kerb Stone	3-38

Table of Contents

	3.21	Tactile pavers	3-40
	3.22	Street furniture	3-42
	3.23	Pedestrian crossings	3-50
	3.24	At-grade pedestrian crossings	3-51
4.0		**Traffic Analysis & Forecasting**	
	4.1	Introduction	4-1
	4.2	Traffic Surveys Planning & Schedule	4-3
	4.3	Traffic Volume Surveys and Analysis	4-6
	4.4	Traffic Forecast	4-13
	4.5	Traffic Projections	4-16
5.0		**Pavement Design Report**	
	5.1	Introduction	5-1
	5.2	Pavement Design Objective	5-1
	5.3	Design Guidelines	5-1
	5.4	Design CBR	5-2
	5.5	Traffic Volume Count Surveys	5-2
	5.6	Traffic Growth Rates	5-3
	5.7	Axle Load Surveys	5-4
	5.8	Million Standard Axles (MSA)	5-5
	5.9	Pavement Investigations	5-5
	5.10	Preliminary Design of Felixible Pavement	5-5
	5.11	Final Flexible Pavement Design Option for Main Carriageway	5-10
	5.12	Recommended Pavement Option	5-12
	5.13	Preliminary Design for Rigid Pavement	5-13
	5.14	Design of Shoulders	5-15
	5.15	Cycle cost Analysis	5-15
	5.16	Flexible Pavement Composition for Service/Slip Road	5-18
6.0		**Obeservations of the Inspection**	
	6.1	Introduction	6-1
	6.2	Existing Road Condition	6-1
	6.3	Observations	6-1
7.0		**Observations and Recommendations**	

Table of Contents

8.0		**Proposals**	
	8.1	General	8-1
	8.2	Proposed Structures	8-3
	8.3	Typical Cross Sections	8-3
	8.4	Service/Slip road	8-4

List of Tables

S.No	Item	Page.no
1.1	Details of Existing Alignment of the Road part in the State of Goa	1-2
2.1	List of references of standards, specifications and guidelines	2-4
3.1	Spacing of single chevron based on the radius	3-6
3.2	Typical warrants for road studs are given in the table below	3-30
3.3	Service Volume of Pedestrian Facility of Unit Width	3-33
3.4	Street light height and spacing as per street type	3-47
3.5	Pedestrian Crossing Level of Service	3-51
4.1	Traffic Surveys Schedule	4-5
4.2	Average Daily Traffic	4-6
4.3	Seasonal variation for Petrol & Diesel vehicles on NH-66 (Near Moita)	4-7
4.4	Seasonal Variation Factors(SVF)	4-9
4.5	Annual Average Daily Traffic (AADT)	4-9
4.6	Peak Hour Factor (PHF)	4-12
4.7	Vehicle registration & Economic Indicators of Goa	4-14
4.8	Elasticity Analysis	4-15
4.9	Projected Growth Rates	4-15
4.10	Traffic Projections Along the Main Road	4-16
4.11	Capacity Analysis with total traffic at Km 528.935	4-17
5.1	AADT for different Survey Location at 528.935 (2024)	5-2
5.2	Actual growth rates in percentages	5-4
5.3	Standard & legal Axle loads	5-4
5.4	Vehicle damage Factor (VDF)	5-4
5.5	Vehicle damage Factor (VDF) adopted	5-5
5.6	Resilient Modulus of Bituminous Mixes, Mpa	5-8
5.7	Million standard axles for developmental traffic	5-9
5.8	Conventional Pavement Composition (Option-1)	5-9
5.9	Composition details Bituminous Pavent With Cemented base and Sub Base with Crack Relief Interlayer of aggregate (Option-2)	5-9
5.10	Composition details Bituminous Pavent With Cemented base and Granular Sub Base With AIL (Option-3)	5-10
5.11	Composition details Bituminous Pavent With Cemented base and Cemented Sub Base with SAMI Layer (Option-3)	5-10
5.12	Comparison of Strains With IIT-PAVE	5-12
5.13	Recommended Pavement Composition (BT, Crack Relief Interlayer of Aggregate, CTB & CTSB)	5-12
5.14	Temperature Differential	5-13

List of Tables

5.15	Rigid Pavement Composition	5-15
5.16	Costs for Ordinary Repairs	5-17
5.17	Periodic renewal costs-Flexible Pavement (at every 5th year)	5-17
5.18	Periodic renewal costs-Flexible Pavement (at every 10th year)	5-17
5.19	Periodic renewal costs-Rigid Pavement (at every 10th year)	5-17
5.20	Total Cost per year	5-18
5.21	Net Present Values	5-18
5.22	Pavement Composition for Service/slip Roads	5-19
7.1	Safety Observations	7-1
7.2	Checklist for Stage Audit of Existing Roads	7-6
8.1	Recommendation of Culverts	8-3

List of Figures		
S.No	**Item**	**Page.no**
1.1	Location Map of the Project	1-4
1.2	Image showing the existing lane configuration at Moita	1-5
3.1	A Footpath showing various zones	3-34
3.2	Recommended space requirement in walking zone	3-35
3.3	Footpath continuing at same continuing along side street (top view)	3-36
3.4	Detail of footpath level along side street (Top view)	3-37
3.5	Shade on footpath	3-38
3.6	Typical 150mm thick kerb stone block	3-39
3.7	Typical 150mm thick kerb stone block	3-39
3.8	Precast rounded Kerb Stone Block	3-40
3.9	Guiding tile	3-40
3.10	Warning tile	3-40
3.11	Incorrect layout of tactile pavers	3-40
3.12	Layout of tactile pavers to indicate turns	3-41
3.13	Plan showing location of seating footpath (top view)	3-41
3.14	Bollard spacing on footpath	3-42
3.15	Bollards designed as seating	3-43
3.16	Broken bollards due to poor implementation	3-43
3.17	Signage placement on footpath	3-43
3.18	Braille Signboard at a Bus-Stop	3-45
3.19	height and spacing of Street light	3-45
3.20	Trees obstructing the street light	3-46
3.21	Street lighting on narrow streets	3-47
3.22	Street lighting on wide streets	3-48
3.23	Placement of utilities on footpath (top view)	3-48
3.24	Detail of service cover when provided on walking zone (top view)	3-49
3.25	Service covers should be located in MUZ	3-49
3.26	Table Top Crossing	3-52
4.1	Index Map of Project Stretch	4-2
4.2	Map showing Traffic Survey Locations	4-4
4.3	Petrol Sales Variation	4-8
4.4	Diesel Sales Variation	4-8
4.5	AADT Modal Split	4-11
4.6	Total traffic & Tollable traffic volume for the location for the location at Km. 528.935	4-12
6.1	Image showing the existing lane configuration & Type of pavement at Moita	6-1

CHAPTER 01. 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 rectifying the Black Spot Locations in various National Highways in Goa through empanelled road safety audit consultants.

In order to fulfil the above task, **Public Works Department(NH)** has been assigned the work of Preparation of DPR for various projects proposed in Annual Plan of Goa and pedestrian count surveys in the state of Goa to M/s Aarvee Engineering Consultants Ltd.

Road Safety Consultant should keep in mind that black spot identification and treatment (Blackspot Rectification Measures) are only one among the many road safety interventions to reduce road crashes and associated fatalities and serious injuries. It has to be keep in mind that only a certain level of reduction in road crashes will be possible through black spot Rectification. The Authority may have to adopt various other interventions to achieve a sustainable reduction in road crashes in their respective jurisdiction. The other measures include road safety assessment, road safety audits and other non-engineering interventions like enforcement, road safety campaigns and post-crash care. It is desirably a comprehensive road safety action plan in line with 'Safer Road and its approach' has to be implemented which cover all aspects of road safety.

This Audit Report provides guidance towards identification of black spots and Rectifications of road crash prone locations through engineering interventions. As per guidelines of MoRTH/NHAI/State PWDs, it gives a systematic process for identifying locations with an unusually high incidence of road crashes, analyzing the contributory factors and then designing and implementing engineering counter measures.

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**

The instant project stretch from Km 527.425 to Km 529.695 forms part of NH-66 (Zuari Package-I) near Moita in North Goa District, where four-laning works have already been completed and the section has been commissioned. Within this stretch, particularly near Km 528.935, frequent movement of cattle across the carriageway has been observed. At present, the crossing is at-grade, resulting in direct interaction between cattle and high-speed highway traffic.

In order to segregate animal movement from the main highway traffic and to mitigate accidents caused due to cattle crossings, it is proposed to develop this location as a grade-separated structure. Further, construction of service roads on both sides of the highway is proposed between the end of the Siridao Flyover Junction and the Agacaim Junction. Additionally, it is proposed to close the two existing median openings along this stretch to improve access control and enhance safety.

The location of the project stretch is shown in Figure 1.1. Traffic surveys conducted at Km 528.900 indicate an existing traffic volume of 59,568 PCU, with a peak hour traffic of 3,762 PCU. The combination of high traffic volumes and at-grade cattle crossings has led to recurring animal–vehicle conflicts, resulting in accidents and traffic congestion.

With the anticipated growth in traffic, this stretch is expected to become increasingly accident-prone, leading to frequent traffic disruptions and posing a significant safety risk to road users. The proposed grade-separated facility, along with service roads and closure of median openings, is therefore essential to enhance road safety, ensure smooth traffic flow, and prevent animal-related accidents on this section of NH-66



(Source : eDAR)

Salient Features of the project:

Project Location	Km 527.425 to Km 529.695 (Moita)
District & state	North Goa & Goa
Existing Lane Configuration	At grade 4 Lane with Paved shoulder with 4m raised median
Pavement type	Rigid Pavement
Type of terrain	Plain/rolling terrain
Classification of Black spot	At grade Cattle crossing & Median Opening
Traffic	Through Traffic: At Km. 528.935 - 59568 PCU

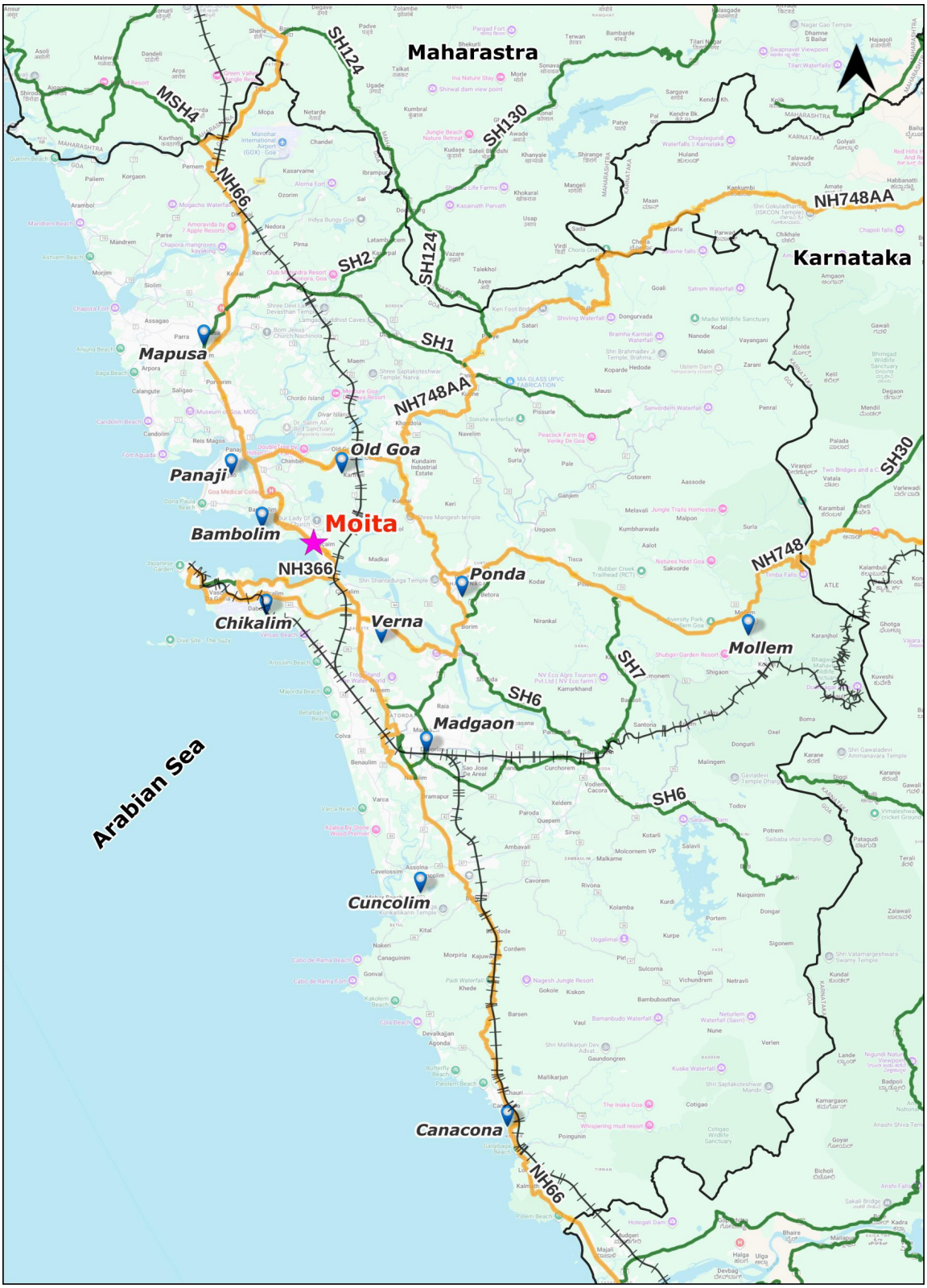


Figure 1.1: Location Map of the Project

1.3 EXISTING ROAD CONDITION

PWD (NH) entrusted M/s Aarvee Engineering Consultants Ltd to study the safety aspects at Moita and propose mitigation measures. Infrastructural Engineering measures can be implemented to decrease the number of crashes, to put an end to the concentration of crashes at that location. This can be defined as "Rectification the Blackspot Sites"

Existing Road is having at grade 4 Lane with Paved Shoulder in the instant stretch.



Fig 1.2: Image showing the existing lane configuration

1.4 IMPORTANCE OF ROAD SAFETY AUDIT

Road safety Audits are differ from conventional traffic safety studies in two key ways: road safety audits are often pro-active investigations, rather than reactive investigations of sites with histories of complaints or poor safety performance, and the investigation team is independent from the staff that is designing the project or maintains the road.

International experience shows that effective road safety management programs should exercise an optimal balance between reactive and proactive strategies in each jurisdiction, based on local conditions. Public agencies implementing RSAs should view them as one of an integrated range of tools intended to further achieve the goals and objectives of a comprehensive road safety management program.

The purpose of a road safety audit is to manage safety by identifying and addressing risks associated with road safety deficiencies. Auditing at different stages of a project, starting right from the planning stage, can lead to the timely elimination of problems and minimize time and costs of retrofitting roads/ transport infrastructure to improve safety at a later stage.

The benefits of conducting a road safety audit are:

a. Identification of potentially unsafe locations along a road,

b. Reducing the severity and likelihood of road accidents,

c. Reducing the need for costly remedial work by rationalizing the design,

d. Minimizing the total cost of a project to the community by preventing accidents, disruption and trauma.

1.5 OBJECTIVE

The objective of the consultancy services is to undertake road safety audit and prepare a road safety audit report for section 527.425 to Km. 529.560 on NH-66 for the purpose of firming up the Authorities requirements.

The application of safety principles in the provision, improvement and maintenance of roads as means of accident prevention can be established through road safety audit. Thus, the purpose of the road safety audit is to ensure that road users would be exposed to minimal risks of accidents in both new roads and existing roads.

The objective of RSA is to identify potential hazards during the planning, design, construction, and operation stages of road projects by experienced road safety specialists and to evolve possible remedial measures to improve road safety, with special emphasis on vulnerable road user group. Through minor modifications to the design, safer road networks can be created, and potential hazards can be eliminated.

1.6 SCOPE

- The scope of the safety Audit Consultants is to review the available drawings and identify the accident-prone spots, They have to conduct detailed survey of such spots and prepare the improvements for removal of black spots.

- Study and Analysis of various Road furniture items and recommendations for providing various Road furniture items including speed limit boards as per site conditions.
- Based on the above studies and safety audit, furnishing a draft safety audit report.
- Based on the observations/comments of the Authority on the draft safety audit report, furnishing a final safety audit report with detailed drawings & cost estimates.
- Accident black spots shall be identified on accident data analysis and site inspections. Accidents data shall be obtained from police department and concessionaire. Subsequently preparation of remedial measures at black-spots locations are to be suggested.
- The scope of the work stated above is not limited it is exhaustive, the Consultants are expected to study and audit all the items required for safe Operation of the Highway as per latest Standards & Specifications and as per the Good Industry Practice.

1.7 PURPOSE OF EXISTING STAGE SAFETY AUDIT

- To improve the safety of road users by proposing mitigation measures for the existing condition of the road.
- To guide highway authority and concessionaire for effective implementation of Road safety practices as per national standards and best international practices
- The audit of existing road aims to ensure that the safety features of a road are suitable with the functional classification of the road.

CHAPTER 2. ROAD SAFETY AUDIT & METHODOLOGY

2.1. INTRODUCTION

Road Safety is a multi-sectoral and multi-dimensional issue. It incorporates the development and arrangement of road infrastructure, provisions for safety of road users and vehicles, legislations and law enforcements, mobility planning, provisions of health and hospital services, child safety, urban land use planning etc. In other words, its ambit spans engineering aspects of both roads and vehicles on one hand and the provision of health and hospital services for trauma cases (in post-crash scenario) on the other. Road safety is a shared responsibility of the Government and a range of civil society stakeholders. The success of road safety strategies in any country depends upon a broad base of support and common action from all stakeholders.

Road safety audit is a formal process (not just an informal check). conducted by persons who are independent of the design. conducted by persons with appropriate qualification, training and experience. an assessment of road safety issues in a road design, a Traffic Management Plan for road works, a newly completed road scheme, or it can be the identification of safety concerns on any existing road.

Central Road Research Institute (CRRI) has studied road safety elements extensively in the past and has come up with various manuals such as Manual for Safety in Road Design (1998), Road Safety Audit Manual (2003) and Revised Road Safety Audit Manual (2010). Indian Road Congress (IRC) has published Special Provision IRC SP: 88 — 2019, Manual on Road Safety Audit. A combination of conventional road safety analysis methods and Road Safety Audit (RSA) approach methods are used in the present study primarily based on identifying substandard features/safety hazards which may lead to accidents.

2.1.1. TYPES OF ROAD SAFETY AUDITING:

Road Safety Audit (RSA) is a systematic process that evaluates the safety performance of a road or intersection. The primary goal of a Road Safety Audit is to identify potential safety issues and recommend measures to reduce the risk of accidents. RSAs are typically conducted at different stages of a road project, including planning, design, and post-construction phases. Here are the key aspects and types of Road Safety Audits.

Road Safety Auditing is to be conducted at five stages of road projects.

i. Feasibility Stage/Preliminary Design Stage:

An audit on completion of the planning or feasibility study stage will examine features such as design standards, route choice and continuity with the existing adjacent network, horizontal and vertical alignments, cross sections and interchange/intersection layouts.

Careful auditing at this early feasibility study stage can help to reduce the costs and lost time associated. auditing at this early feasibility study stage can help to reduce the costs and lost time associated, with changes that may otherwise be brought about during later audits.

ii. Detailed Design Stage:

After the detailed road design (the final DPR) is finished, but before the contract paperwork are prepared, this audit step takes place. Geometric arrangement, pavement markings, signals, lighting, road signs, intersection details, clearances to objects along the side of the road (crash barriers/frangibility), and accommodations for vulnerable road users are typical factors to take into account.

iii. Construction Stage:

This stage of audit takes place during construction of the road works. It examines the provisions for pedestrian safety, advanced warning zones, adequate transition zone lengths, worker safety, effective numbers of reflective signs, safe delineation, credible speed limits, temporary crash barriers, lighting and diversions.

iv. Pre-Opening Stage:

This audit involves a detailed inspection of the new road project immediately prior to its opening. A night -time inspection is particularly important at this stage to check night time / low light related issues.

v. Existing Road:

Road Safety Audit at a fixed interval or at specified times is done to examine the safety assessment of road. The road that is currently in use may have been built decades ago or it may have just undergone renovations or rehabilitation. The purpose of the road audit is to

verify that a road's safety features align with its functional classification. Additionally, it looks for any element that can eventually become a safety concern (such a tree obstructing sightlines at a junction).

2.1.2 Road Safety Audit of Existing Roads:

A Road Safety Audit (RSA) is a formal examination of an existing or future road or intersection by an independent, multidisciplinary team. The primary objective is to identify potential safety issues and recommend measures to mitigate or eliminate those issues. Here are major points to be examined during a Road Safety Audit of existing roads.

The Road Safety Audit process involves a systematic review of these factors, and recommendations are made to improve safety based on the findings. The goal is to enhance the safety of the road network and reduce the risk of accidents and injuries.

Major points to be examined are:

- Road Geometry and Alignment (curves, gradients, and intersections)
- Provision of Signs, Signals, Pavement Markings and Delineation.
- Whether proper speed control is exercised.
- presence and condition of sidewalks, crosswalks, and pedestrian signals.
- Provision of the road surface, including the presence of potholes, ruts, or other defects.
- Safety provided for road construction workers and access to work site.
- Analyze historical accident data for the road segment under review.

This report's aim is to appraise and advise PWD(NH), Goa about the immediate measures to be undertaken to improve Road safety for all road users. The recommendations and /or improvements suggested herein are based on the philosophy of averting road accidents and other accidents in the work road work and also to protect the vulnerable road users and workers in the Road from getting involved in collisions and other mishaps.

2.2. REFERENCES OF STANDARDS, SPECIFICATIONS AND GUIDELINES

In general, general publications, special publications, technical specifications, standards, codes and guidelines of the IRC and publications of the Ministry of Road Transport and Highways (MoRTH) including circulars issued from time to time by the MoRTH shall be followed. Special references to international safety guidelines may be made, as and when required. All the field activities shall only be started after this methodology document is discussed in detail with PWD/MoRTH, modified as per comments / suggestions given by the PWD/MoRTH and finally approved by the PWD/MoRTH. The Table 2.1 below provides a list of most relevant national and international references for the assignment, but not limited to them.

Table 2.1: List of references of standards, specifications and guidelines

Reference	Description
Primary References	
IRC:SP:88-2019	Road Safety Audit Manual
IRC:SP:84-2019	Manual of Specifications and Standards for Four Laning of Highways
IRC:SP:55-2014	Guidelines on Traffic Management in Draft Roads
Other References	
IRC:SP:44-1996	Highway Safety Code
MoRTH	Manual for Safety in Road Design
IRC:SP:32-1988	Road Safety for Children (5-12 Years old)
IRC:35-2015	Code of Practice for Road Markings
IRC:67-2022	Code of Practice for Road Signs
IRC:SP:31-1992	New Traffic Signs
IRC:119-2015	Guidelines for Traffic Safety Barriers
IRC:37-2018	Guidelines for the Design of Flexible Pavements
IRC:SP-84-2019	Manual for Specifications & Standards for Four Lanning of Highways

	Through Public Private Partnership
IRC:SP-85-2011	Guidelines for Variable Message Signs
IRC:73-1980	Geometric Design Standards for Rural (Non-Urban) Highways
IRC:66-1976	Recommended Practice for Sight Distance on Rural Highways
IRC:SP:23-1983	Vertical Curves for Highways
IRC:53-2012	Road Accident Forms A-1 and 4
MoRTH	National Road Safety Policy
MoRTH	Sundar Committee Report on Road Safety and Traffic Management
Additional References	
MoRTH Circular 602	Road Signs & Markings
MoRTH Circular 604	Highway Safety Railings
MoRTH Circular 605	Traffic Regulation
MoRTH Circular 606	Accidents
MoRTH Circular 607	Highway Patrolling
MoRTH Circular 1920	Safety measures
IRC:2-1968	Route Marker Signs for National Highways
IRC:8-1980	Type Designs for Highway Kilometer Stones
IRC:11-2015	Recommended Practice for the Design and Layout of Cycle Tracks
IRC:31-1969	Route Marker Signs for State Routes
IRC:62-1976	Guidelines for Control of Access of Highways
IRC:64-1990	Guidelines for Capacity of Roads in Rural Areas
IRC:79-2019	Recommended Practice for Road Delineators

IRC:80-1981	Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways
IRC:93-1985	Guidelines on Design and Installation of Road Traffic Signals
IRC:103-2012	Guidelines for Pedestrian Facilities
IRC:SP:41-1994	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas
MoRTH	Type Designs for Intersections on National Highways, 1992
References from other countries / practices	
AASTHO	Highway Safety Manual
AASTHO	Highway Safety Design and Operations Guide
AASTHO	AASTHO Safety Leadership Forum V — Toward Zero Deaths (TZD): Aggressive Plans to Meet Aggressive Goals .
AASTHO	AASHTO Strategic Highway Safety Plan —- A Comprehensive Plan to Substantially Reduce Vehicle-Related Fatalities and Injuries on the Nation's Highways

2.3. METHODOLOGY:

The need for RSA is more for accident prevention. Its theme is in the ability to check a design for its fitness for purpose. The process of initiating RSA for the present assignment would include:

- Check the Design's adequacy towards meeting the desired safety norms.
- Objectively analyze the observations as gathered in respective check lists and specify the short comings, if any.
- Recommendations on safety measures, so as to finally ensure "safer people, safer vehicles and safer environment".

  Agreement stipulates the guiding principles as under:

- Safety Requirements aim at reduction in injuries, loss of life and damage to property resulting from accidents on the Project Highway, irrespective of the person(s) at fault.
- Users of the Project Highway include motorized and non-motorized vehicles as well as pedestrians and animals involved in or associated with accidents. Vulnerable Road Users (VRU) include pedestrians as well as riders of motorized two-wheelers, bicycles and other vehicles which do not provide adequate occupant protection.
- Safety Requirements apply to all phases of construction, operation and maintenance with emphasis on identification of factors associated with accidents, consideration of the same, and implementation of appropriate remedial measures.
- Safety Requirements include measures associated with traffic management and regulation such as road signs, pavement marking, traffic control devices, roadside furniture, highway design elements, enforcement and emergency response.

The methodology adopted is as per Stage 5 Audit (existing road) Table 7.5 of the IRC: SP: 88-2019, "Manual on Road Safety Audit" and the guidelines given in Cl.9.9 of IRC: SP: 84-2019.

2.4. SAFETY AUDIT REPORT

This Road Safety Audit Report for Construction Phase is the outcome of the physical inspection of the project corridor under construction. This report will review the safety measures adopted by Concessionaire and will report potential hazards due to the noncompliance of safety norms apart from the possible threats to safety of road users as per the field conditions at different locations. Further, it reviews the safety of completed project highway sections, if any, to identify the gaps in implementation of safety measures. The purpose of this report is to appraise and advise NHAI & the Concessionaire about immediate measures to be undertaken to improve safety for all road users. The recommendations suggested herein are based on the philosophy of obviating road accidents due to wrong judgment of the drivers and to protect the vulnerable road users and workers, if any, from meeting with collisions.

2.5 THE CHECKLISTS

The checklists are useful in conducting the audits. They describe the performance and situations that can affect the road safety. The checklists are prepared for Stage 5 Audit as per those given in IRC: SP: 88 — 2019 and other relevant references. These checklists are used as guides to focus audit towards important matters that should be covered and not be overlooked. When reviewing each of these points, the auditors considered that the road users would have to be used to conditions at day and night, adverse weather conditions etc. The checklist prepared for the study is presented in the Annexure to the report.

CHAPTER -3 . DESIGN STANDARDS

3.1 Road Safety Audit

Road safety audit (RSA) is a formal examination of existing or future road project which interacts with road users, in which an independent, qualified team reports on the project's accident potential and safety performance.

Road Safety is a multi-sectorial and multi-dimensional issue. RSA is the process of evaluation of road schemes to identify the potential safety hazards which may affect any type of road user and to suggest the measures to eliminate or mitigate those problems. The need for RSA is more for accident prevention (and in certain cases towards lessening the nature and quantum of punishment that could befall a user making an error).

In other words, RSA is not a way of rating a project as good or poor and is not a check of compliance with available standards. The theme of RSA is in the ability to check a design for its fitness for purpose.

3.2 Importance of Road Safety Audit

Road safety Audits are differ from conventional traffic safety studies in two key ways: road safety audits are often pro-active investigations, rather than reactive investigations of sites with histories of complaints or poor safety performance, and the investigation team is independent from the staff that is designing the project or maintains the road.

International experience shows that effective road safety management programs should exercise an optimal balance between reactive and proactive strategies in each jurisdiction, based on local conditions. Public agencies implementing RSAs should view them as one of an integrated range of tools intended to further achieve the goals and objectives of a comprehensive road safety management program.

The purpose of a road safety audit is to manage safety by identifying and addressing risks associated with road safety deficiencies. Auditing at different stages of a project, starting right from the planning stage, can lead to the timely elimination of problems and minimize time and costs of retrofitting roads/ transport infrastructure to improve safety at a later stage.

The benefits of conducting a road safety audit are:

a) Identification of potentially unsafe locations along a road,

b) Reducing the severity and likelihood of road accidents,

c) Reducing the need for costly remedial work by rationalizing the design,

d) Minimizing the total cost of a project to the community by preventing accidents, disruption and trauma.

3.3 Different stages of road safety

There are five stages of a road project at which Safety Audit can be conducted, broadly:

1. Feasibility / Preliminary Design Stage
2. Detailed Design Stage
3. Construction Stage
4. Pre-opening Stage &
5. Safety Audit for existing roads

3.3.1 Feasibility /Preliminary design stage audit

Safety Audit during the feasibility / preliminary design stage will examine features of the road such as design standards, route choice and continuity with the existing adjacent road network, horizontal and vertical alignments, cross sections and interchanges/ intersection layouts.

3.3.2 Detailed design stage audit

Detailed Design Stage Safety Audit shall be conducted at the completion of the detailed road designs (Final DPR) but before the preparation of contract documents. During the process of audit, various parameters will be correlated and examined like geometric layout, pavement markings, signals, lighting, road signs, intersection details, clearances to roadside objects and provisions for vulnerable road users.

3.3.3 Construction stage audit

This stage of Audit shall be conducted during the construction of road works. During this Auditor will examine the safety of traffic management plans at each phase of construction, provisions for pedestrian safety, advanced warning zones, adequate transition zone lengths, workers safety, effective retro reflective signs, safety towards delineation of construction zone, credible speed limits, temporary crash barriers, lighting provisions. It will also inspect the provisions for road safety at the road work site during the construction.

3.3.4 Pre-Opening stage audit

This stage of Audit shall be conducted on a new road project immediately prior to its opening. The Audit team should be driven, ridden and walked on the new road to ensure that the safety needs of all road users are provided or not. A nighttime inspection is particularly important at this stage to check installation and visibility of signs, road markings, lighting and any other night time/low light related issues.

3.3.5 safety audit for existIng roads

The audit of the existing road aims to ensure the provision of safety features of a road which are compatible with its functional classification. It also aims to identify any features that may develop over a time into a safety issue.

3.4 Specifications of Road furniture ITEMS

The term "Road Furniture" encompasses all roadside objects used for safety and control of traffic in addition to those for assisting the driver.

Road furniture will guide the road users with the necessary warnings, rules, distance and directional information in order to travel roads and thoroughfares safely.

Based on the above, the different Road furniture items are Traffic signs, Thermoplastic road markings, crash barriers, road studs, rumble strips and retro reflectors etc.,

3.4.1 Traffic signs

The main purpose of road traffic signs is to promote road safety and efficiency by ensuring the orderly movement of all road users on all types of roads both urban & non-urban areas. Road

signs inform the road users about regulations and provide warning and guidance needed for safe, uniform and efficient operation.

Functions of road signs are:

1) It will give timely warning of hazardous situations when they are not self-evident.
2) Signs are of great help in regulating the traffic by communicating messages to the road users about the need to stop, give-way and to limit their speeds.
3) It will also provide the information about highway routes, directions and point of interest.

Different types of road traffic signs are:

1. Warning or Cautionary signs
2. Regulatory signs
   a. Prohibitory signs
   b. Mandatory signs
3. Information signs
   a. Indication signs
   b. Advance direction signs and direction signs
   c. Place and route identification signs.

3.4.2 Specification of Traffic signs

Warning/Cautionary signs:

Broadly, Warning/Cautionary signs are in triangular shape with red border and black symbol in white background. These signs are placed either on or adjacent to the roadway to warn/alert the road users before any potential danger or existence of certain hazardous location so that they can take desired action. Warning signs are of great help in ensuring safety of traffic. Specifications of few of the warning/cautionary signs as per IRC 67 2012 are given below:

Left /Right turn curve sign:

These signs shall be used, wherever there is a need for reduction of speed due to change of direction of alignment and radii of the curvature are below the specified limit. If a road has certain curves where vehicles cannot be allowed to negotiate with the absolute speed limit or the

general operating speed established for the road, such curves shall be provided with curve warning sign on both the approaches.

Ideally, if the difference between the approach speed to a curve and safe negotiating speed derived based on geometric parameters of curve exceeds 15kmph, the curve shall be provided with curve warning sign.

b) Left /Right Hairpin Bend sign:

These signs shall be used to indicate curves of small radii, where the change of direction is so considerable as to amount to a reversal of direction.

c) Left /Right Reverse Bend sign:

These signs shall be erected where two curves in opposite direction are separated by a tangent length less than 120m in (Plains) and 30m in (Hills) respectively.

d) Y - Intersection sign:

The sign should be erected on the approach to a bifurcation of any road. This sign should only be used when the driver needs to be warned of the existence of a junction.

e) Cross road sign:

The sign should be erected in advance to the crossroad where, a sufficiently large volume of crossing or entering traffic with restricted sight distance is likely to constitute a hazard.

f) Pedestrian Crossing sign:

The sign should be erected in advance on both approaches to an uncontrolled pedestrian crossing. This is absolutely essential when visibility of the crossing is impaired by a bend or hump in the road.

g) School zone Ahead sign

The sign should be erected where school buildings or grounds are adjacent to the road.

h) Built-up Area sign:

The sign shall be used to caution the vehicles about Built-up area. This sign shall be placed well ahead of such location.

i) Speed Breaker sign:

The sign should be used to warn the drivers of the presence of the speed breaker. This sign should be posted 50-60m in advance of the speed breaker location.

j) Rumble Strip sign:

The sign should be posted 50-60m in advance of the rumble strips provided on the road to warn the road user to control and reduce the speed. These are provided at the potential hazard locations like major junctions, school zones. Thermoplastic rumble strip sets are proposed as per the specifications mentioned in IRC: 35-2015.

k) Unguarded Railway crossing sign:

The sign should be used on the approaches of railway level crossings where there are no gates or other barriers.

A pair of signs shall be erected, in which: i) an advance warning sign shall be located at 200m away from such crossing & (ii) a second sign to be erected near the crossing.

l) Guarded Railway crossing sign:

The sign should be used to warn traffic on the approaches to guarded railway crossings. A pair of signs shall be erected, in which: i) an advance warning sign shall be located at 200m away from the crossing & (ii) a second sign to be erected near the crossing.

m) Chevron sign:

These signs should be used to warn the drivers about degree of sharpness of a curve at the curved alignment. The chevron signs shall be a vertical rectangle and shall be installed always on the outside of a turn or curve, in line with and at approximately right angle to approaching traffic. Spacing of Single Chevron signs based on the curve radius are given below:

Table 3-1: Spacing of single chevron based on the radius

Curve Radius (m)	Distance between Single Chevron (m)	
	On Curve	Before Curve
50	15	30
100	20	40
200	30	60

300	45	90
400	60	120
500	70	140
>500	80	150

n) Hazard marker sign:

These signs shall be erected before/on roadside hazards like bridges, trees which are abutting the roadway. These hazardous locations shall be illuminated properly by retro reflective object hazard markers signs (OHM) for safe movement of traffic.

o) Series of bends

This sign is warned where more than two curves with sub-standard parameters are being observed on the roadway.

p) Built-up area

Built-up areas are considered where the settlements are abutted continuously for more than 200m. Built-up signs are proposed to warn the possible maneuvers of the people in the settlements.

Regulatory/Mandatory signs:

Regulatory/Mandatory signs, which gives definite directions for the road users to follow. They are further sub-divided into two types.

i) Mandatory Signs:

These signs are intended to convey definite positive instructions when it is desired that road user want to take some positive action. The two most important mandatory signs are "STOP" & "YIELD" or "GIVEWAY" Sign.

a) Stop signs:

This sign is intended for use on roadways where traffic is required to stop before entering a major road. This stop sign shall be used in combination with certain road markings, such as stop line and the word STOP marked on the pavement surface. This sign shall be octagonal in shape and shall have red background and white border. This sign shall be installed on the left side of the approach to which it applies.

b) Give Way Sign:

The GIVE WAY sign is used to assign right of way to traffic on certain roadways at inter-sections, the intention being that the vehicles controlled by the sign must give way. Vehicles controlled by this sign need to slow down or stop when necessary to avoid interfering with conflicting traffic. This sign shall be an equilateral triangle in shape with apex downwards. It shall have a red border and white background. This sign shall be located in advance to the point where vehicles are required to stop or to slow down to yield the right of way.

ii) Prohibitory Signs

These signs generally intended to give instructions to the road users of traffic laws and regulations. The prohibitory sign gives definite negative instructions prohibiting the road user from making particular maneuvers. They cover both at the junctions and between road & junctions. These shall be of circular shape with red border, white background and black symbol.

a) No Stopping & No Standing signs

These signs shall be of circular shape with a red border and blue background. There will be an oblique red bar at 45° for the 'No standing' sign and there will be two oblique red bards at 45° and right angles to each other for 'No stopping and No standing' sign.

"No standing" sign shall be erected where standing of vehicles are prohibited even for a very shorter duration. Whereas "No stopping and No standing" sign shall be erected on a road section where to prohibit stopping of vehicles and also standing of vehicles even for momentary stopping.

b) No Parking signs in urban area

In Urban areas, the "No Parking" sign is used on the roads to prevent any parking of vehicles on the main carriageway which will lead to congestion.

c) Speed Limit & Vehicle Control Signs

These signs shall be erected at the beginning of any section of a road or the side of a structure, which is subjected to prohibition or restriction at the face of entering traffic.

e) Restriction Ends Sign

These signs shall indicate the point at which all prohibitions notified earlier by the prohibitory signs in a roadway are ceases to apply.

f) Compulsory Direction Control Signs

These signs intended to give instructions to the road users in a positive way and those are compulsory/lawfully to be taken with respect to the position of sign installed.

These signs shall be circular in shape with blue background and white border and having symbol in white.

***Informatory* signs:**

Informatory signs are intended to guide the road user regarding their location or facilities available in the vicinity or about the destination.

These information signs are classified as:

i) Direction and Place identification signs

ii) Facility information signs

iii) Other useful information signs

iv) Parking signs etc.,

These signs are in the rectangular in shape.

i) Facility Information signs:

The signs are intended to give the information to the road user regarding location and availability of services in the vicinity.

These signs normally rectangular in shape with blue background and black symbol shall be displayed in White Square to indicate the type of facility. There are two types of sizes for these signs are i.e normal type are 800mm x 600mm and small sized are 600mm x 450mm.

The above norms applicable for the facilities such as Eating Place, Resting place, Light refreshments, First Aid post, Toilet, Fuel Pump, Hospital, Public Telephone, U-Turn a head, FOB, Airport Etc.,

(ii) Other useful Information signs:

Parking signs, Park & ride, Taxi parking and flood gauge signs etc., are comes under other useful information signs. These signs are of same size and colour as those adopted in Facility Information signs.

Route Marker signs:

Route Marker signs are proposed in respect of National Highways, State Highways, Expressways and Asian Highways. The recommended characteristics for route marker signs are:

i) Uniform shape of route markers for different types of roads.

ii) colour coded and simple shapes with contrasting colours of letters for better recognition.

iii) Prominence given to number of route and colour background for quick grasp by the driver.

Normally route marker signs are in retro reflective green colour base for SHs and yellow colour base for NHs with symbol in white colour and border on a rectangular plate with dimensions of 450mm x 600mm.

3.4.3 Road Pavement Markings

Road Markings perform an important function of guiding and controlling traffic on a highway/ road. Specifications and standards for road markings shall be followed as per IRC 35.

The Markings serve as a psychological barrier and thus help to signify the delineation of traffic path and its lateral clearance from hazards location for facilitating safe movement of traffic.

Frequent renewals of road markings have an advantage of conveying the required information to the road user without distracting the attention of driver from the carriageway during the poor visibility/dusty/wet/obliteration conditions.

Sometimes markings shall be provided in conjunction with road signs, most of the times markings shall be provided independently. Road markings normally include longitudinal markings, transverse markings, text and symbols etc., on the road surface.

Commonly, the materials used in the road markings are; Hot applied thermoplastic compound and solvent borne and waterborne road marking paints.

Thermoplastic Markings:

Thermoplastic is the most commonly used pavement marking material on roadways and is a mixture of plasticizer and resins that serves to hold all of the other ingredients together.

Thermoplastic markings possess fast drying time and are highly durable. It has better retro reflective performance and service life than that of ordinary marking paint. Normally, the service life of one application of thermoplastic can be up to 2 to 3 years depending on the amount of traffic plying on that road.

Road markings shall be clearly visible both in day and night.

Colour pattern for markings:

1) White colour generally used for road markings, because of the visibility and good contrast against the road surface.

2) Yellow markings can be used to convey messages where it is not permitted to cross the markings. Yellow colour is also used to show parking restrictions and to impose other traffic controls.

3) Blue colour shall be used to indicate new and special markings which are not conventional they are particularly used to indicate the dedicated bus lanes in the BRT corridor.

4) Green colour should be used to distinguish the bicycle and non-motorized transport facilities provided on the road.

5) Red/Purple colours are used to indicate the hazardous locations.

3.4.4 Classification of Pavement Markings

Pavement markings are broadly classified into seven categories based on the placement of markings with regard to vehicular movement and also based on the function of the markings.

i) Longitudinal Markings

Longitudinal markings are generally provided along the traffic movement. The broken lines, single/double continuous lines and continuity lines are classified under longitudinal markings.

The purpose of longitudinal markings is to navigate the driver for forward movements and to prohibit overtaking manoeuvring at certain hazardous locations.

The continuous longitudinal marking lines can be single and double lines and are not expected to cross in normal conditions.

The continuous longitudinal marking in yellow colour is to signify that the marking provided is strictly prohibited in nature and not to be straddled by vehicles.

ii) Transverse Markings

The transverse markings are provided across the carriageway with broken lines, single/double continuous lines to control the traffic. Transverse markings are such as stop line markings and give way markings. These markings shall always be accompanied with corresponding sign.

iii) Hazard markings

The hazardous pavement markings are used to warn/inform the road user before/ahead of any hazardous location. Chevron and diagonal marking, hatch markings and prohibitory markings are used as hazardous markings.

Normally, hazard markings are provided ahead of any diverging and merging locations and around any hazardous location. These markings shall always be accompanied with corresponding sign.

iv) Block markings

The pavement markings are painted in block shape on the carriageway are classified as block markings. Normally, zebra crossings, triangular and checkered markings and giveway symbol are painted in block shapes.

The application of thermoplastic paint for block marking is generally different from longitudinal markings. The quality of block markings with adequate visibility is of utmost importance.

v) Arrow markings

Arrow markings are generally "arrows" painted on carriageway to inform the road user to take directions/Route mandatorily.

vi) Directional Markings

The directional marking is used to guide the road user to take directions. A word message is written on the carriageway regarding directional purpose.

vii) Facility Markings

The markings on the carriageway are used to indicate the facilities. For Parking, bus lane, bi-cycle lane etc., are facility markings.

3.4.5 Markings for road links:

The markings required to navigate the drivers in mid block sections.

Center line markings:

The centreline markings are used only in single carriageway roads to facilitate the movement of traffic from opposite stream of traffic. Normally, centre line is placed at the centre of carriage-way.

When the pavement is widened on curves, the centreline should be placed in such a manner that the width of the traffic lanes on both approaches of the curves will be maintained around outside curve.

The line marking at the centre of a ramp or slip road or one-way street will be traffic lane and shall be a broken line.

If the centre line is to be painted on the pavement on the approaches to a bridge, it shall be continued over the bridge provided that the width between the kerb is 6m or more. Otherwise the centreline marking on approaches should be discontinued at 30m to 35m distance from each abutment of the bridge.

On undivided carriageway where two lanes are available for one direction, double centreline should be used to separate the opposite stream of traffic.

Traffic lane lines

Traffic lane line marking are used to separate two or more lane carriageways in one direction for smooth and efficient movement of traffic.

Traffic lane line markings shall be avoided if the width each of lane cannot be maintained as per codal provisions.

No overtaking lines

No overtaking zones shall be established on summit curves, horizontal curves and elsewhere on two and three lane highways where overtaking manoeuvring must be prohibited because of restricted sight distance and other hazardous conditions.

On undivided highways with more than 3 lanes, there is no need for crossing of vehicles to make an overtaking.

No-overtaking zone shall be marked by a solid line either single or double along the centre.

No overtaking zone markings shall be indicated when the available sight distance is less than the minimum visibility distance (MVD). The no-overtaking zone lines should be marked always with road studs.

Warning lines

Warning lines are broken lines and are marked on horizontal and vertical curves, where the visibility is greater than Minimum Visibility Distance (MVD) but less than the Warning Sight Distance (WSD).

Warning lines are always single, and they should never be used as part of double line installation (no overtaking zone). Warning lines are preferred at mid-block sections passing through urban and ribbon settlements and also at few locations where less visibility due to absence of street lights.

Border or edge lines

The border or edge lines are intended to indicate the end of the carriageway and it helps to delineate the limits upto which driver can run safely.

Carriageway edge lines shall ordinarily be provided only on roads with two or more than two lanes. These shall be in the form of a single continuous white line placed on the carriageway 150mm from the edge.

Continuous edge line shall be broken continuity line in case of merging/diverging for slip roads, auxiliary lanes and at locations of bus and truck lay-bys etc.

3.4.6 Stop & giveway markings

Stop Line:

Stop line indicates the location on the ground beyond which the vehicles should not proceed further at the vicinity of traffic signals, pedestrian zebra crossings and approaches of minor roads. Stop line shall be provided in conjunction with the stop sign.

Single Stop line: Single stop line shall be provided at the traffic signals and ahead of the pedestrian crossing. Single Stop line shall be solid white transverse line of 200mm wide on urban roads and 300mm wide in rural roads.

Single stop line shall ordinarily be located not less than 2 meters and not more than 3 meters in advance from the desired location. At traffic signals, the line shall be normally located 1m before the nearest primary signal.

Double Stop line: Double stop line is used exclusively at junctions controlled by "STOP" signs. Double Stop lines shall consist of two continuous lines each of 200mm wide and in between spacing shall be 300mm.

Give Way Lines:

The give way marking consists of two broken lines laid side by side, each comprising of 600m in length, 200mm wide and spaced 300mm each other.

The give way lines shall be supplemented by the hollow triangular Give way approach marking and a Give way roadside sign.

3.4.7 Markings for speed reduction and pedestrian crossings:

Markings for Speed breakers:

Markings for speed breakers shall be provided in advance to any hazardous location. These will help to warn the road user about the blackspot location. For better visibility, the markings shall be made up of retro reflective materials.

Thermoplastic Bar Markings:

Thermoplastic bar marking is a softer treatment to reduce the speed. One set of bar marking comprises of 6 bars of 300mm wide and spacing between the strips are 600mm. Each trip of thermoplastic strip shall be 5mm high and shall be applied across the full width of the carriageway.

Markings for pedestrian crossings:

Markings for pedestrian crossings shall be provided at important intersections where there is a possibility of conflict between vehicles and pedestrians. In view of providing safety to the pedestrians the markings shall be provided at the junctions and locations where a greater number of pedestrian cross movement have been observed.

3.5 Road Studs

Retro reflective studs (RRPM) are used to supplement longitudinal/ transverse road markings, which would improve visibility during the night-time and adverse weather conditions. Road studs are also used across the carriageway to serve as speed arrestor through the creation of rumbling sensation to the road user.

3.5.1 Types of road studs:

Studs shall be made of plastic material with reflectors for all types of roads. These reflectors should have abrasion resistant protective coating. The road studs shall be placed on broken longitudinal markings. The studs with different colours of reflectors such as white, red and yellow are normally used in National Highways.

Road studs shall be used on both uni-directional and Bi-directional roads to delineate the centreline and edge line.

Road studs in white colour are normally used to indicate the traffic lane line and center of carriageway. Whereas red colour road studs are used to indicate left edge of the running carriageway in order to warn the road user.

Yellow colour road studs are used to indicate the right edge of the running carriageway in case of multi –lane divided carriageways.

Green colour studs are used to indicate crossable edge lines such as bus and truck lay-bys.

Solar powered Road studs are more effective which can immediately give attention to the road users. These are normally placed at the hazardous locations.

Road studs shall be proposed as per the codal provisions mentioned in IRC: 35-2015

3.6 Roadside and median safety barriers:

Safety barriers:

The longitudinal roadside barriers are basically meant to shield two types of road side hazards i.e., embankments and road side obstacles and also for preventing the vehicles veering off the sharp curves at all embankments with height more than 3m or more shall have safety barriers at the edge of formation. W-beam barrier shall be provided along all the curves having radii upto 450m for complete length of curves including transitions.

Types of road safety barriers:

a) Semi-rigid type

i) "W" beam type steel barrier

ii) Thrie beam type steel barrier

b) Rigid type (i.e. concrete crash barrier)

c) Flexible type (i.e Wire rope fencing)

Specifications of safety barriers shall be followed as per the IRC SP 73 / SP 84/ SP 87 manuals for 2 lane/4 lane and 6 lane respectively.

3.7 Specifications of Traffic camling measures

Generally, roads are designed by considering the maximum permissible speeds of vehicles which are traveling with maximum safety and convenience.

But at certain locations, such as approaches to sharp curves, congested/accident-prone locations, urban areas, manned and unmanned level crossings and residential locations control of speed becomes necessary to promote smooth & efficient movement of traffic and to enhance safety.

The term "Traffic Calming" is a technique have emerged primarily as a society's requirement towards safety. These techniques have played an important role in enchasing road safety by ensuring reducing the driving speeds and smaller speed difference among the road users.

The main theme of traffic calming is to reduce the adverse impact of motor vehicles on built-up areas. The techniques usually involve in reducing vehicle speeds, providing more space for pedestrians and cyclists, will improve the local environment.

The basic principle of Traffic Calming remains universal, used to lower the vehicle speeds in order to reduce accidents, pollution and enhance livability of surrounding areas. Measure such as road narrowing, roundabouts, rumble strips and road humps, reduce negative effects of motor vehicle use, and alter driver behavior and improve conditions for non-motorized street users.

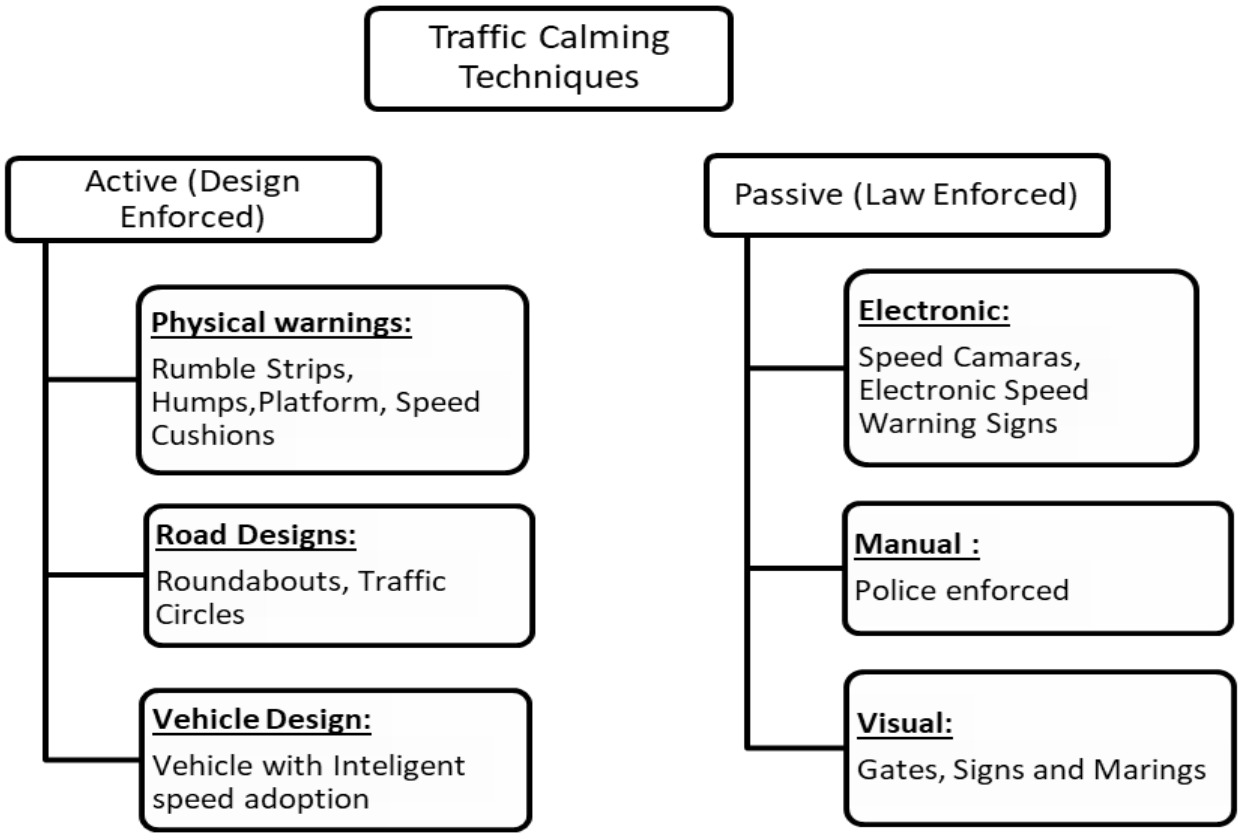
The standards and specifications of traffic calming measures shall be adopted as per IRC 99.

3.7.1 Necessity of Traffic Calming

Past studies have shown that traffic calming can reduce accident levels by up to 40% and have a significant impact on reducing the severity of accidents, economic loss, and air pollution. The main advantage of Traffic Calming is that it is a self – enforcing and does not require any complicated traffic control devices.

These are highly cost effective, but which gives benefits with a value more than the cost.

Classification of Traffic Calming Techniques



Active or Design Enforced:

Pro-active or design enforced approaches are highly effective since these can achieve almost 100% success rates in managing speeds on the road with relatively low level of capital expenditure.

A very high percentage of road accidents are attributable to human error. Changing human behavior of drivers and other road users is a tricky and very significant challenge.

Passive or Law Enforced:

Passive measures include speed cameras and electronically displayed speed warning signs and the restrictions enforced by police personnel (manually) for certain traffic movements and also visual measures like gates, signs and markings. Law can be enforced by violating the instructions and crossings the limits set therein.

3.7.2 Traffic calming measures in urban areas

Traffic calming can help in creating more attractive urban environments. Traffic measures can even reduce the amount of land devoted to streets and parking, which in turn can increase green-space and reduced impervious surface, resulting environmental and financial benefits. Traffic calming schemes generally incorporate a wide range of measures designed to complement each other in both speed reduction and environmental.

The Principle techniques are categorized into four areas:

- Vertical deflections
- Horizontal deflections
- Road Narrowing
- Central Islands.

Vertical Deflections:

Vertical shifts in the carriageway are the most effective and reliable measure for reducing the speed. Few of the techniques are used to achieve these are:

- Speed Breaker
- Speed Bumps

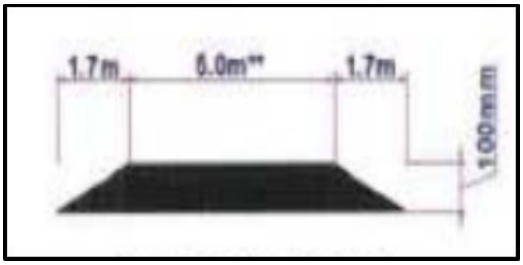
- Speed Table (Raised Crosswalks)
- Uneven Road surface and stone set pavement.
- Raised Intersections

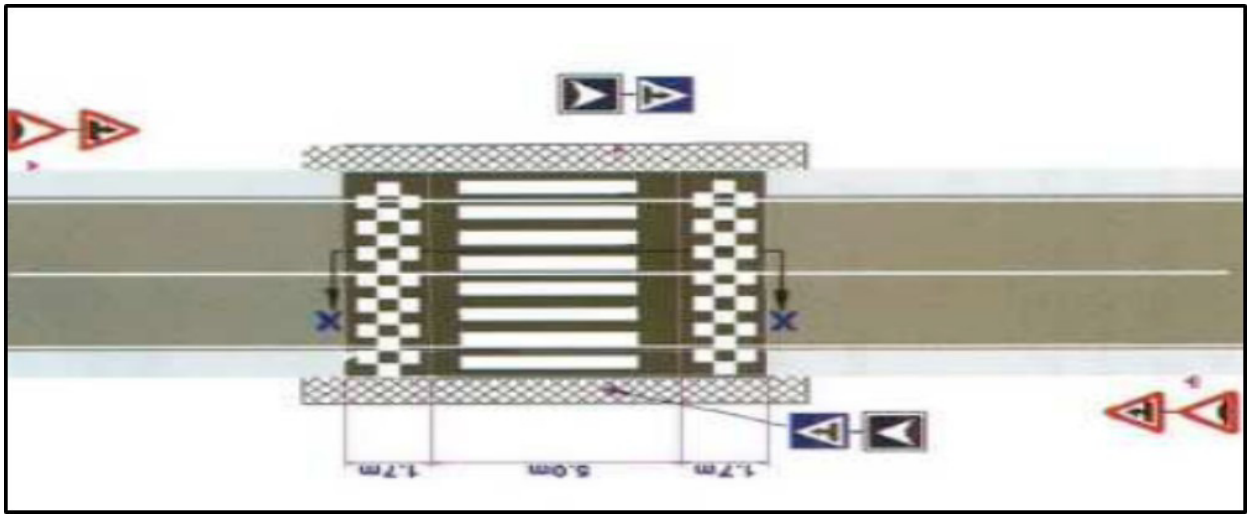
Speed breakers may be of several varieties, they are normally used to reduce the vehicular speeds and helps in maintaining the efficient movement of traffic flows among the road users. Normally, rounded (circular) and flat topped being the most common in nature. Speed breakers are not recommended on bus routes because of the discomfort caused to passengers.

Speed Bumps are pre-cast in nature, and they can be easy to fix on the road. The bumps can be nailed to the pavement. It is normally recommended to use for local and collector streets.

Speed Table (Raised Crosswalks), which is the raised crossing extends the full width of the carriageway between the kerbs and extends over a longer length of road than humps. Speed Table is a solution, where vertical deflection can be achieved by reducing the traffic speeds and flat-topped portion used for cross movement of pedestrians. The surface should be of different material to the carriageway and footpath. Speed table is more suitable than road humps when the measures are implemented on bus routes.

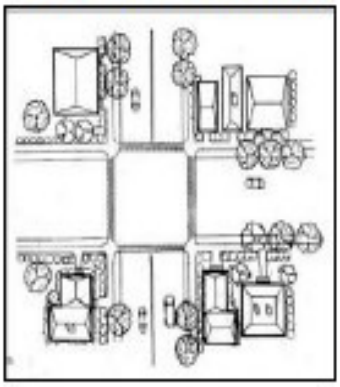






Uneven Road surface and stone set pavement is another way of reducing the speed. By changing the surface texture, speed gets reduced due to discomfort. The accidents which are normally occurred due vertical shift of Speed breakers and speed humps, those can be avoidable with uneven road surface and stone set pavement.

Textured Crosswalks



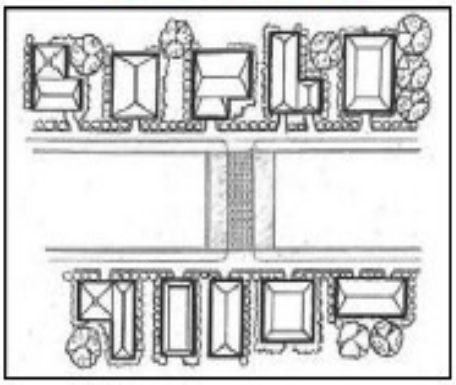
Speed Humps



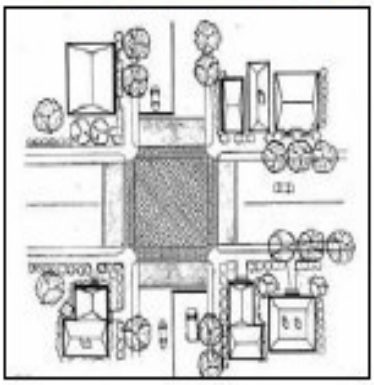
Speed Cushions



Raised Crosswalks



Raised Intersections

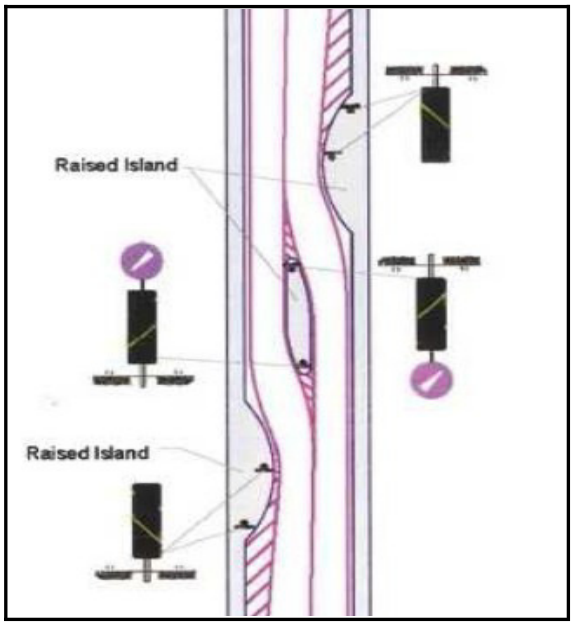


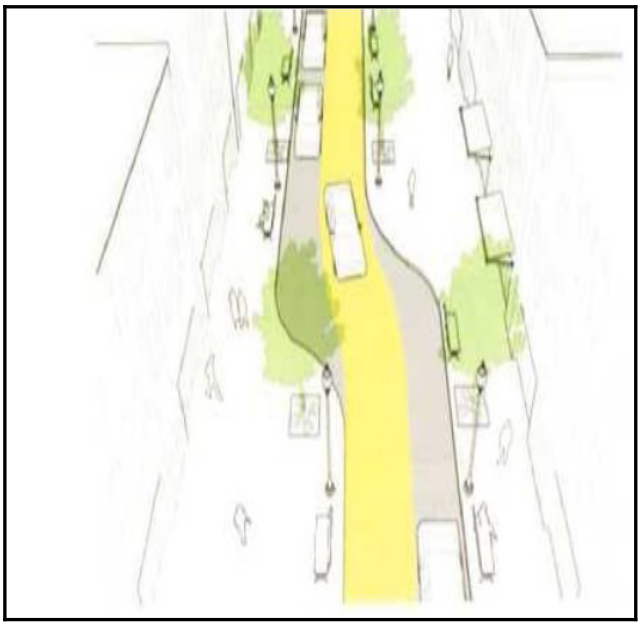
Horizontal Deflections:

Horizontal shifts in the carriageway are less effective than vertical ones in achieving reducing the speed. However, their impact is significantly increased when it is used in combination with vertical shifts. Few of the techniques are normally used are:

1 Chicanes
2 Curb Extension/Bulb-Outs/Bump-Outs
3 Gateways
4 On street parking
5 Raised Median Islands
6 Traffic Circles

Horizontal shifts are generally gained through chicanes. The speed reducing impact of chicanes is reduced if the measure has to allow for the passage of Heavy goods vehicles. Horizontal deflection by Chicanes shall always be provided with hazardous markings and retro – reflective hazard markers.





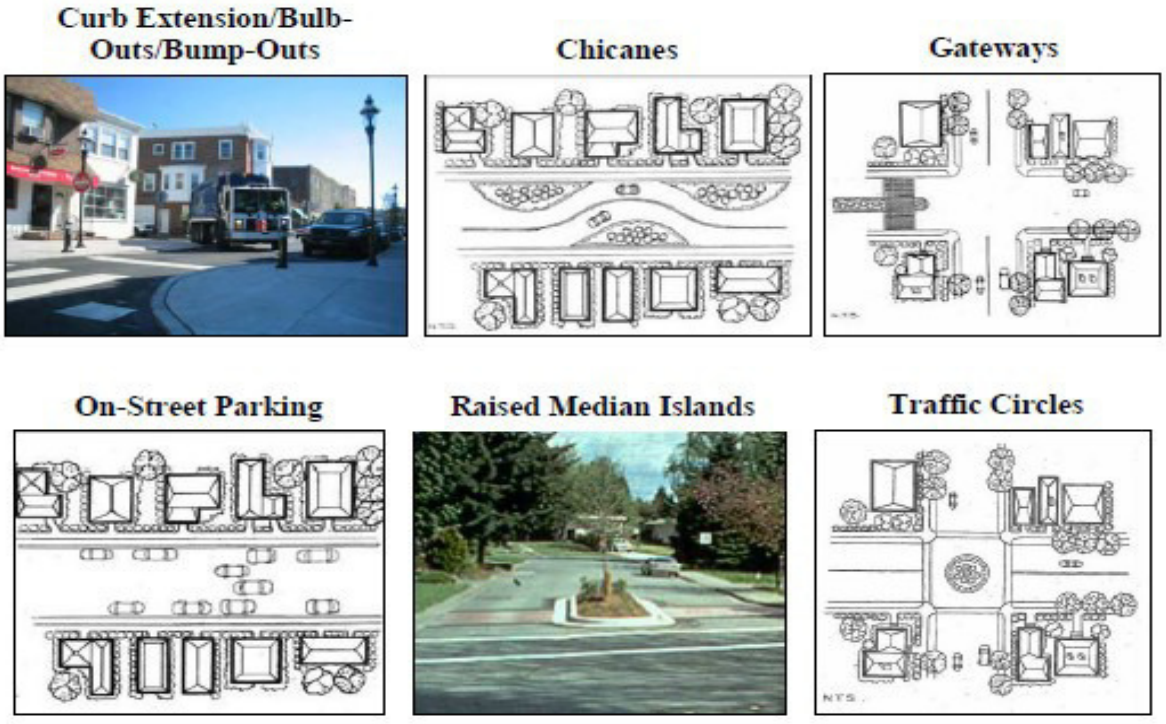
Road Narrowing:

Road narrowing may be considered as another supportive measure to vertical deflections. It acts as a reminder or encouragement to drive slowly or calmly but not as a reducing the speed. It is the way of narrowing the carriageway at specific locations.

It is more effective when it is combined with speed tables. The extra space created by road narrowing is generally used to provide widened footpath.

Central Islands:

Providing central Island in a undivided carriageway in an urban street is an effective measure, which would not only reduce the speed, but serves as a refuge space for pedestrians. However, proper care shall be taken to provide a bigger and wider island at centre to place a hazard marker sign with pavement markings.



3.7.3 Objective and Impact of traffic calming measures

Objective of Traffic calming measures:

- Controlling/reducing the vehicular speeds at different points along the corridor.
- Reinforcing the vehicle hierarchy
- Reducing the number of accidents
- Reduction in air, noise pollution and
- Increases neighborhood interaction and crime prevention

Impact of Traffic calming measures:

- Reduces the disturbance I traffic flow and thereby increases the average speed of all vehicles
- Slowing down the vehicle speeds significantly on access roads, moderately on second-ary roads and much less on main roads.
- Reduces the number/severity of traffic jams which are caused by road accidents.

- Traffic calming generally reduces the traffic noise.
- Traffic calming measures Improves Quality of Life in the Neighborhood.
- Most measures are "Self-Policing" by Slowing Vehicles in the absence of enforcement.
- Traffic calming measures typically achieve high benefit-cost ratios and reduce the burden of cost of road traffic accidents on the emergency services, the state and society in general.

3.7.4 Disadvantages of traffic calming measures

- Traffic calming measures (essentially vertical deflection measures) can also cause inconvenience to emergency vehicles. Thus, the response time for the emergency services increases and may in the worst case increase the risk of loss of life.
- Vertical Deflections (speed humps, speed cushions etc.) also causes discomfort to passengers of large vehicles, such as buses.
- Vertical deflection may also increase noise pollution, particularly in residential areas and can be minimized by proper design.

1. Vertical deflection may also slightly increase the fuel consumption of vehicles and so may affect air quality

3.7.5 Recommended Traffic calming measures :

Traffic Calming Measures mentioned in the above sections are considered as a base line for the recommendation of the measures to be implemented for the corridors under project scope. The influencing villages along the project corridors are studied in view of road safety and the following Traffic Calming Measures are recommended for implementation.

a Traffic Circles, Raised Median Islands, Speed Humps, Textured Crosswalks & Raised Crosswalks.

b Measure to control the Speed – Speed Breaker, Speed Limit Signs

c Pedestrian Safety Facilities – Foot Paths, Pedestrian Crossing facilities & Pedestrian Guard Railing

d Parking Facilities – Parking Sign, No Parking Sign

e Safety measures at Schools, Bus Stops and Railway Crossings.

f Road Markings – Carriageway Markings, Object Markings & Reflective Pavement Markings (RRPM)

g Others – Overtaking Prohibited signs, No Stopping and No Standing Signs

3.8 Measures to control traffic speed:

Specifications and necessity of Horizontal and vertical deflections are already discussed in the earlier sections. Provisions of speed breaker shall be followed as per IRC 99 and for IRC 67 for traffic signs for reducing the speeds.

Speed breakers are normally used to reduce the vehicular speeds and helps in maintaining the efficient movement of traffic flows among the road users. Normally, rounded (circular) hump in shape with width greater than the wheelbase of most of the vehicles using the road. These are normally used in the following locations:

- At intersections of minor and major crossroads and at mid-block sections in urban areas, where it is desirable reduce the speeds for safe and efficient movement of traffic.
- Few of the Local streets at school, college or university campuses, hospitals, residential areas etc., and where it is necessary to restrict the speed of traffic stream in view of pedestrian safety.
- Railway Level crossings
- Sharp Curves with poor sight distance

Drivers should be warned in the presence of speed breakers by posting suitable advance warning signs. The warning signs should be of the design 'HUMP OR ROUGH ROAD' detailed in IRC: 67.

Speed limit signs shall be used to indicate the speed restrictions where at the beginning of a section of the road or area covered under speed restriction zone.

3.9 Pedestrian safety measures:

Specifications for providing pedestrian facilities shall be followed as per IRC 103. Few of the provisions are given below:

- Provision of Foot Paths (A portion of right of way of road used for the movement of pedestrian traffic) at urban locations,
- Pedestrian Crossing facilities (raised crosswalks) at intersections and at heavy pedestrian movement areas.

Foot paths shall be provided as per IRC 103, where pedestrian cross movement is relatively high and at urban locations. In order to be effective, the sidewalks should be provided on both sides of the road and above the level of the carriageway separated by kerbs. Height of the kerb at the edge should, however, not exceed the height of a standard public step riser i.e. 150 mm.

The minimum 1.8m (width) x 2.2 m (Height) walking zone should be clear of all obstructions – both horizontally and vertically. No Utility ducts, Utility poles, electric, water or telecom boxes, trees, signage or any kind of obstruction should be placed within the "Walking Zone".

The land use adjacent to road network significantly influences generation of pedestrian traffic. Recommended width of footpath along various land uses are given below:

Land Use	Recommended Width of Footpath
Minimum obstacle free walkway width and Residential/Mixed Use Areas	1.8 m
Commercial/ Mixed Use Areas	2.5 m
Shopping Frontages	3.5 m to 4.5 m
Bus Stops	3 m
High Intensity Commercial Areas	4 m

Source: *IRC-103-2022 – Table-2*

Specifications of **Pedestrian crossing facilities** shall be followed as per IRC 103.

- Pedestrian must be given the shortest possible direct route to cross the street; therefore, the most preferred crossing is "at-grade".

- Mid-Block Crossings must be provided for people to cross the street safely between building entries or bus stop locations or active land uses on opposite sides of the street.
- Crossings must be provided at all T-Junctions.

At grade pedestrian crossing both near intersection and mid-block, raised pedestrian crossing (Tabletop) should be made mandatory in case of multilane roads with heavy volume of vehicular traffic.

As per specifications minimum 3 m wide pedestrian crossing and 2.5 m wide cycle crossing must be provided at all road crossings.

Standards at Mid-block:

S.No	Land Use	Spacing Range (m)
1	Residential Area	80-250 m
2	Commercial/Mixed Use Areas	80-150 m

Pedestrian guard railing is an important parameter placed in the vicinity of Zebra crossing and it should have sufficient length to deter pedestrian from crossing the road at any arbitrary point along the road. Preferably pedestrian guard rails should be set-back from edge of the carriageway by at least 150 mm. To be clearly detectable, guard-rails should be 1100 mm high from the median level.

3.10 Parking Facilities:

Parking Signs, as per IRC-67 the sign may be located at the edge of the carriageway to indicate the authorized parking places where vehicles can be parked. Parking signs for different classes of vehicles i.e Auto Rickshaws, Bicycle, Cycle Rickshaw, Scooter and Motorcycle, and Taxis are indicated in IRC-67: Figures 18.01 to 18.06).

No Parking/Parking restriction Signs: "No Parking" signs are erected on the roads to prevent any parking of vehicles on the main carriageway which will lead to traffic congestion/traffic hazards. Whereas "**Parking restriction"** the parking is not allowed for specific period of time to control the traffic management. These signs must follow as per the guidelines given in IRC 67.

3.11 Safety features at school zones and bus stops:

"School zone" a head sign should be erected where school buildings or grounds are adjacent to the road. Specifications shall be followed as per IRC 67.

"Bus Stop" location sign shall be erected at the places where the buses are designated to stop. Specifications shall be followed as per IRC 67.

3.12 Safety features at Curve locations:

Wherever project highway is on a curve, there shall be advance cautionary sign for sharp curves and chevron signs at outer edge of the curve. Chevron signs shall be installed based on the radii of the curve as per the details given below:

1. If the curve radii upto 450m shall be provided with curve warning sign in advance of hazard and single chevron on outer edge of curve. Generally, if the difference between the approach speed and permissible negotiating speed of any curve is more than 15kmph, the curve warning sign and speed limit sign shall be placed on both sides.
2. The curve radii between 451m & 750m, single chevron sign shall be installed on outer edge with spacing of 75m.
3. The curve radii between 751m & 1200m with deflection angle more than 20^0 single chevron sign shall be installed.
4. The curve radii between 751m & 1200m with deflection angle less than 20^0 and radii between 1201m & 2000m forgiving type delineator posts at 40m spacing on outer edge of curves.

3.13 Road Studs

Retro reflective studs (RRPM) are used to supplement longitudinal/ transverse road markings, which would improve visibility during the nighttime and adverse weather conditions. Road studs are also used across the carriageway to serve as speed arrestor through the creation of rum-bling sensation to the road user.

The studs with different colours of reflectors such as white, red and yellow are normally used in National Highways.

Road studs shall be used on both uni-directional and Bi-directional roads to delineate the centerline and edge line.

Road studs in white colour are normally used to indicate the traffic lane line and centre of carriageway. Whereas red colour road studs are used to indicate left edge of the running carriageway in order to warn the road user.

Yellow colour road studs are used to indicate the right edge of the running carriageway in case of multi –lane divided carriageways.

Green colour studs are used to indicate crossable edge lines such as bus and truck laybyes.

Solar powered Road studs are more effective which can immediately give attention to the road users. These are normally placed at the hazardous locations.

Road studs shall be proposed as per the codal provisions mentioned in IRC: 35-2015

Table 3-2: Typical warrants for road studs are given in the table below:

S.No	Description of the section		Length	Spacing	Location & colour
1	All sections of project highway having horizontal curves	Curve radii upto 450m	Curve length including transition with 20 m on either side.	6 m	Red-White Bi-directional on shoulder side & Yellow-Yellow Bi-directional on centre line of No overtaking portions and White-White Bi-directional for centre line of other reaches
2		Curve radii 450m to 750m		9 m	
3		Curve radii 751m to 2000m and critical section		18 m	
4	All sections of Project Highway having horizontal curves	Length of highway where vertical gradient is 2.5% and above and its vertical curves	Length including vertical grade and curves and adjoining 180 m portion on either side	9 m	
5	All sections of Project Highway where overtaking prohibited	Sections where overtaking prohibited	Length of no overtaking zone.	6 m	
6	All Major/Minor Bridge, ROB and all structures	Structure	Structure portion and adjoining 180 m on	9 m	Red-White Bi-directional on shoulder side & Yellow-Yellow

			either side		Bi-directional on centre line of No overtaking portions and White-White Bi-directional for centre line of other reaches
7	(Interchange/ Flyover/VUP)	Approaches	Approach length including the length of accel-eration/ deceler-ation length if any and 180 m adjoining on either side	18 m	
8	Built-up areas	Built-up area/Settle-ment/Village	Length of built up from the start to end	9 m	
9	All entry/exit slip roads/ramps and its acceleration/de-celeration lanes	Entry/exit slip roads and ramps	Length of both side edge lines of slip roads/ ramp+ edge line of acceleration/ deceleration lane	9 m	Red Colour on edge lines
10			Chevron/ diag-onal marking on gorge	6 m	Red Colour for Chevrons/diagonal markings
11		Continuity line for acceleration/deceler-ation lane for entry/ exit of slip	Length of cross-able continuity line for lane changing of entry/exit slip roads	8 m	Green Colour for crossable continuity line
12	All junctions and median openings	Storage lane and ac-celeration/ decelera-tion lanes including 180 m on either side	Length of Shoulder and median edge lines	9 m	Red colour on shoulder side and Yellow colour for median sides
13			Chevron/ diag-onal markings	6 m	Red Colour for Chevrons/diagonal markings
14		Across the carriage-way	At the start of acceleration lane	3 rows at 1 m apart	Green Colour

15	Pedestrian Crossing	For zebra crossing marking	At four corners of all block of Zebra crossing markings	2 rows & at 0.5 m spacing	Yellow Colour

 # Source: *IRC SP 73 2023*

3.14 Safety features at overtaking zones

"Overtaking Prohibited signs" shall be erected at the beginning and at intervals within, of such sections where sight distance is restricted, and overtaking will be hazardous. The sign may be dispensed with pavement markings as per IRC-35 provided for "No Overtaking Zones". The "No Overtaking" sign should be erected on each side of the road at the start of the affected length and should be supplemented by repeater signs at intervals not exceeding 400 m. (IRC-67-2012: Figure 14.23)

Markings in "no overtaking" zones shall be established on summit curves, horizontal curves and elsewhere on two and three lane highways where overtaking maneuvering must be prohibited because of restricted sight distance and other hazardous conditions.

On undivided highways with more than 3 lanes, there is no need for crossing of vehicles to make an overtaking.

No-overtaking zone shall be marked by a solid line either single or double along the center.

No overtaking zone markings shall be indicated when the available sight distance is less than the minimum visibility distance (MVD). The no-overtaking zone lines should be marked always with road studs.

No Stopping and No Standing Signs

As per IRC-67-2012, the sign shall be erected on sections of the road where the controlling authority has decided to prohibit stopping of vehicles and standing and even momentary stopping. A definition plate can be attached to signpost to convey the message more precisely. (IRC-67-2012: Figure 14.28)

3.15 Safety features at pedestrian crossings:

Markings for Speed breakers:

Markings for speed breakers shall be provided in advance to any hazardous location. These will help to warn the road user about the blackspot location. For better visibility, the markings shall be made up of retro reflective materials.

Markings for pedestrian crossings:

Markings for pedestrian crossings shall be provided at important intersections where there is a possibility of conflict between vehicles and pedestrians. In view of providing safety to the pedestrians the markings shall be provided at the junctions and locations where a greater number of pedestrian cross movement have been observed.

3.16 Pedestrian Level of Service

Pedestrian facilities with insufficient space leads to unpleasant and unsafe walking experience. Pedestrian facility should provide enough space for safe and comfortable walking, The width should be provided based on the current and expected pedestrian numbers, street type (arterial, collector or local), and adjoining lanl-use. Pedestrian facility width should be designed for Level of Service" (LOS) B. LOS C is acceptable only in case of space constraints.

Table 3-3 gives pedestrian LOS for walking infrastructure in relation to predominant adjoining land use. Pedestrian flow is given in pedestrian/hour/meter (ped/him) width of walking zone.

Table 3-3: Service Volume of Pedestrian Facility of Unit Width

LOS Considered	Service Volume of Service volume of Pedestrian Facility of Unit Width, Pedestrians/Hour/ Meter (ped/h/m) in both direction				
	Commercial	Institutional	Terminal	Recreational	Residential
LOS - B	1285	1145	1360	1360	1430
Los — C	1800	1600	1900	1900	2000

In case of streets with mixed land use, consider the LOS standard for predominant land use adjoining the facility.

Service volume on facility with pedestrian flow in one direction can be taken as 1.5 times more of the flow given for LOS-B and LOS-C in above table.

3.17 Footpath

Footpaths segregate and protect pedestrians from motorized vehicles on urban streets to provide safe walking, and help to improve vehicle flow. Footpaths must be provided on all street types where vehicular speeds exceed 15 kmph2. Walkable footpaths are safe, continuous, secure, comfortable and livable for all including children, elderly, and the persons with physical disabilities. Good footpaths provide places for people to sit, socialize and play.

If footpaths are not provided, then street should be traffic calmed3 to ensure vehicle speeds are below 15 kmph for safe co-existence of pedestrians and motorized vehicles. This can be considered especially for local streets and narrow crowded commercial streets.

3.18 Footpath Design

1. Level of service is defined as a qualitative measure used to determine how well a facility is operating from traveler's perspective.

2. As per the Global Street Design Guide. it is safe for pedestrians to share the space with motorists at Speeds below 15 kmph.

3. Traffic Calming measures ensure pedeastrian and vehicle safely by reducing vehicular speed. Traffic Calming measures include vertical displacements (for e.g. speed Pumps. Tabletop, surface treatment) and horizontal displacement.



Figure 3-1: A footpath showing various zones

Pedestrian/walking zone- It is the clear walking space for pedestrians, clear of any obstructions. It is recommended to provide minimum 2m wide walking zone to ensure two wheelchairs can pass each other. A clear height of 2.4m from the finished footpath floor level should be maintained in walking zone. IRC:SP:117 should be further referred for details on the minimum clearances required by different pedestrian groups.

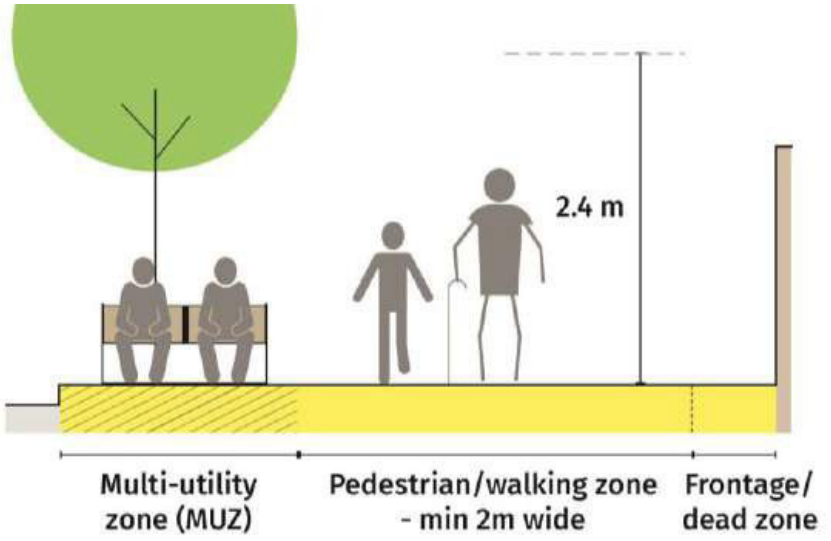


Figure 3-2: Recommended space requirement in walking zone

Height –The height of the footpath should be 150mm from the adjoining finished carriageway level to ensure comfortable access to all pedestrians especially the elderly and children, and prevent illegal parking by not allowing vehicles to mount over the footpath.

Surface – Footpath surface should be even, firm, free from cracks and well-drained. Surface should be of anti-skid material to ensure usability and safety in all-weather conditions. Vitrified tiles should be used for tactile pavers as they have high load bearing capacity and are durable. Footpath surface should have gradient (slope) to prevent accumulation of water. Transverse slope (along the footpath width) can range between 1:50 to 1:100. It should not be steeper than the mentioned slope to prevent

fall and rolling back of wheelchair users, however, ensure that the footpath height of 150mm is maintained at the kerb edge. Any break in the surface, such as drainage channels or expansion joints (to prevent cracks in concrete) in the surface should not be greater than 10mm and

should cross perpendicular to the direction of movement. This will prevent walking sticks and wheels getting caught in the gaps.

Continuity of the footpath – Footpath should continue at same level across side streets and property entrances for seamless movement.

Vehicle access ramps of 1:8 slope should be provided to access side streets. Ramps also slow down vehicles at the intersection, thereby improving safety of pedestrians and other road users. This is recommended where local streets join collector or arterial streets and the inter-section is without signal. Bollards should be provided to prevent vehicles encroaching the foot-path space. Ensure that one bollard spacing provides wheelchair access. Provide tactile pavers before and after the bollards to warn the visually impaired on obstacles.



Figure 3-3: Footpath continuing at same continuing along side street (top view)

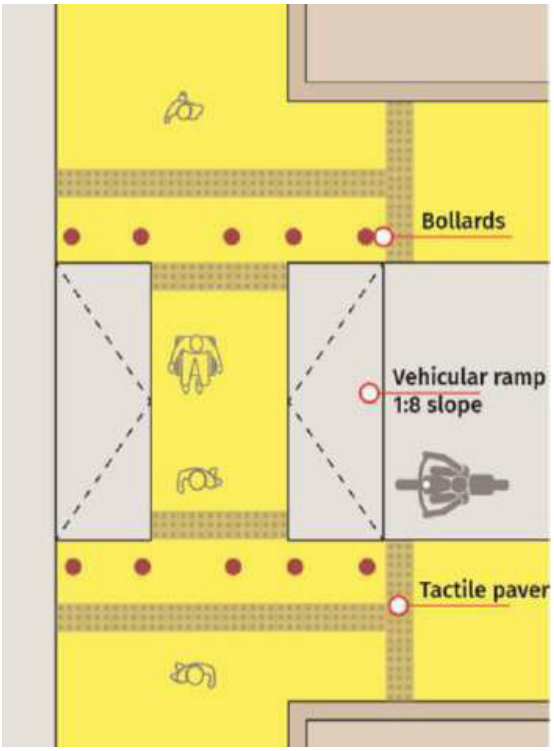


Figure 3-4: Detail of footpath level along side street (Top view)

3.19 Shading on pedestrian facilities

All the pedestrian infrastructure including bus-stops,IPT stands, seating spaces, foot-over bridges and skywalks should be well-shaded to ensure pedestrian safety. Footpaths are usually shaded by trees. On narrow streets, abutting buildings provide shade. Ensure minimum clear-ance of 2.4m between shade and finished footpath floor level to maintain clear walking height and ensure visibility to road signages. Other on-street shading elements include colonnades and shaded walkways. Colonnades can be considered along retail commercial streets. Shaded walkways can be considered to connect railway/metro station or major building to the nearest bus-stop and/or IPT stand for comfortable transfer.

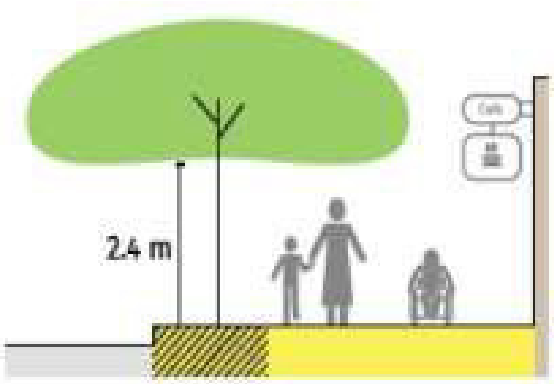


Figure 3-5: Shade on footpath

It is recommended that bus-stops, IPT stands, foot-over bridges (including staircase) and sky-walks be shaded by permanent roofing to protect from heat and rain. All the support systems (post, poles, columns and others) for shading should be located in MUZ or dead zone, and not obstruct pedestrian movement.

3.20 Kerb stone

Kerb stone is placed along the footpath edge. Pre-frabricated concrete kerb stones are preferred as they stronger, easy to install and have uniform finish. However, in some cases in-situ construction of kerb stones can be done if the site needs a lot of variation in the edge. The top level of kerb stone should align with the final finished footpath level. It should not exceed 150m. Kerb stones are placed over PCC mortar base. Curved and angular kerb stone blocks can be used to create bulb-outs.

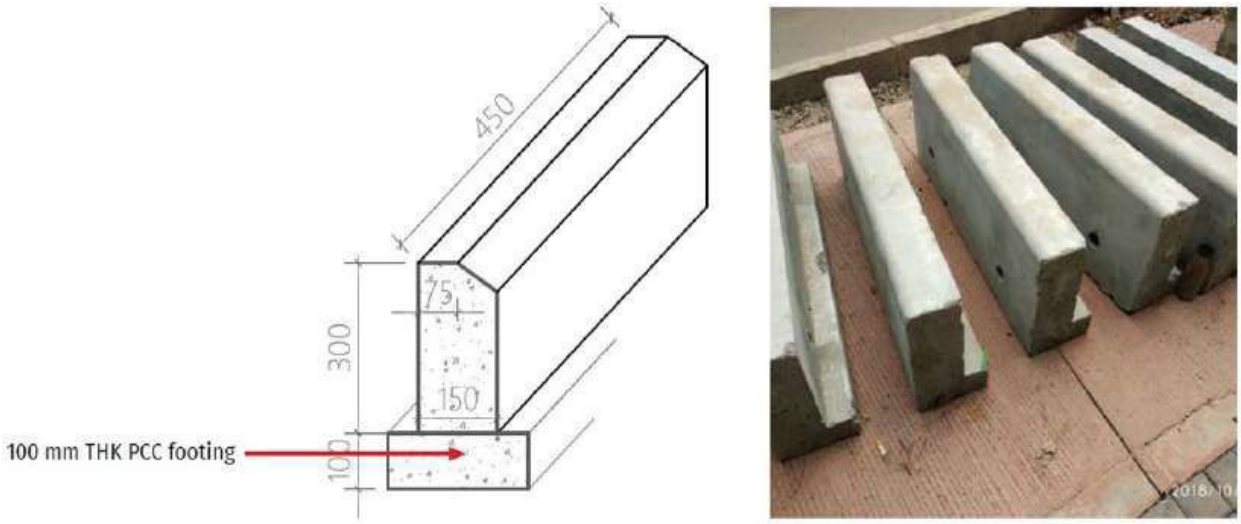


Figure 3-6: Typical 150mm thick kerb stone block

Saucer drains and openings to catchment pits should be laid along the footpath kerb to channelise and collect storm water runoff. Saucer drains can also be provided along with the kerb stone as a single unit as shown in figure 7.

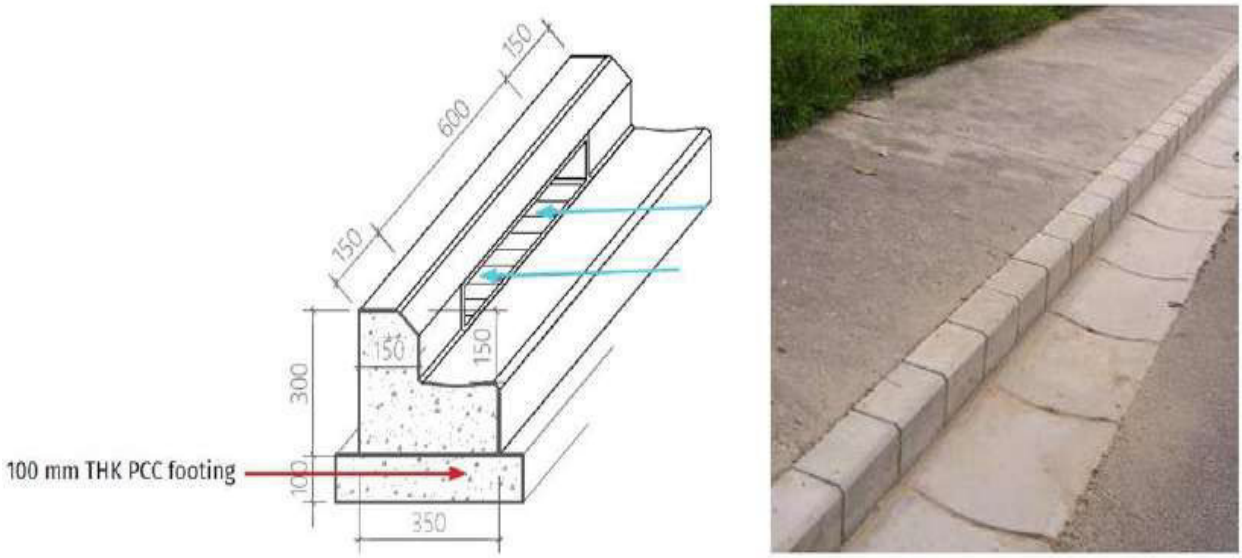


Figure 3-7: Typical 150mm thick kerb stone block



Figure 3-8: Precast rounded Kerb stone Block

Precast rounded kerb stones of desired radii can be used for intersections and parking bays

3.21 Tactile pavers

Visually impaired pedestrians need guidance while walking to find their way, overcome obstacles and cross safely. Detail specification of tile design can be referred in IRC:SP:117.



Figure 3-9: Guiding tile

Guiding tiles have straight continuous lines that indicate the route. They are helpful in large areas such as transport terminals, public spaces and wide footpaths (more than 4m) for easy navigation, as the usual guidance given by the edge of the footpath or compound wall is not within the reach of stick used by visually impaired to navigate. Only warning tiles are recommended on footpaths with width less than 4m.

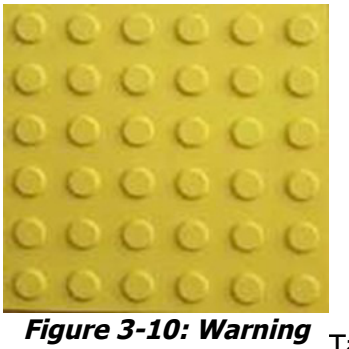


Figure 3-10: Warning tile

Warning tiles helps to warn against level difference and obstacles, and further informs on how to navigate. It should be placed at the beginning and end of the ramps and stairs. Warning tiles should be provided at property entrances, intersections and pedestrian crossings. Two sets of pedestrian warning tiles should be provided, so that the pedestrian does not miss it.

Tactile pavers should be used in a correct and consistent manner.



Figure 3-11: Incorrect layout of tactile pavers

Tactile pavers should be laid 600mm away from the edge of footpath kerb edge, compound wall and any other obstructions to avoid collision. Pavers should be provided in line of travel avoiding obstructions such as service cover, tree pits/guards, lamp posts, bollards and others. Unglazed vitrified pavers are preferred over ceramic/cement ones, as they have good load-bearing strength and are durable. Stainless tactile studs can also be used. Tactile paver colour should be contrasting to the surrounding surface. IRC:SP:117 should be referred for more details on tactile pavers.

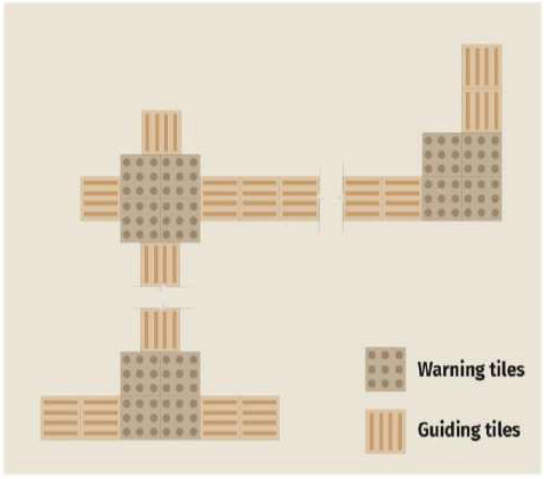


Figure 3-12: Layout of tactile pavers to indicate turns

3.22 Street furniture

Street furniture includes seating, street light, signage, bollard, wastebin, children play element etc. Street furniture should be located in MUZ, and not obstruct pedestrian movement. All street furniture should be convenient to use, universally accessible, vandal proof, durable and easy to maintain. Installation of street furniture must be accompanied by a maintenance plan. Street furniture should be painted in contrasting colour for persons with low vision. Furniture should be fixed at the same level as surface level. Pedestal-mounted furniture should be avoided. Furniture protruding (for eg. wastebins) inside the walking zone should be avoided. It is recommended that street fixtures like bus shelters, utility boxes, seating, bollards, wastebins, etc. are installed prior to the paving of the footpath.

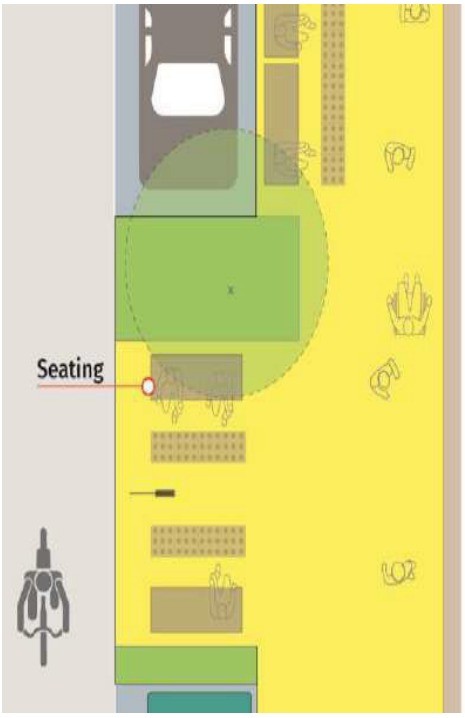


Figure 3-13: Plan showing location of seating footpath (top view)

Seating – Seating enable pedestrian to rest and socialize. It should be well-shaded and comfortable to sit. It should be provided as per the context. Seating may be provided parallel to the pedestrian movement on wider footpaths as shown. Seats may have back rest and armrest. Seat should be at 0.45m in height and depth (not including the back rest).

Wastebins –

Wastebins should be provided at regular intervals. It is recommended that wastebins be available at every 50-75m distance. The opening of the bins should not be above 800mm. Dustbins should be placed near all transit stops and vending areas. Dustbins attached to street lights should not protrude into the walking zone. Regular cleaning of dustbins is required to ensure pleasant walking experience. Garbage dump on streets should be prevented, and city-level waste management plan should be implemented.

Bollards -

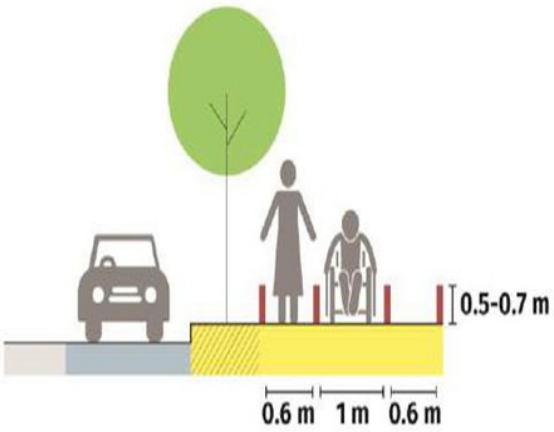


Figure 3-14: Bollard spacing on footpath

Bollards should be provided at locations on footpath where illegal vehicle encroachment is possible such as around property entrance access ramps, raised pedestrian crossings or kerb edge of footpath. Bollard (outer edge of bollard) should be placed 0.25m away from the footpath kerb edge to ensure proper fixing of bollard after kerb stone, and prevent mounting of vehicles. Bollards should be 0.5-0.7m high with a clear spacing of 0.6m between them and one with 1m clear width to ensure movement of wheelchair users, caregivers with pram and persons with luggage. Bollards can be placed on footpath kerb edge at 3m center to center distance to prevent mounting of vehicles. Refer Annexure 4 for more details on bollard material.



Figure 3-15: Bollards designed as seating



Figure 3-16: Broken bollards due to poor implementation

Pedestrian guardrails:

Continuous guardrails on footpath without frequent opportunities to enter and exit makes pedestrians feel trapped inside, and they begin to walk on carriageway. In the absence of frequent

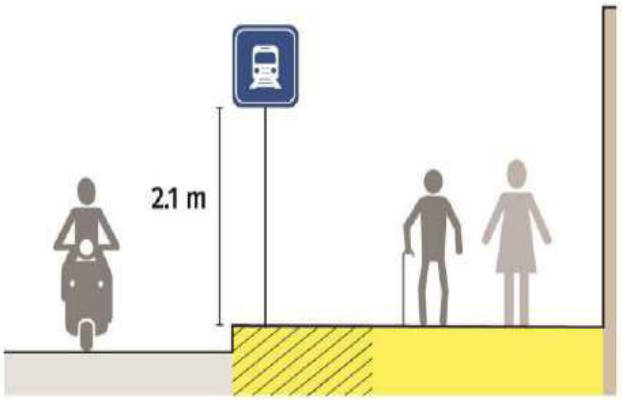
crossing opportunities or crossings at preferred locations, pedestrians tend to jump over median guardrails. Pedestrian guardrails if not provided thoughtfully, adds to the discomfort of pedestrians. Hence, pedestrian guardrails should be only used where there is evidence that pedestrian safety can only be achieved by providing guardrails. Pedestrian guardrails may not be required in most cases if sufficient walking space, and frequent and safe crossings are available. It is recommended to avoid kerb-side guardrails on streets with undivided carriageway, where crossing is frequent and vehicle speeds are under 40kmph. Guardrails may be considered at -

- Around intersections on arterial roads to direct pedestrians towards safe crossings. However, ensure crossings are planned along pedestrian desired lines to avoid increase in walking length.
- Around school and aanganwadi entry/exit to protect children.
- Streets or locations that have high pedestrian volumes and fast-moving vehicles, and there are chances that pedestrians may spill over carriageway.

Following design considerations to be incorporated in pedestrian guardrails-

- The guardrails to be around 0.7-0.9m high to deter pedestrians from climbing over it and ensure visibility.
- The balusters should be placed such that the pedestrians cannot pass through the gap.
- Guardrail (outer edge) should be located 0.25m away from the footpath kerb edge.
- They should be aesthetically designed to enhance the street character.
- Provide appropriate entry and exit points along the pedestrian desired line to prevent pedestrians from climbing over the guardrails.
- If a continuous guardrail is provided along the stretch, it is recommended that a gap be provided at every 20m to allow exit during emergency – for instance, pedestrian can escape any unfortunate event that may be threat to their personal security.

Signage:



Signages inform pedestrians and other road users to navigate on urban streets. There should be no clutter of signages, unnecessary signages should be avoided. Signages on directions, parking, and others that helps to navigate and induce safe driving should be provided.

Figure 3-17: Signage plcement on footpath

A clear height of 2.1m should be maintained between the signage bottom and the finished footpath floor level as shown in figure 34. Signage should be placed perpendicular to the line of traffic, on the left side of the road with clear visibility except for 'Parking' and 'No Parking' signs which shall be placed parallel to the carriageway as per IRC:67. Signages should be placed in the MUZ. Multiple informatory signs and advertisements can be combined on a single pole to reduce clutter. IRC:67 on road signages should be referred. Braille signboards should be located between 1.4-1.6 meters from floor level for persons with visual impairments.



Figure 3-18: Braille Signboard at a Bus-Stop

Contrasting colour should be used to differentiate signage content from the background. Typically, white is used for the content and blue for background. The colour combinations red/green and yellow/blue should not be used to avoid confusion to persons with colour blindness.

IRC:SP:117 should be referred for details. Periodical testing of retro reflective sign boards to be done as mentioned in IRC:67 to assure the performance of the sign boards. Non-performing sign boards (not meeting the minimum Ra values) which are under the warranty period should be replaced, and damaged sign boards to be replaced on immediate basis.

Street lights -

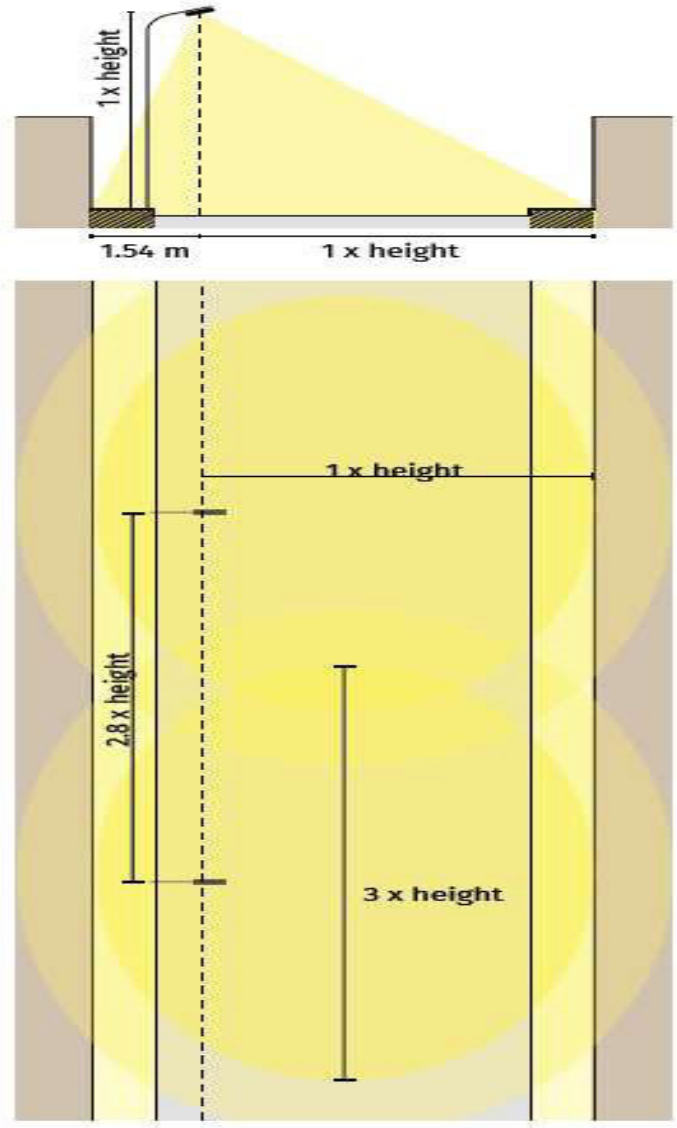


Figure 3-19: height and spacing of Street light

The entire RoW width should be well-lit. Warm white LED light is preferred. 25-30 lux level of lighting should be available on footpath. Spacing between two light poles should be approximately three times the height of the fixture to ensure complete lighting. Light poles should be no higher than 12m to reduce undesired illumination of private properties. It is recommended to have flexible and reboundable type retro-reflective sheets of Type IV on street light poles. Pedestrian lights on footpath and cycle track should not exceed beyond 6m. Table 3 recommends the height and spacing of street lights.

Table 3-4: Street light height and spacing as per street type

Street type	Pole height (m)	Spacing (m)
Footpath or cycle track	3-6	9-16
Local street (less than 12m width)	8-10	25-27
Arterial or Collector (more than 12m width)	12	30-33



Figure 3-20: Trees obstructing thes-treet light

Placement of street lights should be coordinated with trees to avoid dark spots. An integrated plan of trees and street lights location should be prepared.

A single row of light is sufficient for streets upto 12 m wide. Dual lights can be mounted on a single central post, if lighting is insufficient.

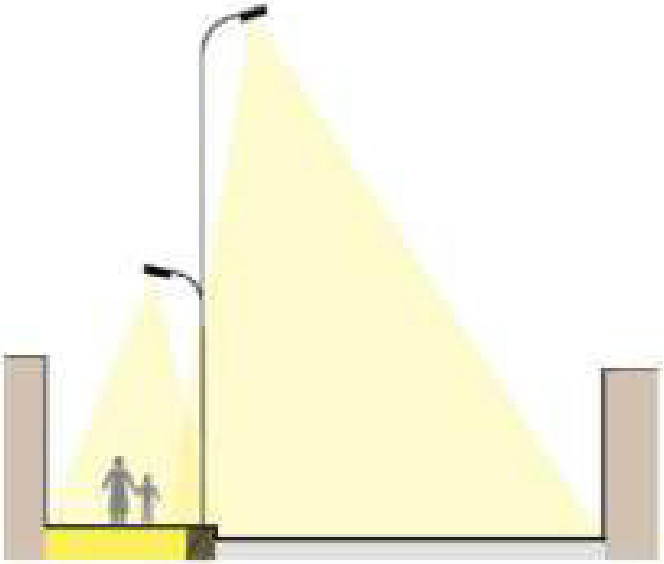


Figure 3-21: Street lighting on narrow streets

For wider streets, multiple rows of posts can support lights at different levels

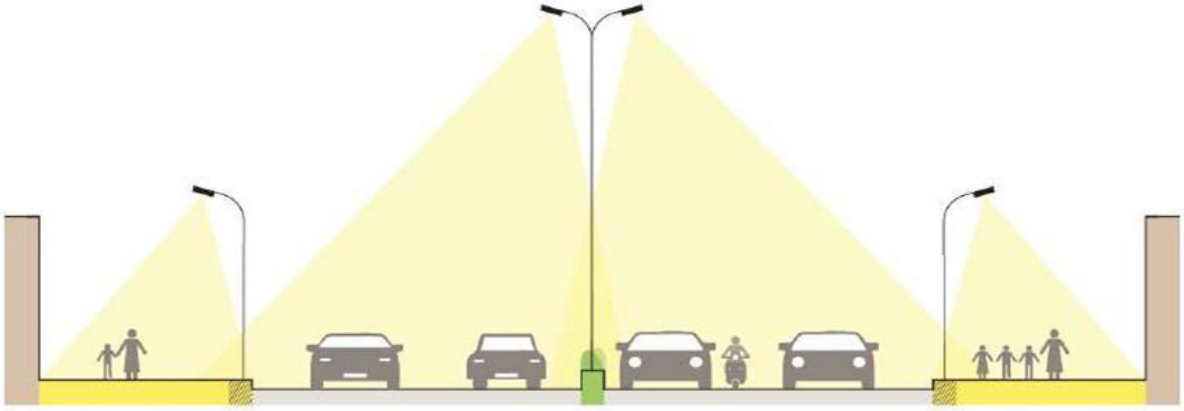


Figure 3-22: Street lighting on wide streets

Utilities -

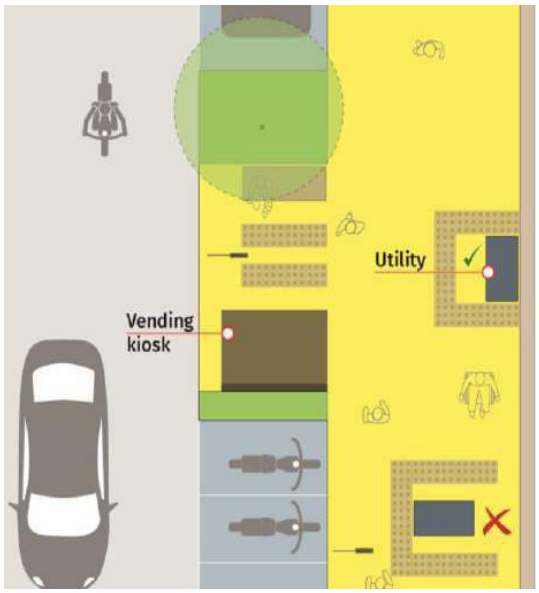


Figure 3-23: Placement of utilities on footpath (topview)

Improper placement of overground such as utility boxes and uneven service covers impedes pedestrian movement. Utility boxes should be placed in MUZ or dead zone without disrupting the pedestrian movement. Any service covers on the footpath should be placed in MUZ. They should be avoided on cycle tracks. However, if they come on walking zone or cycle track, the covers should be in level with footpath surface.

Warning tiles should be provided to indicate the visually impaired persons to change the direction. The gratings of the service covers should be perpendicular to the movement of wheels of a wheelchair. Openings of grating should not be more than 10mm wide.



Figure 3-25: Service covers should be located in MUZ

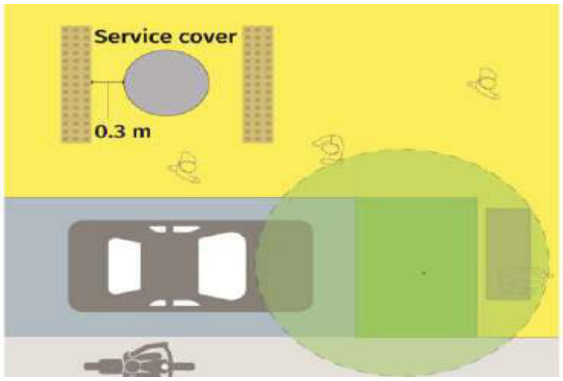


Figure 3-24: Detail of service cover when-provided on walking zone (top view)

Mapping Utilities

• While retrofitting existing footpaths, mapping of all utility lines running under ground is necessary

for precise excavation so as to prevent damage to these lines.

• While excavation, at least 2 m around tree trunk should be left un excavated to prevent damage to

the roots. Precautions should be taken to avoid damaging of existing utility lines.

• Ducts are recommended for all underground utilities than trenches. Ducts may be conduits, tubes

or pipes such as RCC, PVC hume pipes. Ducts are cost effective and provide flexibility. Where

trees obstruct the continuous passage of utility lines, the lines should be continued around the trees

via flexible ducts. Manholes should be provided at regular intervals for maintenance. IRC:98

should be further referred for guidelines on accommodation of utility services on urban streets.

Public toilets and drinking water facilities

It is recommended that public toilets be located off-street. Walking along public toilets should be pleasant. They should be universally accessible. IRC:SP:117 should be referred for details on universally accessible toilet design. They should be safe for women and children to use. Hygienic public toilets and drinking water facilities should be available within 5-minute walking distance of major destinations such as transit stations, markets, public parks etc.

3.23 Pedestrian crossings

Pedestrians of all age groups, gender and abilities should be able to cross streets safely and conveniently. Pedestrians cross at mid-block and at intersections. Frequent opportunities for at-grade crossings should be available on urban streets. Crossings that are located far apart increases the walking distance which leads pedestrians to cross randomly. Similarly, if the waiting time to cross increases, the pedestrians tend to become impatient, and cross in an unsafe condition subjecting themselves to the risk of road crash. Table 4 recommends LOS for pedestrian crossing as per the Indian Highways Capacity Manual. Pedestrian delay is defined as the waiting time a pedestrian has to invest before crossing.

Table 3-5: Pedestrian Crossing Level of Service

LOS	Pedestrain Crossing Level of Service
A	≤ 5
B	5 – 10
C	11 – 12
D	26 - 45

Pedestrian crossings are of two kinds – at-grade and grade-separated. At-grade pedestrian crossings provide crossing at the street level, whereas grade-separated infrastructure provide crossing above or below the street level. Foot-over bridges and subways are grade-separated pedestrian crossings. Atgrade pedestrian crossings are recommended over grade-separated ones, as they provide quick, short and comfortable crossing. Pedestrian crossings should be provided at every 80-150m in urban areas. On undivided streets where pedestrians tend to cross at any points, such streets should be traffic calmed to ensure vehicles speeds are below 20kmph. Pedestrian crossings should be minimum 2 m wide. 4m wide crossings are recommended on streets with high pedestrian volumes such as schools, transit stations, shopping complex etc. Pedestrian crossings should be clearly visible to all road users by appropriate markings as per IRC:35.

3.24 At-grade pedestrian crossings

At-grade pedestrian crossings are mainly of two kinds – tabletop / raised crossing, and painted zebra crossing.



Figure 3-26: Table top crossing

Tabletop crossing Tabletop or raised crossings are recommended at all unsignalized crossings, as it provides comfortable and safe crossing to all road users including persons on wheelchair, elderly and caregivers with pram. It allows pedestrians to cross at the same level as the footpath . It also acts as a traffic calming measure that ensures road safety to both pedestrians and motorists.

crossing is raised at the same level as the adjacent footpath finished level. Ramps of 1:8 slope is provided for vehicle access. Crossing should be minimum 2m wide. Bollards should be provided at both ends of the crossing and at median, to prevent vehicles from (especially two-wheelers) taking U-turns and entering the footpath. Atleast one bollard spacing should ensure access to wheelchair users. It is recommended to provide traffic calming measure (speed hump) 10-20m before the crossing as per IRC:99. This will help to slow down the vehicle in advance and ensure pedestrian safety. Tactile pavers should be provided to guide visually impaired persons. Provision for storm water drainage before the ramp should be provided. Asphalt concrete may be used for the tabletop surface.

Painted zebra crossing -

Zebra crossings are painted at the level of carriageway. Kerb ramps on footpath should be provided at both the ends of the zebra crossing for access to wheelchair users, caregivers with prams and elderly. Following design guidelines should be followed for kerb ramp:

- The kerb ramp slope should not be steeper than 1:15 and slopeon flared sides should be 1:10.
- The width of kerb ramp should be equal to the width of the pedestrian crossing.
- Ensure minimum clear 1.2m wide walking space is available after bollards.

- Warning tactile pavers should be provided at the ramp top and bottom as to warn a visually impaired person on the level difference due to ramp slope and the beginning of the carriageway.
- The carriageway surface at the ramp bottom should be well drained.

'STOP' line should be provided before the zebra crossing as per IRC:35, if the crossing is signalized. Stop line provides buffer space between zebra crossing and waiting vehicles.

Pedestrian refuge at median

Pedestrian refuge at median provides safe space for pedestrians to wait while crossing the divided carriageway. It is recommended that the minimum median width be 1.2m. 2m median width should be provided for a cyclist to wait. For wheelchair and pram access, median level should be at the same level as tabletop crossing or as carriageway level incase of zebra crossing. Pedestrian median refuge should be properly highlighted with the help of road markings, delineators, median markers or solar studs based on the site requirement.

Source: *IRC 103:2022*

4.0 Traffic Analysis & Forecasting

4.1 Introduction

4.1.1General

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.

4.1.2 Project Location

The instant project stretch from Km 527.425 to Km 529.695 forms part of NH-66 (Zuari Package-I) near Moita in North Goa District, where four-laning works have already been completed and the section has been commissioned. Within this stretch, particularly near Km 528.935, frequent movement of cattle across the carriageway has been observed. At present, the crossing is at-grade, resulting in direct interaction between cattle and high-speed highway traffic.

In order to segregate animal movement from the main highway traffic and to mitigate accidents caused due to cattle crossings, it is proposed to develop this location as a grade-separated structure. Further, construction of service roads on both sides of the highway is proposed between the end of the Siridao Flyover Junction and the Agacaim Junction. Additionally, it is proposed to close the two existing median openings along this stretch to improve access control and enhance safety.

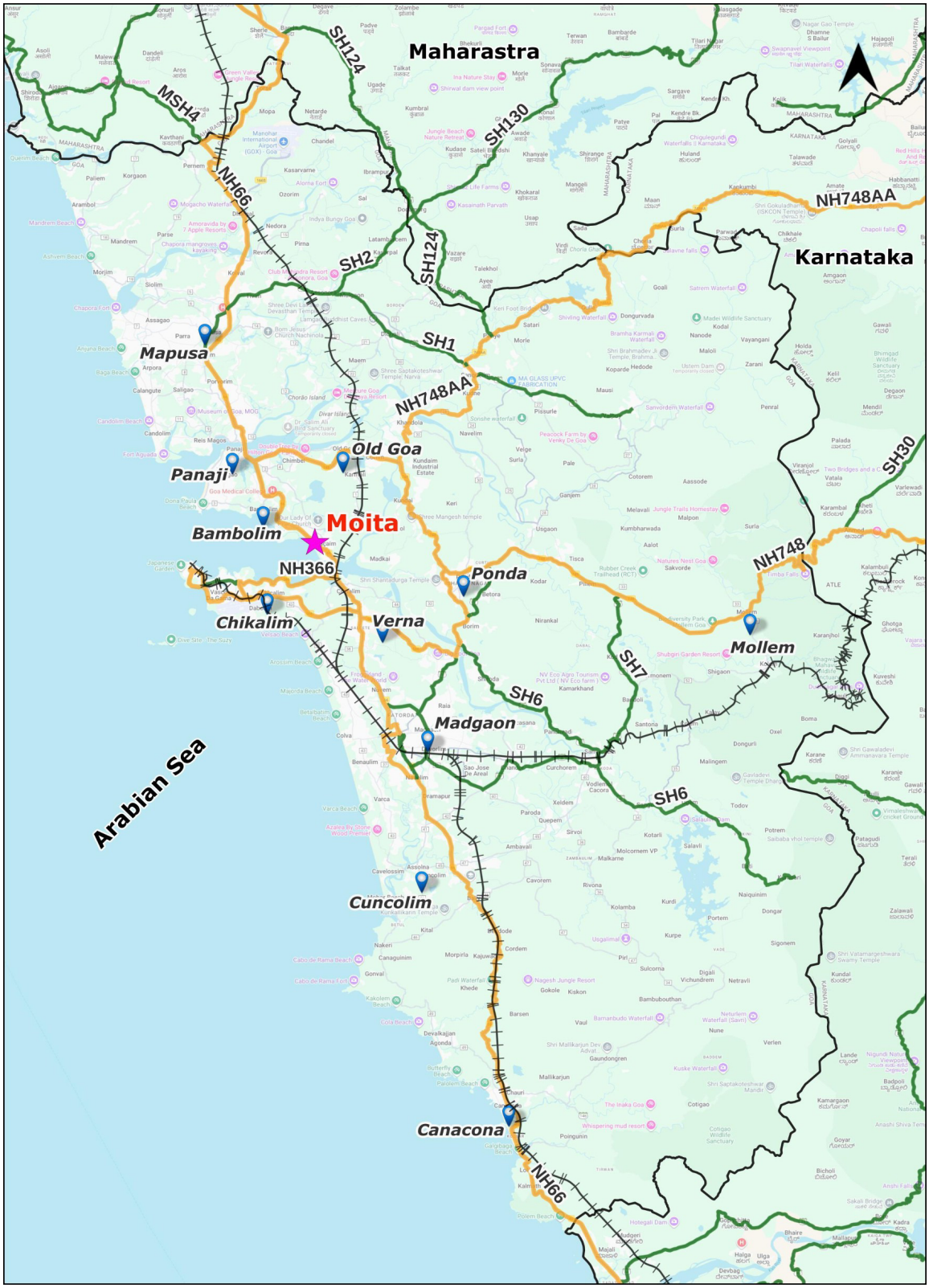


Fig. – 4.1: Index Map of Project Stretch

4.2 Traffic Surveys Planning & Schedule

4.2.1 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 Volume Count survey for Moita at Km 528.935 on NH-66.



Fig.– 4.2: Map showing Traffic Survey Locations

4.2.2 Schedule of Traffic Surveys

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

Table – 4.1: Traffic Surveys Schedule

S. No.	Type of Survey	Location	Date of Survey	Duration of Survey
1	Classified Traffic Volume Count	Km. 528.935	30.09.2024	24 hours

4.2.3 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.

4.2.4 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.

4.3 Traffic Volume Surveys and Analysis

4.3.1 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.

4.3.2 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

4.3.3 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 – 4.2: Average Daily Traffic

Mode	Km 528.935
Two Wheelers	18254
Three Wheelers	14
Car / Jeep / Van	30975
Car Yellow board	4201
Tata Magic	0
RTC Bus	228
Private Bus	509
School/College bus	7
Mini Bus	338
2 Axle	386
3 Axle	285
M Axle	244

Mode		Km 528.935
HEM		2
LCV/LGV		1771
Mini LCV		1793
Three Wheeler goods		18
Tractor		0
Tractor with trailer/others		0
Non-Motorized Vehicles		22
Govt. Exempted Vehicles		59
Tollable Traffic (vehicles)		40739
Tollable Traffic (PCU's)		45485
Total Vehi-cles	Motorized	59084
	Non-Motorized	22
	Total Traffic	59106
Total PCUs	Motorized	54742
	Non-Motorized	13
	Total Traffic	54755

4.3.4 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 – 4.3: Seasonal variation for Petrol & Diesel vehicles on NH-66 (Near Moita)

Km. 528.935 on NH-66		
Near Moita Section		
Month of the year	MS (kl)	HSD (kl)
Jan	317	437
Feb	282	463
Mar	280	439
Apr	260	444

Km. 528.935 on NH-66		
Near Moita Section		
Month of the year	**MS (kl)**	**HSD (kl)**
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	**1.10**	**1.08**

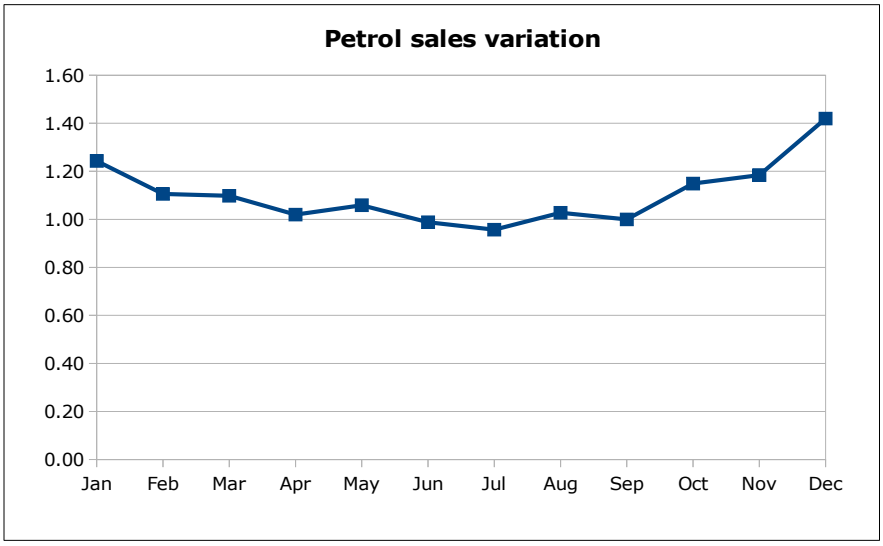


Figure – 4.3: Petrol Sales Variation

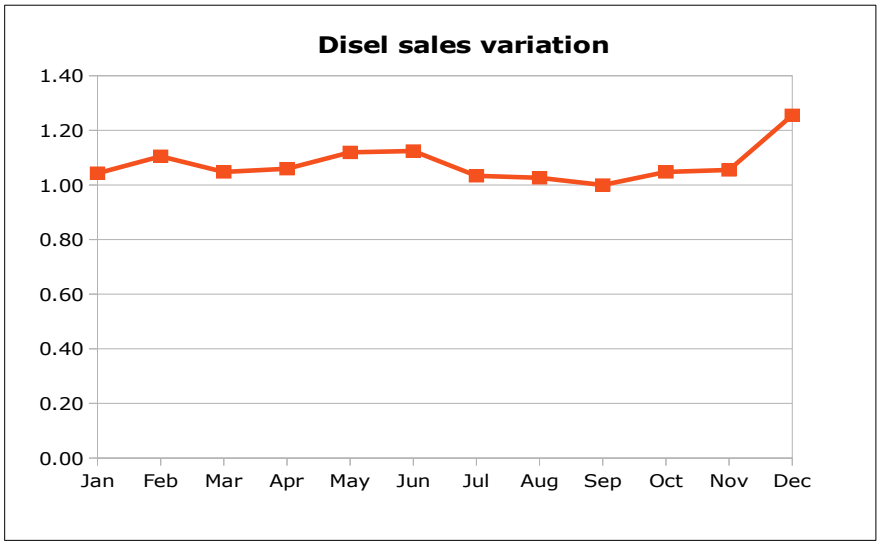


Figure – 4.4: Diesel Sales Variation

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

Table – 4.4: Seasonal Variation Factors(SVF)

S. No.	Section	Petrol	Diesel
1	NH-66	1.10	1.08

4.3.5 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 – 4.5: Annual Average Daily Traffic (AADT)

Mode	Km 528.935
Two Wheelers	20079
Three Wheelers	15
Car / Jeep / Van	33707
Car Yellow board	4571
Tata Magic	0
RTC Bus	245

Mode		Km 528.935
Private Bus		548
School/College bus		8
Mini Bus		364
2 Axle		415
3 Axle		307
M Axle		263
HEM		2
LCV/LGV		1906
Mini LCV		1930
Three Wheeler goods		19
Tractor		0
Tractor with trailer/others		0
Non-Motorized Vehicles		22
Govt. Exempted Vehicles		64
Tollable Traffic (vehicles)		44266
Tollable Traffic (PCU's)		49374
Total Vehicles	Motorized	64444
	Non-Motorized	22
	Total Traffic	64466
Total PCUs	Motorized	59555
	Non-Motorized	13
	Total Traffic	59568

4.3.6 AADT Modal Split

- Car (White board) Traffic is about 52.29%. Trucks (2A, 3A, Multi Axle) contribute 7.09%. Two wheelers constitute 31.15% in the total traffic along the corridor as shown in Figure – 4.5

- The share of non motorized vehicles is negligible

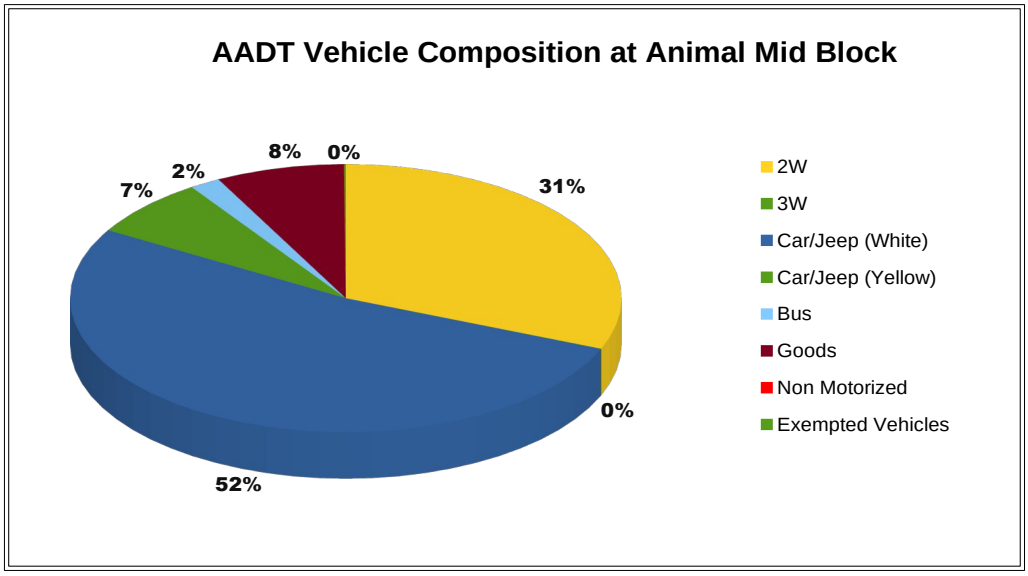


Figure – 4.5: AADT Modal Split

4.3.7 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.

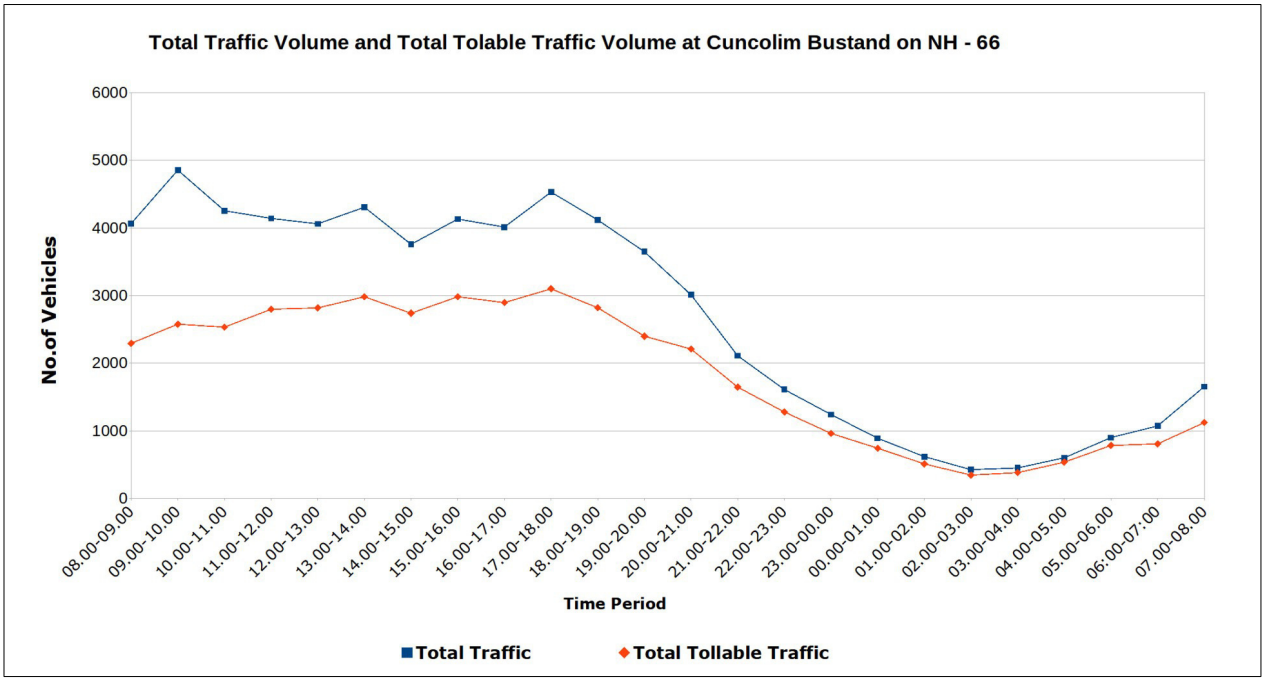


Figure – 4.6: Total traffic & Tollable traffic volume for the location at Km.528.935

4.3.8 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 – 4.6: Peak Hour Factor (PHF)

S. No.	Volume Count Location	Peak Hour	Peak Hour Volume	AADT	Peak Hour Percentage(%)
1	Km 528.935 on NH-66	17.00-18.00	3762	59568	6.32

4.4 Traffic Forecast

4.4.1 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.

4.4.2 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 –4.7: 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

4.4.3 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.

4.4.4 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 – 4.8 : 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 – 4.9 : 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

4.5 Traffic Projections

4.5.1 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 – 4.10: Traffic Projections Along the Main Road

Year	2W	3W	Cars	BUS	M. Bus	2 Axle	3 Axle	M Axle	LGV/ LCV	M. LCV	Tractors	Total volume (nos.)	Total volume (PCU)
Km 528.935													
2024	20079	15	38278	801	364	415	307	265	1906	1930	0	64382	59441
2029	25627	19	48854	1022	464	530	392	338	2433	2463	0	82170	75864
2034	32707	25	62351	1304	593	677	500	431	3105	3144	0	104872	96823
2039	41744	31	79577	1665	756	864	638	550	3963	4012	0	133846	123574
2044	53277	40	101563	2125	965	1102	814	703	5058	5121	0	170826	157715
2049	67996	51	129623	2712	1232	1407	1039	897	6455	6535	0	218022	201289
2054	86782	65	165435	3461	1572	1796	1326	1144	8239	8341	0	278257	256901

4.5.2 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, average 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 – 11: Capacity Analysis with total traffic on Main at Km 528.935

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	20079	15	33707	4571	0	245	548	8	364	415	307	263	2	1906	1930	0	0	21	1	0	64382	59441	6 lane divided
2025	21083	16	35392	4800	0	258	575	8	382	436	322	276	2	2002	2026	0	0	22	1	0	67601	62413	8 lane divided
2026	22138	17	37161	5040	0	271	604	8	401	458	338	290	2	2102	2128	0	0	23	1	0	70982	65534	8 lane divided
2027	23244	17	39020	5292	0	284	634	9	421	481	355	304	2	2207	2234	0	0	24	1	0	74531	68810	8 lane divided
2028	24407	18	40971	5557	0	298	666	9	442	505	373	319	3	2317	2346	0	0	26	1	0	78257	72251	8 lane divided
2029	25627	19	43019	5834	0	313	699	10	464	530	392	335	3	2433	2463	0	0	27	1	0	82170	75864	8 lane divided
2030	26908	20	45170	6126	0	329	734	10	488	557	411	352	3	2555	2586	0	0	28	1	0	86279	79657	8 lane divided
2031	28254	21	47429	6433	0	345	771	11	512	585	432	370	3	2682	2716	0	0	30	1	0	90592	83640	8 lane divided
2032	29666	22	49800	6754	0	363	809	11	538	614	453	388	3	2816	2851	0	0	31	1	0	95122	87822	8 lane divided
2033	31150	23	52290	7092	0	381	850	12	564	645	476	407	3	2957	2994	0	0	33	2	0	99878	92213	8 lane divided
2034	32707	25	54904	7446	0	400	892	12	593	677	500	428	4	3105	3144	0	0	34	2	0	104872	96823	8 lane divided
2035	34343	26	57650	7819	0	420	937	13	622	711	525	449	4	3260	3301	0	0	36	2	0	110116	101664	8 lane divided
2036	36060	27	60532	8210	0	441	984	14	653	746	551	472	4	3423	3466	0	0	38	2	0	115621	106748	8 lane divided
2037	37863	28	63559	8620	0	463	1033	14	686	783	578	495	4	3595	3639	0	0	40	2	0	121403	112085	8 lane divided
2038	39756	30	66737	9051	0	486	1085	15	720	823	607	520	4	3774	3821	0	0	42	2	0	127473	117689	8 lane divided
2039	41744	31	70074	9504	0	510	1139	16	756	864	638	546	4	3963	4012	0	0	44	2	0	133846	123574	8 lane divided
2040	43831	33	73577	9979	0	536	1196	16	794	907	670	573	5	4161	4213	0	0	46	2	0	140539	129752	8 lane divided
2041	46022	35	77256	10478	0	562	1256	17	834	952	703	602	5	4369	4423	0	0	48	2	0	147566	136240	8 lane divided
2042	48323	36	81119	11002	0	591	1319	18	876	1000	738	632	5	4588	4645	0	0	51	2	0	154944	143052	8 lane divided
2043	50740	38	85175	11552	0	620	1384	19	919	1050	775	664	5	4817	4877	0	0	53	3	0	162691	150205	8 lane divided
2044	53277	40	89434	12129	0	651	1454	20	965	1102	814	697	6	5058	5121	0	0	56	3	0	170826	157715	8 lane divided
2045	55940	42	93905	12736	0	684	1526	21	1014	1158	855	732	6	5311	5377	0	0	59	3	0	179367	165601	8 lane divided
2046	58737	44	98600	13373	0	718	1603	22	1064	1215	897	768	6	5576	5646	0	0	61	3	0	188335	173881	8 lane divided
2047	61674	46	103531	14041	0	754	1683	23	1117	1276	942	807	7	5855	5928	0	0	65	3	0	197752	182575	8 lane divided
2048	64758	49	108707	14743	0	791	1767	24	1173	1340	989	847	7	6148	6224	0	0	68	3	0	207640	191703	8 lane divided
2049	67996	51	114142	15481	0	831	1855	26	1232	1407	1039	889	7	6455	6535	0	0	71	3	0	218022	201289	8 lane divided
2050	71396	54	119850	16255	0	873	1948	27	1294	1477	1091	934	8	6778	6862	0	0	75	4	0	228923	211353	8 lane divided
2051	74966	56	125842	17067	0	916	2045	28	1358	1551	1145	981	8	7117	7205	0	0	78	4	0	240369	221921	8 lane divided
2052	78714	59	132134	17921	0	962	2148	30	1426	1629	1203	1030	8	7473	7566	0	0	82	4	0	252387	233017	8 lane divided
2053	82650	62	138741	18817	0	1010	2255	31	1498	1710	1263	1081	9	7846	7944	0	0	86	4	0	265007	244668	8 lane divided
2054	86782	65	145678	19758	0	1061	2368	33	1572	1796	1326	1135	9	8239	8341	0	0	91	4	0	278257	256901	8 lane divided

5.0 Pavement Design Report

5.1 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 rectifying the Black Spot Locations in various National Highways in Goa through empanelled road safety audit consultants.

In order to fulfil the above task, **Public Works Department(NH)** has been assigned the work of Preparation of DPR for various projects proposed in Annual Plan of Goa and pedestrian count surveys in the state of Goa to M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd.

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.

5.2 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.

5.3 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

5.4 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.

5.5 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 for Moita section at Km. 528.935 on NH-66 by trained personnel, 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-5.1: AADT for the survey location at Km. 528.935 (2024)

Mode	Km 528.935
Two Wheelers	20079
Three Wheelers	15
Car / Jeep / Van	33707
Car Yellow board	4571
Tata Magic	0
RTC Bus	245
Private Bus	548
School/College bus	8
Mini Bus	364
2 Axle	415
3 Axle	307
M Axle	263

Mode		Km 528.935
HEM		2
LCV/LGV		1906
Mini LCV		1930
Three Wheeler goods		19
Tractor		0
Tractor with trailer		0
Non-Motorized Vehicles		22
Govt. Exempted Vehicles		64
Tollable Traffic (vehicles)		44266
Tollable Traffic (PCU's)		49374
Total Vehicles	Motorized	64444
	Non-Motorized	22
	Total Traffic	64466
Total PCUs	Motorized	59555
	Non-Motorized	13
	Total Traffic	59568

5.6 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-5.2: 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 %

5.7 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-5.3: 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-5.4: Vehicle Damage Factor (VDF) adopted

Mode	Adopted VDF
LCV	2.41
2A	3.37
3A	3.91
MA	6.65

5.8 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

5.9 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

5.10 Preliminary Design of Flexible Pavement

5.10.1 General

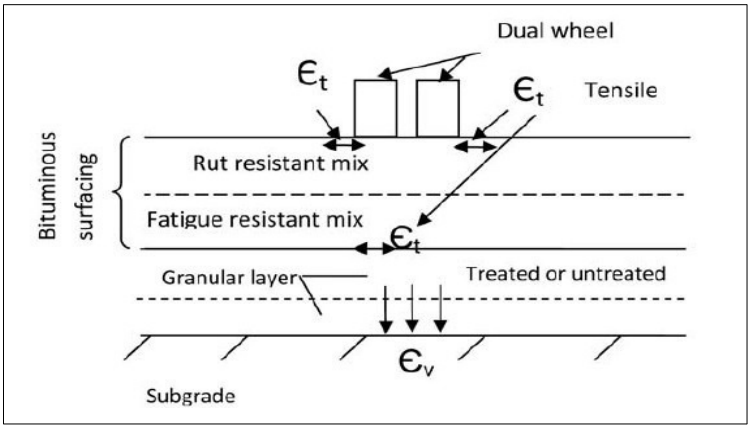
The flexible pavement is modeled as an elastic multi layer structure. Stresses and strains at critical locations are computed using linear layered elastic model. The stress – strain analysis software IIT-PAVE has been used for the computation of stress and strain in flexible pavements as mentioned below

- 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.



5.10.2 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%.

5.10.3 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)

5.10.4 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.

5.10.4.1 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 water 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

5.10.4.2 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.

5.10.4.3 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-5.6: 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	-

5.10.5 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% subgrade CBR. Cumulative standard axles calculated for the 20 year design life for leg wise is given in the Table-5.7.

Table-5.7: Million standard axles for developmental traffic

	Cumulative MSA	Design MSA
At Moita (Km 528.935)	54.00	60

Anticipating heavy commercial traffic movement on the proposed highway due to the future developments flexible pavement is adopted for **60 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-5.8: Conventional Pavement Composition (Option-1)

Section	Eff. CBR (%)	MSA for 20 yrs design life	Bitumen Grade	Crust Composition (mm)				
				BC	DBM	WMM	GSB	Total
Moita	10	60	VG-40	40	115	250	200	**605**

Table-5.9: 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
Moita	10	60	VG-40	40	60	100	100	200	**500**

Table-5.10: 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
Moita	10	60	VG-40	40	60	100	160	200	**560**

Table-5.11: 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
Moita	10	60	VG-40	40	60	SAMI	140	200	**440**

5.11 Final Flexible Pavement design Option for Main carriageway:

As per the equations mentioned in 2.3.2 and 2.3.3: Following are the results observed from the IIT-PAVE Software for crust composition mentioned in the below table.

Calculation of Allowable Strains at Critical Locations:

Allowable Horizontal Tensile Strian (E_t): At Bottom of the Bituminous layer

$N_f = 2.021 \text{ X } 10\text{-}4 \text{ X } (1/E_t)^{3.89} \text{ X } (1/M_R)^{0.854}$ ---------> 1 (90% Reliability)

Tensile Strian(E_t) **= 170** Micro Strain (Allowable Tensile Strain)

Allowable Horizontal Tensile Strian(E_t): At Bottom of Cement Treated Base layer

Tensile Strian (E_t) **= 69.91** Micro Strain (Allowable Tensile Strain)

$$N = RF\left[\frac{\left(\frac{113000}{E^{0.804}}+191\right)}{\varepsilon_t}\right]^{12} \longrightarrow \mathbf{2}$$

Where,

RF = reliability factor for cementitious materials for failure against fatigue
= 1 for Expressways, National Highways, Sate Highways and Urban Roads and for other categories of roads if the design traffic is more than 10 msa
= 2 for all other cases

N = No of standard axle load repetitions which the CTB can sustain

Allowable Vertical Compressible Strian(E_v): At top of the sub-grade layer

$N = 1.41 \text{ X } 10^{-8} \text{ X } (1/Ez)^{4.5337}$ --------> 3 (90% Reliability)

Compressive Strian(E_v) **= 357** Micro Strain.

Calculation of Maximum Strains at Critical Locations by IIT-PAVE:

VIEW RESULTS

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```
No. of layers                 5
E values (MPa)          3000.00  450.00 5000.00  600.00   76.83
Mu values                  0.350.350.250.250.35
thicknesses (mm)         100.00  100.00  100.00  200.00
single wheel load (N) 20012.00
tyre pressure (MPa)        0.80
Dual  Wheel
  Z         R       SigmaZ       SigmaT      SigmaR      TaoRZ       DispZ       epZ         epT         epR
100.00     0.00-0.2933E+00 0.5545E+00 0.4670E+00-0.1871E-01 0.2958E+00-0.2169E-03 0.1646E-03 0.1252E-03
100.00L    0.00-0.2933E+00-0.5106E-01-0.6418E-01-0.1871E-01 0.2958E+00-0.5621E-03 0.1646E-03 0.1252E-03
100.00   155.00-0.1681E+00 0.2025E+00-0.2768E+00-0.8998E-01 0.2869E+00-0.4737E-04 0.1194E-03-0.9629E-04
100.00L 155.00-0.1681E+00-0.4658E-01-0.1185E+00-0.8998E-01 0.2869E+00-0.2452E-03 0.1194E-03-0.9629E-04
300.00     0.00-0.5880E-01 0.3215E+00 0.2449E+00-0.1869E-01 0.2543E+00-0.4008E-04 0.5500E-04 0.3584E-04
300.00L    0.00-0.5880E-01 0.2133E-01 0.1214E-01-0.1869E-01 0.2543E+00-0.1119E-03 0.5499E-04 0.3584E-04
300.00   155.00-0.6336E-01 0.3451E+00 0.2578E+00-0.3940E-01 0.2615E+00-0.4281E-04 0.5929E-04 0.3747E-04
300.00L 155.00-0.6336E-01 0.2282E-01 0.1235E-01-0.3940E-01 0.2615E+00-0.1203E-03 0.5929E-04 0.3747E-04
500.00     0.00-0.1777E-01 0.6691E-01 0.5615E-01-0.2852E-02 0.2373E+00-0.8089E-04 0.9553E-04 0.7310E-04
500.00L    0.00-0.1771E-01 0.1063E-02-0.2213E-03-0.2852E-02 0.2373E+00-0.2344E-03 0.9553E-04 0.7297E-04
500.00   155.00-0.1902E-01 0.7178E-01 0.6372E-01-0.4228E-02 0.2430E+00-0.8815E-04 0.1010E-03 0.8421E-04
500.00L 155.00-0.1902E-01 0.1185E-02 0.2294E-03-0.4228E-02 0.2430E+00-0.2539E-03 0.1010E-03 0.8421E-04
```

Table-5.12: Comparison of Strains With IIT-PAVE :

S. No	Allowable Strains			IIT-PAVE Results		
	Tensile Strain below BT layer (E_t)	Tensile Strain below CTB lyer (E_t)	Vertical Compressive (E_v)	Tensile Strain below BT layer (E_t)	Tensile Strain below CTB (E_t)	Vertical Compressive Strain (E_v)
1	170	69.91	357	164.6	59.29	253.9

Note: Bituminous mixes are carried out based on MS-2 and MoRT&H Clause 505.3.2 provisions, it was assumed 3.5% air voids and 11.5% binder content by volume of the mix for DBM, and the crust thickness were worked out using eq 3.4 as given in IRC:37-2018.

However, contractor/concessionaire shall carry out the actual mix design of DBM with proposed aggregates and binder to get the best properties. Properties such as air voids and optimum binder content thus arrived shall be used for determining the actual pavement Composition. Hence, the crust composition given above is for indicative purpose only.

5.12 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 cemented base, cemented sub base and Aggregate Inter-Layer is adopted for flexible pavement.

Table-5.13: Recommended Pavement Composition (BT, Crack Relief Interlayer of Aggregate, CTB & CTSB)

Section	Eff. CBR (%)	MSA for 20 yrs design life	Bitumen Grade	Crust Composition (mm)					
				BC	DBM	AIL	CTB	CTSB	Total
Km. 528.935 at Moita	10	60	VG-40	40	60	100	100	200	**500**

5.13 Preliminary Design of Rigid Pavement

Rigid pavement has been designed in accordance with IRC:58-2015. The area of toll plaza including the flared portion shall be provided with concrete pavement. Rigid pavement for entire project corridor including toll plaza is considered as second alternative in accordance with IRC:58-2015.

(a) Design Life and Traffic parameters:

30 years design period has been considered. The cumulative number of commercial vehicles over 30 years design life is estimated and considered as design traffic. The design Tyre pressure has been taken as 0.80 Mpa cemented base and 0.56 MPa for granular layers.

(b) Wheel Base Characteristics

Axles with spacing of less than 4.5m (transverse joint spacing) are considered for estimation of top-down cracking damage analysis. The percentage of axles with less than 4.5m wheel base is estimated from the axle load survey.

(c) Temperature Differential:

According to Table-1 of IRC:58-2015, the temperature differential is a function of geographical location of the project road and the temperature differential to be adopted for the project area (Goa) is given below:

Table-5.14: Temperature Differential

Concrete Thickness	150 mm	200 mm	250 mm	300 mm – 400 mm
Temperature Differential (^{0}C)	14.6	15.8	16.2	17.0

(d) Modulus of Subgrade reaction:

Dry Lean Concrete (DLC) sub base is generally recommended for a modern concrete pavement, particularly those with high intensity of traffic.

- CBR of the subgrade soil is considered 10 % and k-value becomes 54.53 Mpa/m.
- 150 mm DLC layer is provided as sub-base.
- Effective k-value, after providing DLC layer is 298.47 MPa/m

e) Concrete Strength

The 90 days flexural strength for the pavement quality concrete (PQC) has been taken as 4.95 Mpa for the purpose of design.

(f) Modulus of Elasticity, Poisson's Ratio & Coefficient of Thermal Expansion

The modulus of elasticity (E) and Poisson's Ratio (μ) of the cement concrete vary with concrete materials and strength. The elastic modulus increases with increase in strength, and Poisson's ratio decreases with increase in the modulus of elasticity. The coefficient of thermal expansion of concrete (α) is dependent to a great extent on the type of aggregates used in concrete.

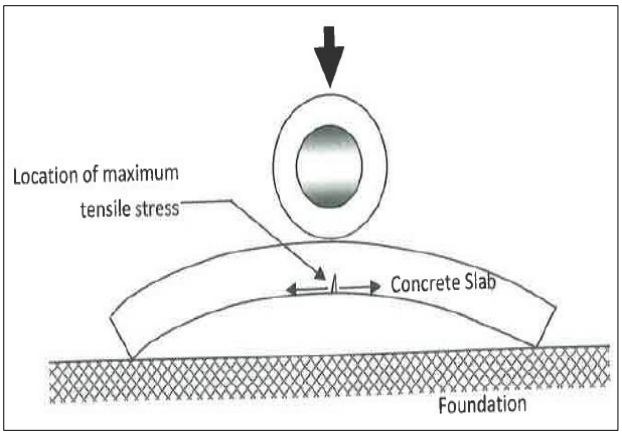
The values of the various parameters adopted are:

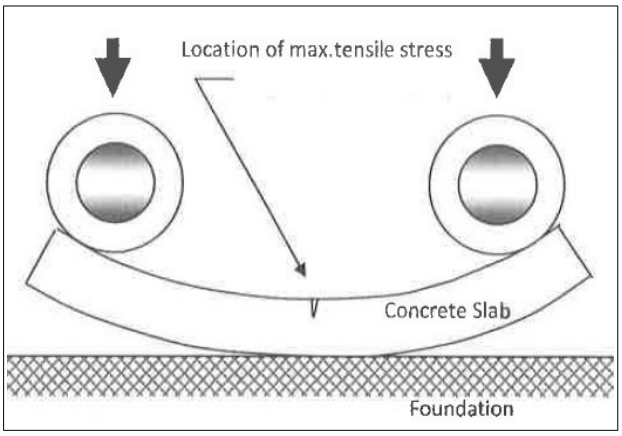
Modulus of Elasticity (E)	=	30,000 MPa
Poisson's Ratio (μ)	=	0.15
Coefficient of thermal expansion (α)	=	10 x 10^{-6}/ °C

g) Design of slab thickness

The flexural stress due to the combined action of traffic loads and temperature differential between the top and bottom fibers of the concrete slab is considered for design of pavement thickness. Positive temperature during day time will create bottom-up cracking and negative temperature during night will create top-down cracking in concrete slab. Hence analysis has been done for these two cases. For bottom-up cracking case, the combination of load and positive non-linear temperature differential has been considered where as for top-down cracking analysis, the combination of load and negative linear temperature differential has been taken.

For a trial slab thickness and other design parameters, the pavement will be checked for cumulative bottom-up and top-down fatigue damage. Cumulative fatigue damage (CFD) for bottom-up cracking is significant only during 10 AM to 4 PM because of higher stresses, hence the day traffic during the six hour (10 AM to 4 PM) is considered for bottom-up cracking analysis. Where as CFD for top-down cracking is significant only during 12 AM to 6 AM, hence the six hour night time traffic (12 AM to 6 AM) is considered for top-down cracking analysis.





(h) Design Thickness

Following Rigid Pavement design elements are proposed for the project road and details are provided in Annexures of Pavement Design Report.

Table-5.15: Rigid Pavement Composition

S.No	Item	Crust Composition Details
1	PQC of M40 grade (mm)	300
2	DLC of M10 grade (mm)	150
3	GSB (mm)	150
4	Dia. of Dowel bar (mm)	34
5	Length of Dowel bar (mm)	450
6	Spacing of Dowel bar (mm)	300
7	Dia. of Plain tie bar (mm)	12
8	Length of Plain tie bar (mm)	580
9	Spacing of Plain bar (mm)	370
10	Dia. of Deformed bar (mm)	12
11	Length of Deformed bar (mm)	640
12	Spacing of Deformed bar (mm)	595

5.14 Design of Shoulders

Earthen Shoulder: Earthen shoulder shall be covered with 150 mm thick layer of granular material confirming to the requirements given in Clause 401.2.1 of MoRT&H specifications.

5.15 CYCLE COST ANALYSIS

Life Cycle Cost Analysis has been conducted during the project development stage. The levels of detail in the analysis are consistent with the level of investment. Basically, the process involves following steps:

- Develop rehabilitation and maintenance strategies for the analysis period.
- Establish the agency costs for construction, rehabilitation & maintenance strategies.
- Estimating the agency costs for construction, rehabilitation, and maintenance
- Estimate user and non-user costs
- Develop expenditure streams
- Compute the Net present value (NPV)

The primary purpose of LCCA is to quantify the long-term economic implications of initial pavement decisions. Various rehabilitation and maintenance strategies can be employed over the analysis period. The next step is to obtain estimates of expected lives for the various rehabilitation and maintenance strategies. Agency costs include all costs incurred directly by the agency over the life of the project. The costs typically include expenditures for preliminary engineering, contract administration, construction, including construction supervision, and all future maintenance (routine and periodic), resurfacing and rehabilitation.

These are generally developed for each pavement design strategy to visualize the extent and timing of expenditures. LCCA is a form of economic analysis used to evaluate the cost efficiency of various investment options. Once all costs and their timings have been established, the future costs must be discounted to the base year and added to the initial cost to determine net present value (NPV). NPV is calculated as follows.

Inputs For The Life Cycle Cost Analysis:

$NPV_O = (B_O - C_O) + [(B_1 - C_1)/(1+i)^1] + [(B_2 - C_2)/(1+i)^2] + \ldots\ldots\ldots\ldots + [(B_t - C_t)/(1+i)^n]$

Where,

NPV_O = Net Present Value in the year 0.

B_t = Value of benefits which occur in the year 1.

C_t = Value of costs which occur in the year 1.

I = Discount rate per annum in decimals.

N = Number of years taken for analysis.

5.15.1 METHODOLOGY

Life Cycle Cost (LCC) has been carried out with the following options, for the sections as mentioned below.

- Flexible Pavement Option (Alternate-1)
- Rigid Pavement Option (Alternate-2)

In the Life Cycle Cost Analysis, the present values of all the costs for each of the alternative have been computed. The alternative giving the lowest present value of the costs is to be considered as the most advantageous option from economic perspective.

Net Present value has been computed for Flexible as well as Rigid Pavement option. The Net Present values of both options are given in Table-25.

The options for Life cycle cost analysis are,

Option A : Flexible pavement with Cement Treated base and cement treated sub base

Option B : Rigid pavement

Routine maintenance for Flexible and Rigid pavements have been considered from the MORT&H guidelines 1997 prices, cost for the year 2021 has been computed with an escalation of 5.0% (whole sale index price). It is calculated based on the Guidelines given in 'Report of the Committee on Norms for Maintenance of Roads in India, MORT&H, published by IRC, 2001.The ordinary repair costs and periodic renewal costs for the configurations with flexible and rigid pavement options are given in Tables below.

Table-5.16: Costs for Ordinary Repairs

S. No	Item	1997 Prices (in Rs)		2025 Prices (in Rs)	
		Flexible Pavement	Rigid Pavement	Flexible Pavement	Rigid Pavement
1	Ordinary Repairs	223201	299158	874977	1172739

Table-5.17: Periodic renewal costs-Flexible Pavement (at every 5th year)

Flexible Pavement Overlay (Functional) - at every 5th year							
Layer	Thickness (mm)	Thickness (m)	Width (m)	Total Length (m)	Quntity (cum)	Rates (INR)	Cost(INR)
BC	40	0.04	20	2270	1816	14417.53	26182234.48
Total(INR)							**26182234.48**

Table-5.18: Periodic renewal costs-Flexible Pavement (at every 10th year)

Flexible Pavement Overlay (Structural) - at every 10th year							
Layer	Thickness (mm)	Thickness (m)	Width (m)	Total Length (m)	Quntity (cum)	Rates (INR)	Cost(INR)
BC	40	0.04	20	2270	1816	14417.53	26182234.48
DBM	60	0.06	20	2270	2270	12228.96	33311687.04
Total(INR)							**59493921.52**

Table-5.19: Periodic renewal costs-Rigid Pavement (at every 10th year)

Replacement of Cracked Slabs 20% of Length of the project- at every 10th year							
Layer	Thickness (mm)	Thickness (m)	Width (m)	Total Length (m)	Quntity (cum)	Rates (INR)	Cost(INR)
PQC	300	0.3	20	454	2724	9783.86	26651234.64
Total(INR)							**26651234.64**

Table-5.20: Total Cost per year

S.No	Item	2024 Prices (in Rs)		2031 Prices (in Rs)		2036 Prices (in Rs)	
		Flexible Pavement	Rigid Pavement	Flexible Pavement	Rigid Pavement	Flexible Pavement	Rigid Pavement
1	Initial cost	168152641	219232525	-	-	-	-
2	Ordinary Repairs	-	-	2794779	3745866	3566925	-
3	Periodical Renewals	-	-	36841033	-	106842535	47861788

In the Life Cycle Cost Analysis, the present values of all the costs for each of the alternatives have been computed. Net Present value per Km has been computed for Flexible as well as Rigid Pavement option. Net Present Values for Flexible and Rigid Pavement are given in Table-5.21.

Table-5.21: Net Present Values

Location	Flexible pavement (BT+AIL+CTB+CTSB) (in. Cr)	Rigid Pavement(in. Cr)
Km 527.425 to Km 529.560	10.25	10.62

Recommended option: Rigid pavement is proposed since the adjoing stretch has already been constructed with rigid pavement, ensuring continuity and uniform pavement performance.

5.16 PAVEMENT COMPOSITION FOR SERVICE/SLIP ROAD

As per *MoRTH Circular RW/NH-33044/33/2025-S&R(P&B) dated on 3rd Nov 2025,* In high rainfall areas (annual rainfall >1500mm, or stretches prone to water logging) or where main carriage way is rigid pavement, service road and slip road preferably be of rigid pavement.

Service/slip road pavement composition is designed for traffic loading. The crust composition and thickness of component layers as worked out and given below in Table-5.22.

Table-5.22: Pavement Composition for Service/slip Roads

S.No	Item	Crust Composition Details
1	PQC of M40 grade (mm)	300
2	DLC of M10 grade (mm)	150
3	GSB (mm)	150
4	Dia. of Dowel bar (mm)	34
5	Length of Dowel bar (mm)	450
6	Spacing of Dowel bar (mm)	300
7	Dia. of Plain tie bar (mm)	12
8	Length of Plain tie bar (mm)	580
9	Spacing of Plain bar (mm)	370
10	Dia. of Deformed bar (mm)	12
11	Length of Deformed bar (mm)	640
12	Spacing of Deformed bar (mm)	595

CHAPTER 06. OBSERVATIONS OF THE INSPECTION

6.1 Introduction

A road safety inspection was carried out to comprehensively assess the existing deficiencies along the project highway through detailed visual inspection.

6.2 Existing Road Condition

Existing Road is having 4 Lane with Paved Shoulder in the instant stretch. The existing road in the project stretch comprises a four-lane carriageway with paved shoulders. The main carriageway is constructed with rigid pavement.



Figure-6.1: Image showing the existing lane configuration & Type of pavement at Moita

6.3 Observations:

- The traffic volume is significantly high (59,568 PCU) in the stretch.
- The project stretch is provided with rigid pavement throughout its length; however, it was observed that flexible pavement exists at the junction location. During the rainy season, potholes develop in the flexible pavement portion at the junction, causing unsafe driving conditions. These potholes increase the risk of skidding, sudden braking, and loss of vehicle control, particularly for high-speed and heavy vehicles.

- Frequent cattle crossings were observed at this location. Due to uninterrupted high-speed traffic flow, pedestrians and cattle face considerable difficulty in safely crossing the carriageway, leading to unsafe and vulnerable conditions.
- The width of the median is observed to be **4.0 m**; There is no median plantation provided along the project stretch. The absence of median plantation reduces glare protection from opposing traffic, particularly during night-time, and does not provide visual guidance to drivers.



- A village road is observed connecting to the main carriageway; however, no proper acceleration and deceleration lanes are provided. The absence of these lanes results in unsafe entry and exit movements between the internal road and the main carriageway, increasing the risk of side-impact and rear-end collisions, especially under high-speed traffic conditions.



- Two median openings are observed at Km 527.860 and Km 529.350, provided for U-turn movements.



- Cattle crossing activity is observed at Moita village, causing obstruction to through traffic on the main carriageway. During interaction with local residents, it was informed that agricultural land and dense vegetation abut both sides of the highway, resulting in frequent animal movement across the road. Owing to the high traffic volume and operating speeds on the highway, cattle face considerable difficulty in safely crossing

the carriageway, thereby creating unsafe conditions for both animals and vehicular traffic.





- Rumble strips observed at the median opening to minimize the speed of the vehicle.



- The land use along the project stretch predominantly consists of agricultural fields with scattered built-up areas. This land-use pattern generates frequent pedestrian, local traffic, and cattle movement across and along the highway for access to agricultural lands and habitations.



- There is no footpath observed on either side on the road, Pedestrian are facing difficulty in walking along the stretch on paved/earthen shoulders.
- Pavement markings, highway lighting and sign boards at few locations are observed.


LEADERS

FEW PHOTOGRAPHS OF THE INSTANT STRETCH:













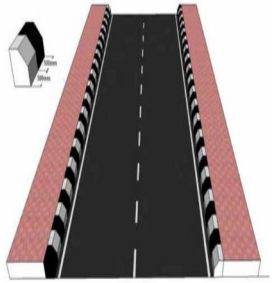
CHAPTER 7. OBSERVATIONS AND RECOMMENDATIONS

Table 7.1 – Safety Observations

Safety Consultant Team	Aarvee Engineering Consultants Limited Mr. P.V. Ratna Kumar Mr. LVSS Kumar Mr. K Suneel
Date of Visit	21/08/2024

Sl. No.	Safety concern & Audit findings		Recommendations	Priority	Client response
	Descriptions with images	**Risk**	**Descriptions (with figures if any)**		
1	**Intersections**				
	Cross roads are directly merging with the main carriageway, resulting in uncontrolled entry and exit movements. 	High	Cross roads shall be connected to the service road instead of directly merging with the main carriageway, to regulate traffic movements and reduce conflict points.	High	

Sl. No.	Safety concern & Audit findings		Recommendations	Priority	Client response
	Descriptions with images	Risk	Descriptions (with figures if any)		
2	**Roadside Hazards**				
	Cross-road traffic approaching from the village has inadequate sight distance due to the presence of vegetation, resulting in poor visibility of the main carriageway.	High	Vegetation obstructing the sight lines shall be cleared immediately to improve visibility.	High	
3	**Drainage**				
	Drainage on rigid pavement is well maintained. However, there is a patch of flexible pavement at the moita junction where rain water observed to be logged and not properly drained.	High	Vehicular underpass with Slip road is proposed as a long term measure which eventually eliminates the water logging. However, as a short term measure, the Existing BT shall be laid with overlay by providing camber.	High	
4	**Signs, pavement markings and delineation**				
	Junction sign boards and Cattle crossing sign boards are not observed.	High	Sign boards indicating the junction, cattle crossing and village name shall be installed.	High	
	Sign boards shall be maintained properly.	High	Sign boards shall be maintained properly.	High	

Sl. No.	Safety concern & Audit findings		Recommendations	Priority	Client response
	Descriptions with images	**Risk**	**Descriptions (with figures if any)**		
	 Faded Kerb Painting on the median	High	Kerb stone shall be painted with vertical black and white stripes of 500 mm wide as per fig. 14.3 of IRC:35-2015 	High	
5	**Vulnerable Road Users (pedestrians, bicyclists, two wheelers and three wheelers, and animal drawn carts)**				
	The safety of bicyclists & Pedestrians shall be ensured At-grade cattle crossing on the main carriageway shall be avoided to eliminate conflicts with through traffic.	High	At present, pedestrians walking along the project stretch do not have a continuous and proper walkway. Accordingly, a footpath has been proposed and provided along the entire length of the stretch to ensure safe pedestrian movement.	High	

Sl. No.	Safety concern & Audit findings		Recommendations	Priority	Client response
	Descriptions with images	**Risk**	**Descriptions (with figures if any)**		
			Further, a cattle underpass is proposed at Km 528.935 near Moita. The said underpass shall also serve as a pedestrian crossing facility, thereby segregating pedestrian and cattle movements from the main carriageway and significantly reducing traffic conflicts and safety risks.		
6	**Lighting and night time issues**				
	The safety of road users shall be ensured at night by providing reflective sign boards, blinkers and lighting arrangements	High	The safety of road users shall be ensured at night by providing reflective sign boards, blinkers and lighting arrangements	High	
7	**General road safety considerations**				
	At few locations, gravel/sand is observed at Median shyness, on Paved shoulders and Service road which may result in skidding	High	The Main carriageway and service road shall be maintained properly and free from any gravel/sand.	High	
	There is a village road connecting the main road with no proper acceleration/deceleration lanes leading to unsafe entry and exit to internal road.	High	Slip road shall be provided between Siridao flyover and agaciam flyover for	High	

Sl. No.	Safety concern & Audit findings		Recommendations	Priority	Client response
	Descriptions with images	**Risk**	**Descriptions (with figures if any)**		
			continuity of the service road between Panjim and Margao.		
	Two median openings are observed in the stretch.	High	All existing median openings shall be closed, and U-turn movements shall be permitted only at the flyovers at Agaciam and Siridao. Local traffic shall be facilitated through the service roads to ensure controlled access and improved safety on the main carriageway.	High	

Table 7.2- CHECKLIST FOR STAGE AUDIT OF EXISTING ROADS

Issue	Yes	No	NA	Comments
1. Sight Distances				
Are all sight distances adequate for the speed of traffic using this road?	Yes			
Are safe overtaking opportunities provided?	Yes			
Are U turn provisions conspicuous and "safe"?		No		
2. Intersections				
Are all intersections clear and visible?		No		
Are all traffic signals conspicuous, functioning properly and safely?			NA	
Are roundabouts visible and recognisable from all approaches?			NA	
3. Interchanges				
Are sight lines open and free of obstruction at all merges and diverges?			NA	
Are the distances between decision-making points sufficient for safety at the operating speed?			NA	
Is the direction sign for each interchange clear and easily understood at the operating speed?			NA	
4. Cross Sections				
Are lane widths, shoulder widths and bridge widths, "safe" for the traffic volume and mix?	Yes			
Are medians and islands of adequate width for the safety of likely users?	Yes			
Are the shoulders suitable for use by all vehicles and road users, including pedestrians, cyclists and animals?	Yes			
Is appropriate super elevation and extra width of carriageway provided on curves?			NA	
5. Roadside Hazards				
Are all larger (more than 100mm diameter) sign supports located outside the clear zone if they are not frangible?		No		
Are all crash barriers correctly and safely installed?	Yes			

Are any hazards within the agreed clear zone for this road?			NA	
Are crash barriers used only where necessary?	Yes			
Are impact attenuators provided in gore area?			NA	
Are all the crash barriers correctly installed?	Yes			
6. Drainage				
Is the road well drained?	Yes			Except at the location of Flexible pavement
Are all drains outside the clear zone, covered, or behind suitable barrier?	Yes			
7. Signs, pavement markings and delineation			NA	
Do all signs and pavement markings satisfy the 6C's of good signage and pavement marking practice?	Yes			
Is the speed zone "safe", and clearly signed?	Yes			
Are road signs and road markings tested for retro-reflectivity and conforming to relevant IRC standards?	Yes			
Is the road well delineated (warning signs, plastic guide posts, chevron alignment markers) installed as necessary and spaced in accordance with installation guidelines?		No		
Is there a need for more signs to warn, inform, guide, control or delineate?	Yes			
8. Vulnerable Road Users (pedestrians, bicyclists, two wheelers and three wheelers, and animal drawn carts)				
Do all vulnerable road users have connectivity along the road, with suitable lateral clearance to motor traffic?		No		
Are pedestrians (particularly the young, old and disabled) able to safely walk along the road?		No		
Is the road free of "squeeze" points where vulnerable road users are exposed to nearby moving traffic?		No		
Are pedestrians (particularly the young, old and disabled) able to safely cross the road?		No		
Are dropped kerbs provided at all intersections and mid-block locations where pedestrians are to cross?			NA	

Is the number and placement of the pedestrian facilities adequate and safe for the situation and the pedestrian numbers?		No		
Are all the formal crossings clearly marked and conspicuous on each approach?		No		
Are the correct signs and pavement markings installed at each pedestrian facility?		No		
Is each crossing facility well illuminated at night so that pedestrians can be seen by drivers/riders?		No		
Do all mid-block traffic signals have pedestrian push buttons?		No		
Are pedestrian paths provided through medians to permit pedestrians to cross "at road level" and to assist disabled pedestrians?		No		
Has adequate provision been made for safe parking and stopping by three-wheelers/cycle rickshaws?		No		
Does the road allow adequate visibility for an approaching driver to see a pedestrian waiting to cross the road?		No		
Does the road allow adequate visibility funnel for an approaching driver to see a vehicle waiting to cross the carriageway from side road or storage space of median?		No		
Are bus stops located where passengers will use them?			NA	
Are bus stops well delineated and lit?			NA	
9. Access to Property and Developments				
Are all accesses to/from adjoining properties "safe"?			NA	
10. Lighting and Night Time Issues				
Are the illumination levels of an appropriate standard, consistent with the needs of the location, pedestrian and other factors?	Yes			
Are the lighting columns frangible? If not, are they located outside the clear zone?	Yes			

Are all signs easy to see and read at night?	Yes			
Are the critical locations (intersections, pedestrian facilities, bus bays, bus stops, truck lay bye, toll plaza, etc) conspicuous at night?	Yes			
Is lighting provided on road sections passing through built up areas, service roads, above and below the grade separator, underpass,etc	Yes			
Is the "through route" well signed, line marked and obvious to road users at night?	Yes			
Is the road free of visual deceit for road users at night?	Yes			
Is all lighting adequate and safe?	Yes			
Is there a need for more signs to warn, inform, guide, control or delineate?	Yes			
Are there any lighting poles in the median(less than 2m wide) unprotected by crash barriers?	Yes			
11. General Road Safety Considerations				
Is the road as safe as practical given the local weather conditions (sunrise, sunset, snow, fog, storms, and wind)?	Yes			
Is the road surface free of gravel and sand, and with good skid resistance?		No		

Yes = likely to be satisfactory for safety

No = there are possible safety issues

NA = not applicable

CERTIFICATION & RECOMMENDATION

1. The Audit Team conducted the Road Safety Audit of the existing highway during the months of February, March, April, and August 2024

2. A cattle underpass shall be provided at Moita to facilitate safe cattle movement across the highway, thereby ensuring uninterrupted and safe passage of through traffic.

3. In addition to the proposed grade-separated structure and their approaches, a continuous service road shall be provided between the Siridao Flyover and the Agaciam Flyover to facilitate local traffic movement and maintain continuity.

4. Road furniture shall be provided in accordance with the relevant IRC/MoRTH manuals and guidelines

5. A new drain-cum-footpath shall be constructed along the entire length of the slip road to ensure proper drainage and safe pedestrian movement

6. All median openings shall be closed, and U-turn movements shall be permitted only at the flyovers at Siridao and Agaciam.

Certified by

SENIOR SAFETY AUDITOR & TEAM LEADER

8.0 PROPOSALS

8.1 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 rectifying the Black Spot Locations in various National Highways in Goa through empanelled road safety audit consultants.

In order to fulfil the above task, **Public Works Department(NH)** has been assigned the work of Preparation of DPR for various projects proposed in Annual Plan of Goa and pedestrian count surveys in the state of Goa to M/s Aarvee Engineering Consultants Ltd.

Road Safety Consultant should keep in mind that black spot identification and treatment (Blackspot Rectification Measures) are only one among the many road safety interventions to reduce road crashes and associated fatalities and serious injuries. It has to be keep in mind that only a certain level of reduction in road crashes will be possible through black spot Rectification. The Authority may have to adopt various other interventions to achieve a sustainable reduction in road crashes in their respective jurisdiction. The other measures include road safety assessment, road safety audits and other non-engineering interventions like enforcement, road safety campaigns and post-crash care. It is desirably a comprehensive road safety action plan in line with 'Safer Road and its approach' has to be implemented which cover all aspects of road safety.

The instant project stretch from Km 527.425 to Km 529.695 forms part of NH-66 (Zuari Package-I) near Moita in North Goa District, where four-laning works have already been completed and the section has been commissioned. Within this stretch, particularly near Km 528.935, frequent movement of cattle across the carriageway has been observed. At present, the crossing is at-grade, resulting in direct interaction between cattle and high-speed highway traffic. In order to segregate animal movement from the main highway traffic and to mitigate accidents caused due to cattle crossings, it is proposed to develop

this location as a grade-separated structure. Further, construction of service roads on both sides of the highway is proposed between the end of the Siridao Flyover Junction and the Agacaim Junction. Additionally, it is proposed to close the two existing median openings along this stretch to improve access control and enhance safety.

Following provisions are considered in the estimate:

- Construction of Cattle Underpass at Km. 528.915 (1 x 7 x 3.0m).
- Construction of Service/Slip road of 7.5m(including shyness) width for a length of 4.270 km(including both sides)
- Rigid pavement is proposed for both the main carriageway and the service roads. Also Access road of 3.75m for CUP is considered from cross roads.
- Construction of Drain cum Footpath along with railing for a length of 4.270km(including both sides)
- Construction 2 Nos of Bus Shelters
- Provision of Thrie-Beam crash barrier along with Flexible median markers for a length of 4.540 km(including both sides).
- Provision of Highway lighting
- Provision of Footpath tiles above the Cover slab on drain
- Provision of Road furniture including flexible median markers, convex mirrors, Road studs, solar blinkers, road markings, sign boards etc.
- Improvement of 2 no. of Major and 4 no.of minor junctions.
- Provision Anti Carbonation paint for Structures``
- Retaining/Toe wall of length 500m is considered.
- Provision of 4 No of Rain water Harvesting pits at CUP location.
- Shifting of Utilities

8.2 Proposed Structures

8.2.1 Cattle Underpass

1 No.of Cattle Underpass has been proposed at Km. 528.915 at Moita junction.

S.No	Chainage	Span Arrangement	Location
1	Km. 528.915	1 x 7 x 3.0m	Moita

8.2.2 Cross drainage structures

Based on the information collected from reconnaissance survey and preliminary calculations, hydraulic performance of existing structures has been analyzed, and the following recommendations have been made.

Table-8.1: Recommendation of Culverts

S.No.	Existing type of culvert	No. of Culverts	Recommendation
1	Pipe Culvert	07	Retained & widening
2		12	Retained with Rehabilitation
Total		**19**	

8.3 Typical Cross sections

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

S.No	From	To	Length	TCS	Remarks
1	527.425	527.520	0.095	X	-
2	527.520	527.750	0.230	I	-
3	527.750	527.800	0.050	II	-
4	527.800	527.845	0.045	VII	-

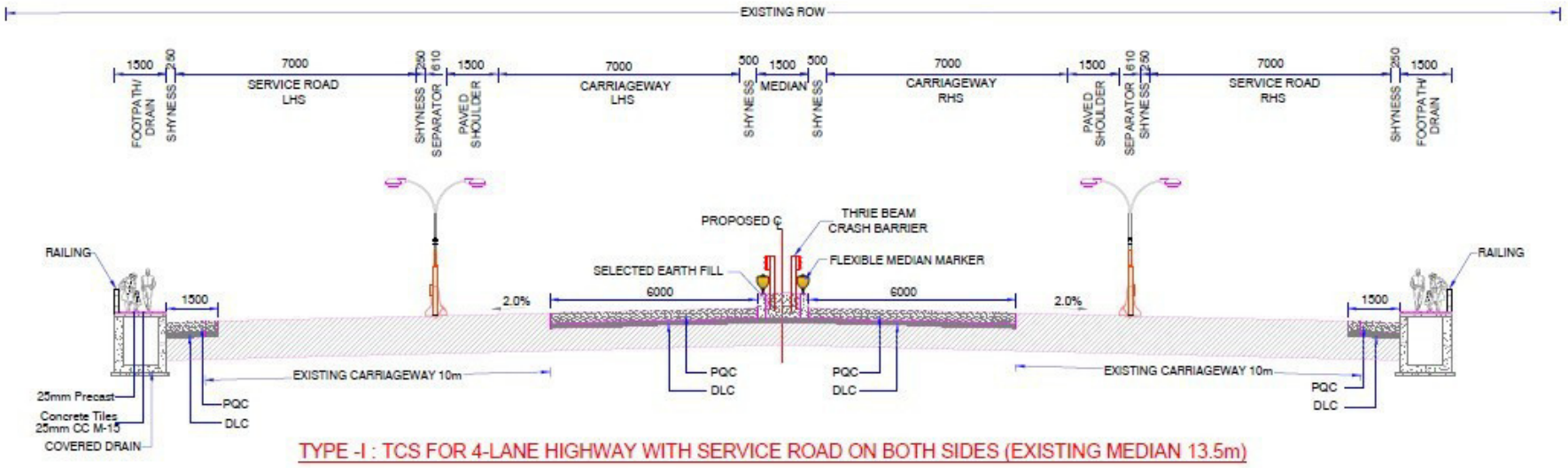
S.No	From	To	Length	TCS	Remarks
5	527.845	527.875	0.030	IX	-
6	527.875	527.920	0.045	VII	-
7	527.920	527.970	0.050	II	-
8	527.970	528.105	0.135	I	-
9	528.105	528.180	0.075	II	-
10	528.180	529.080	0.900	IV	-
11	529.080	529.200	0.120	III	CUP @ Km 528.915 Span 7 x 3.0m
12	529.200	529.560	0.360	V	-
13	529.560	529.695	0.135	VI	-
Total			**2.270**		

8.4 Service road/slip road

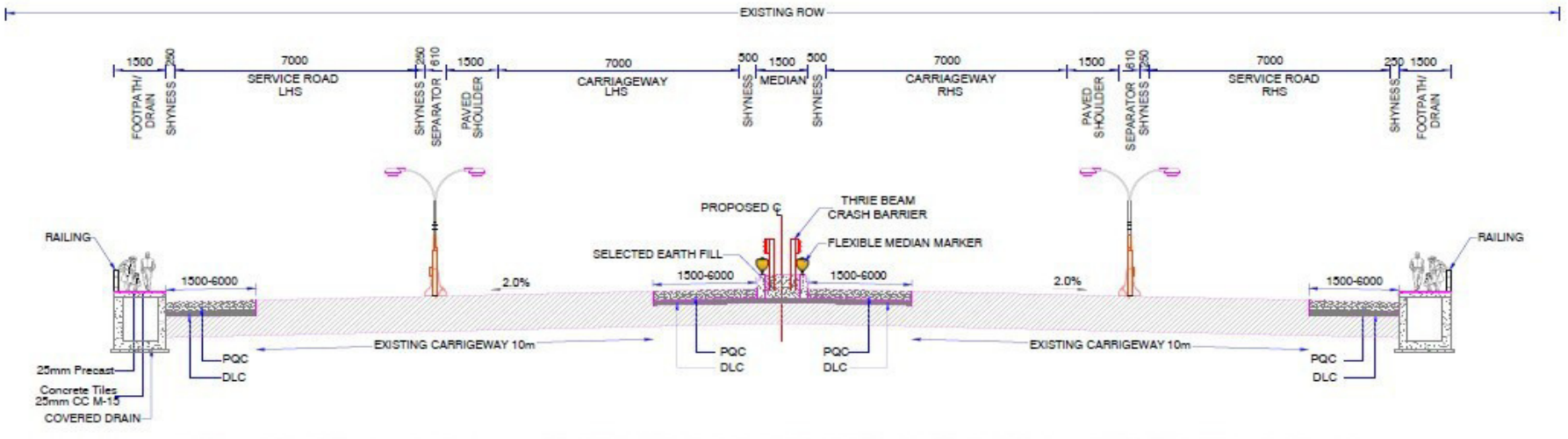
7.5m service road (including shyness) is proposed for the Local traffic.

S. No	From (km)	To (km)	Width (including shyness) (m)	LHS (km)	RHS (km)	Total (km)	Remarks
1	527.425	529.560	7.5	2.135	2.135	4.270	Widening
2	529.560	529.695	6.0 – 7.5	0.135	0.135	0.270	Existing
Total				**2.270**	**2.270**	**4.540**	

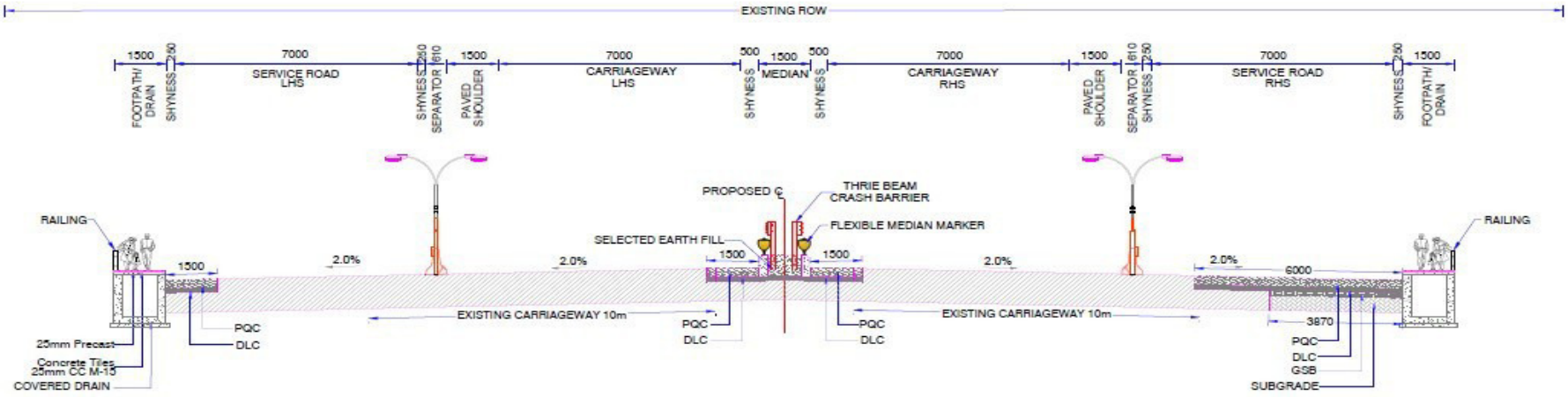
Typical Cross sections



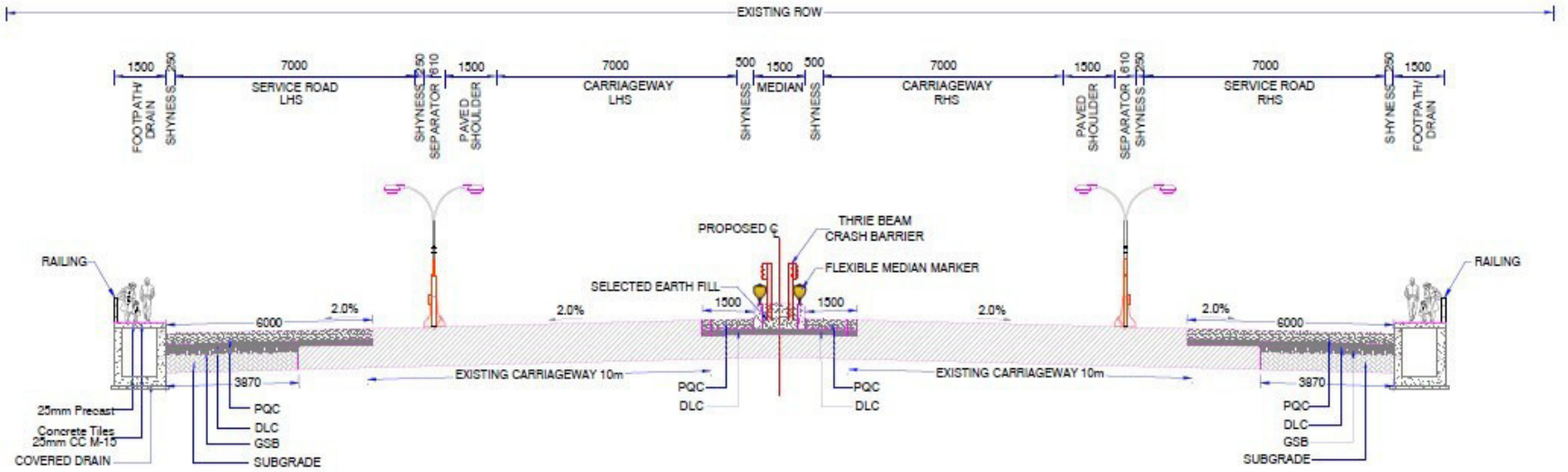
TYPE -I : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN 13.5m)



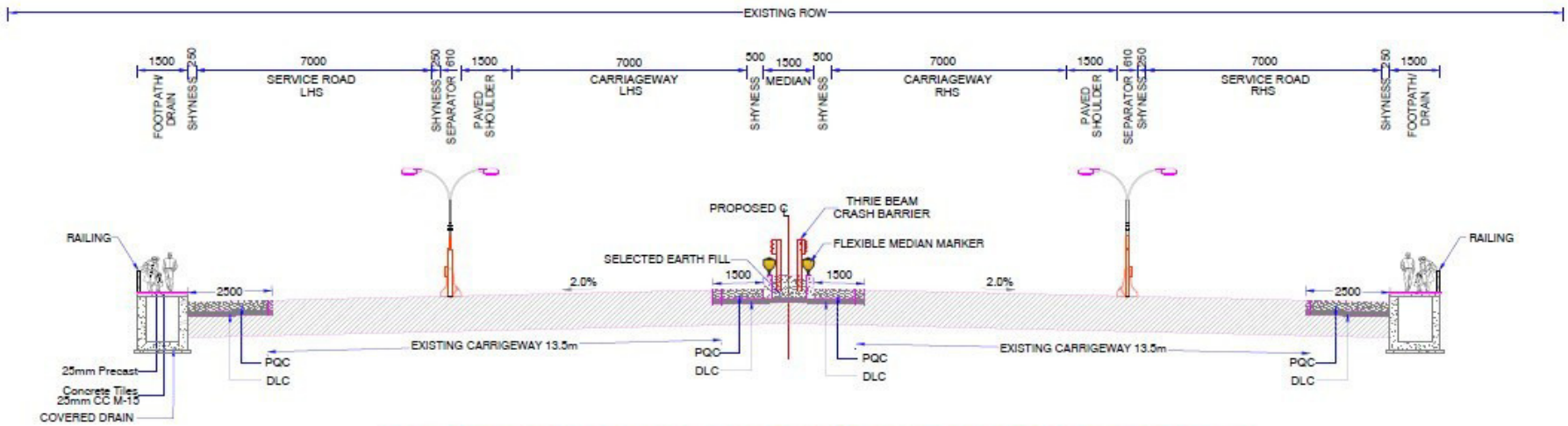
TYPE -II : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN VARIES BETWEEN 4.0mTO 13.5m)



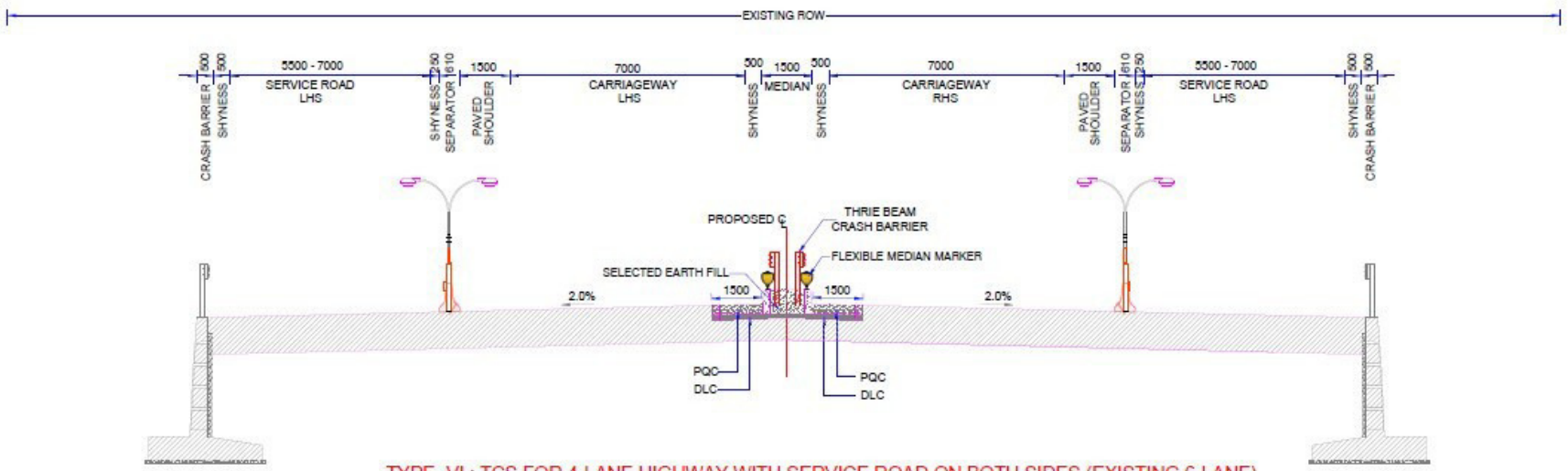
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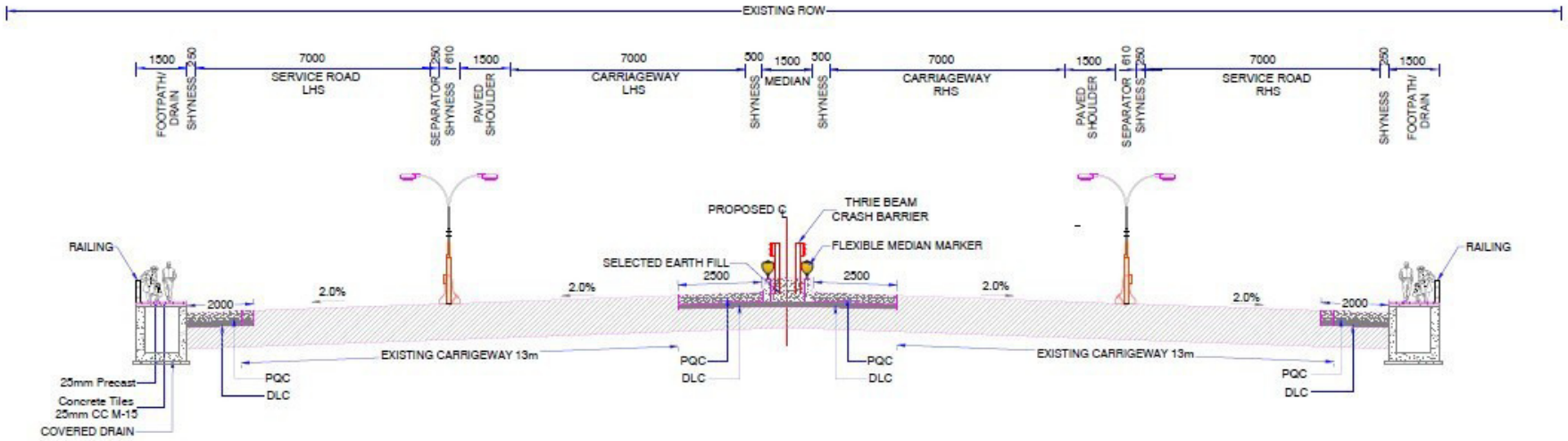
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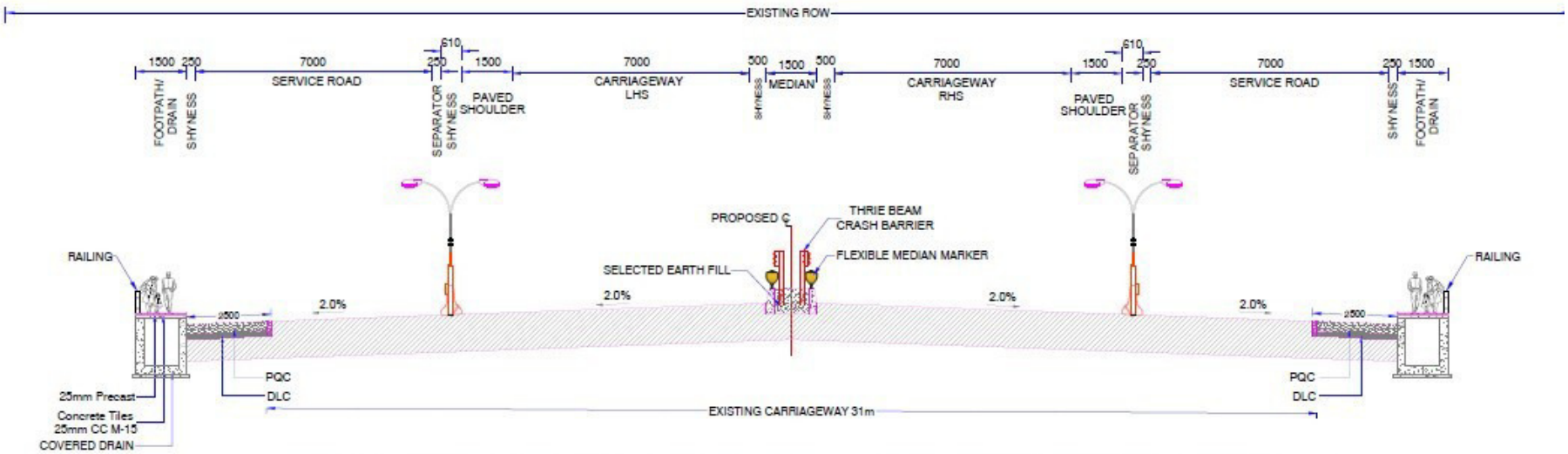
TYPE -V : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 6-LANE)



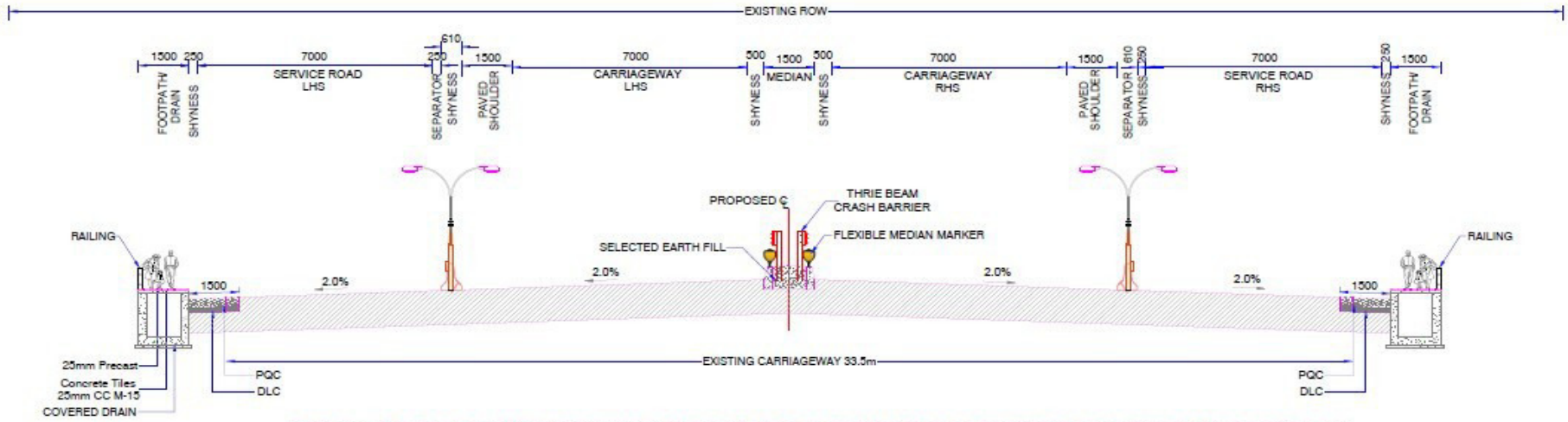
TYPE -VI : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 6-LANE)



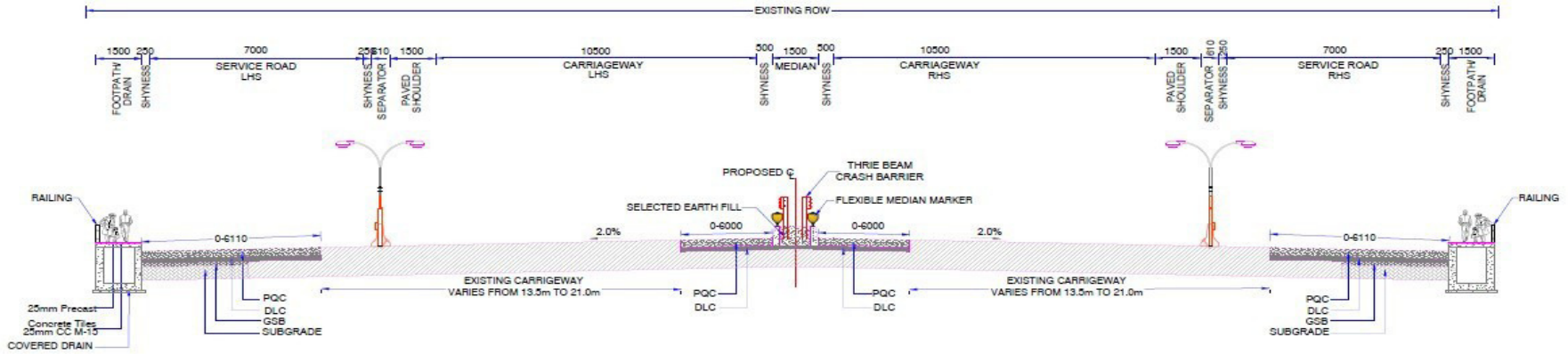
TYPE -VII : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (MEDIAN OPENING APPROACH WITH 6.5m MEDIAN)



TYPE -VIII : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN OPENING-CW 31m)



TYPE -IX : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN OPENING-CW 33.5m)

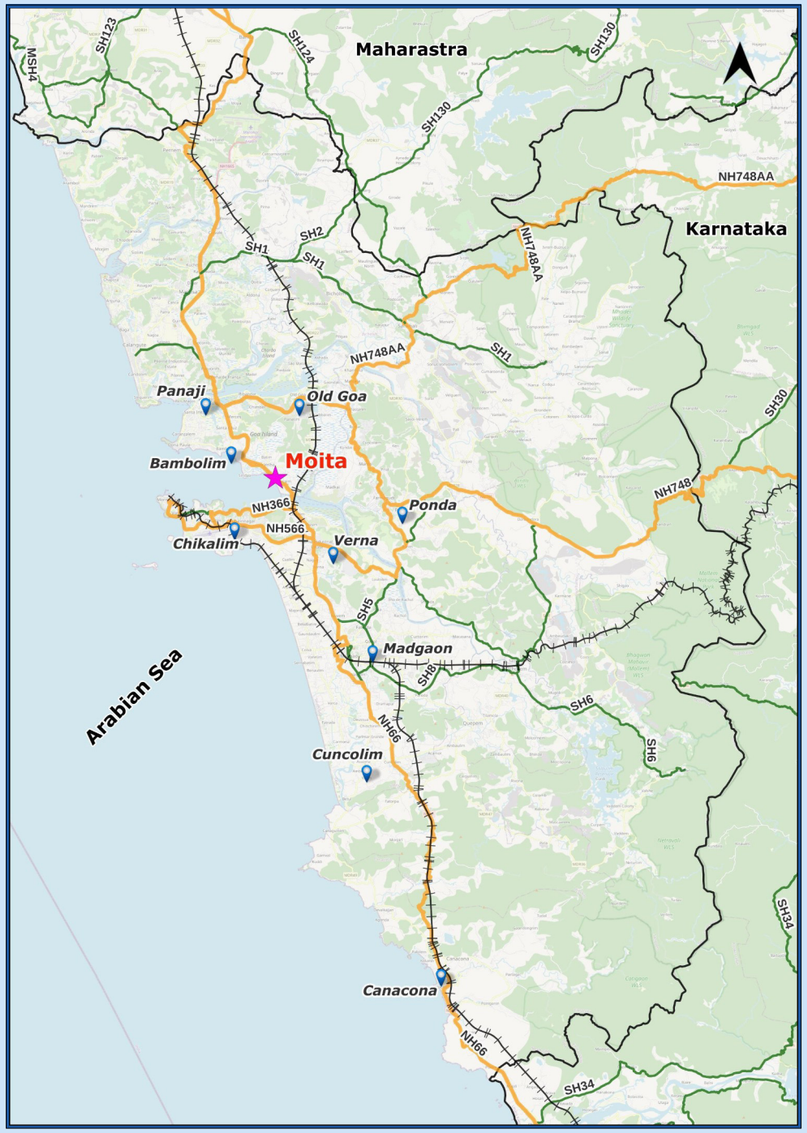


TYPE -X : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 6-LANE WITH MEDIAN VARYING FROM 1.5m to 13.5m)

GOVERNMENT OF GOA

PUBLIC WORKS DEPARTMENT (NATIONAL HIGHWAYS)

Construction of Cattle Underpass near Moita at Km. 528.915 and Construction of Service road between Km. 527.425 to Km. 529.695 on NH-66 in the state of Goa.









HIGHWAY DRAWINGS

Consultant

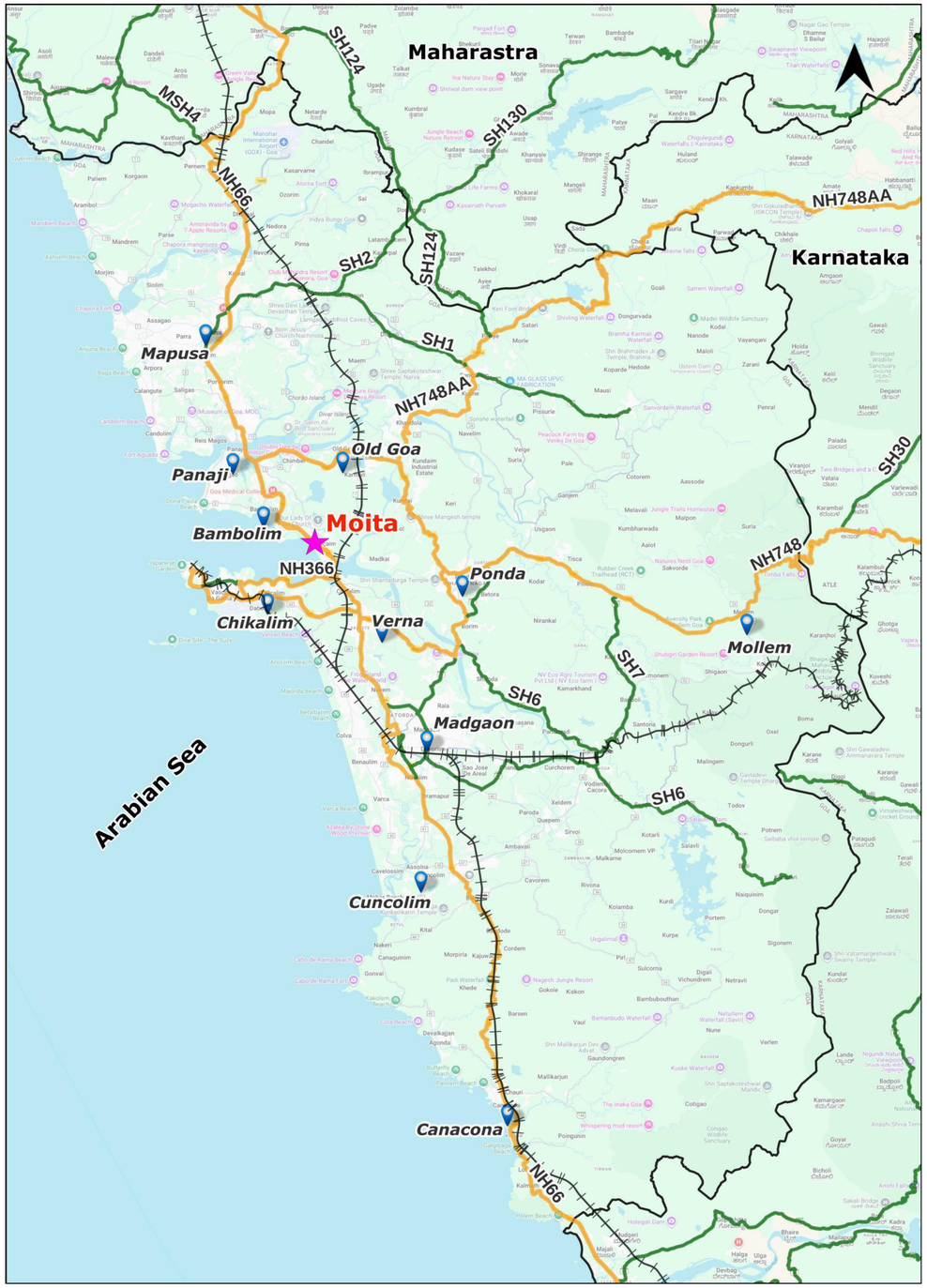
aarvee engineering consultants limited

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Tel: +91-40-4848 3456, 2373 7633; Fax: +91-40-23736277

e-mail: aarvee@aarvee.net; web: www.aarvee.com

INDEX MAP



DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

REVISION NO	DATE	DESCRIPTION	REVISED BY
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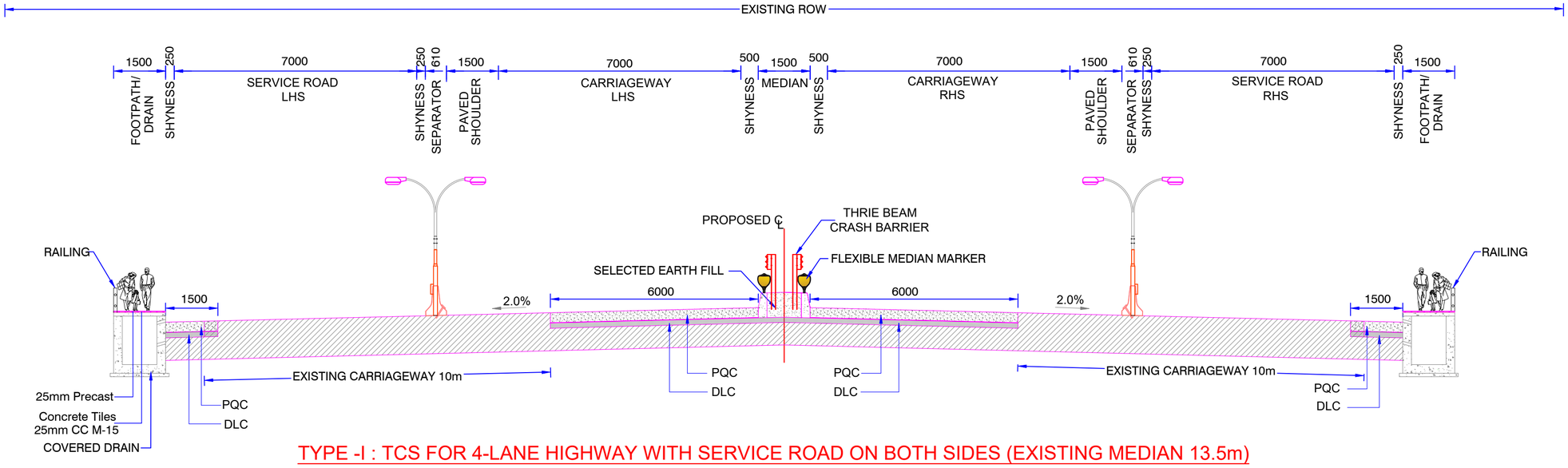
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

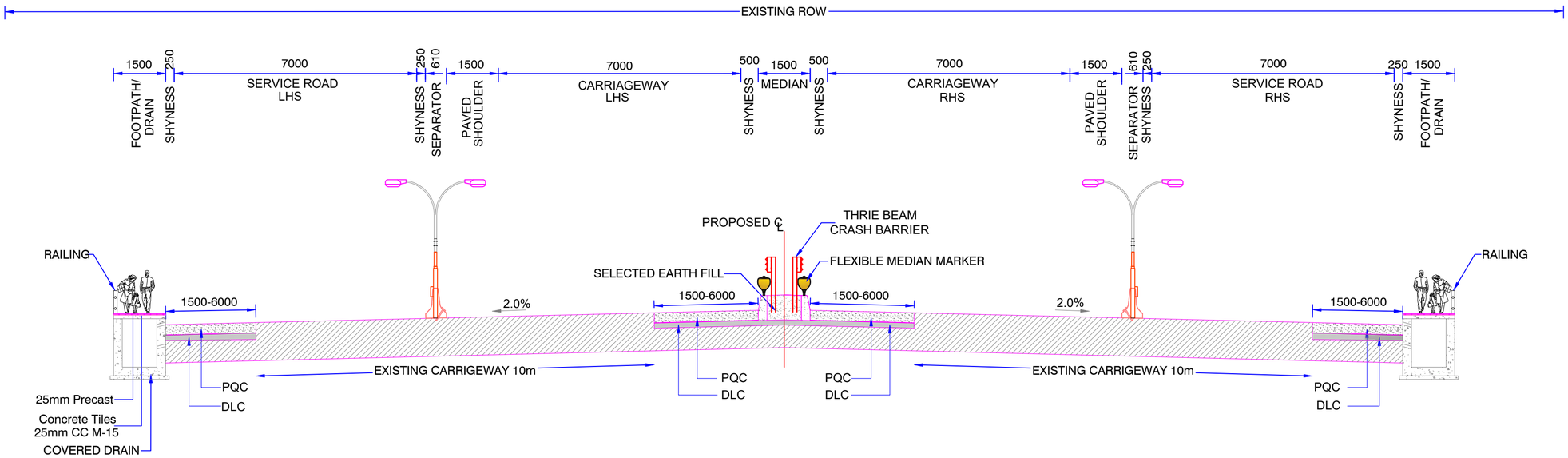
INDEX MAP

DRG. NO. NH-66 / GOA / INDEX MAP

TYPICAL CROSS SECTIONS



TYPE -I : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN 13.5m)



TYPE -II : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN VARIES BETWEEN 4.0mTO 13.5m)

NOTE :
ALL DIMENSIONS ARE IN MM

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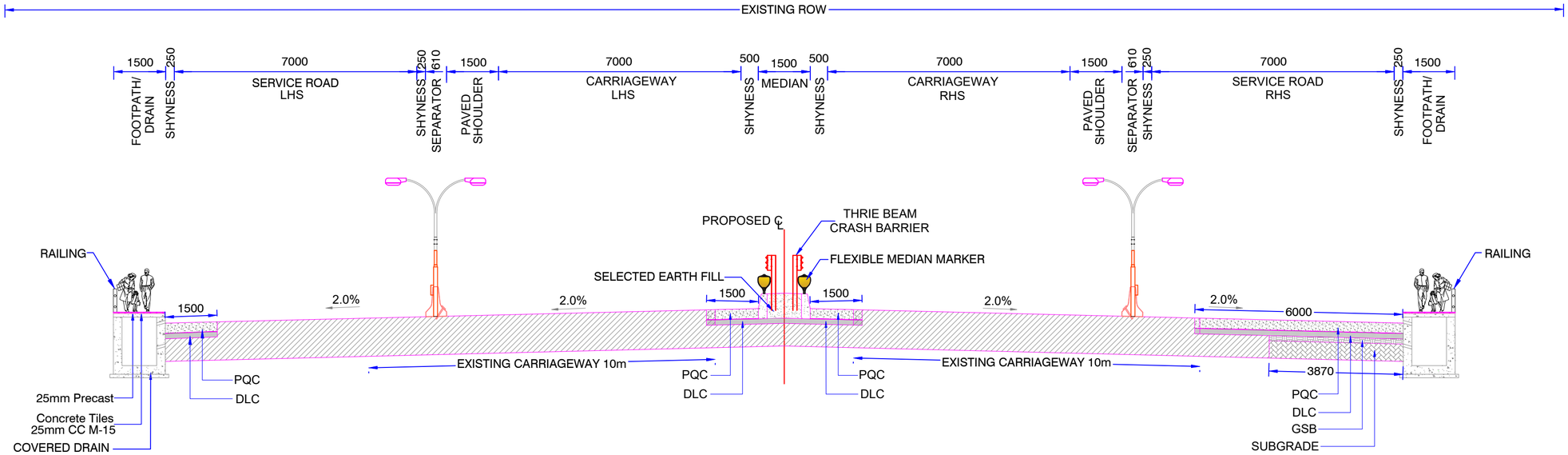
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CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

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TYPICAL CROSS SECTIONS

DRG. NO.2667 / GOA / NH-66 / TCS / 01 | R0



TYPE -III : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 4.0m MEDIAN)

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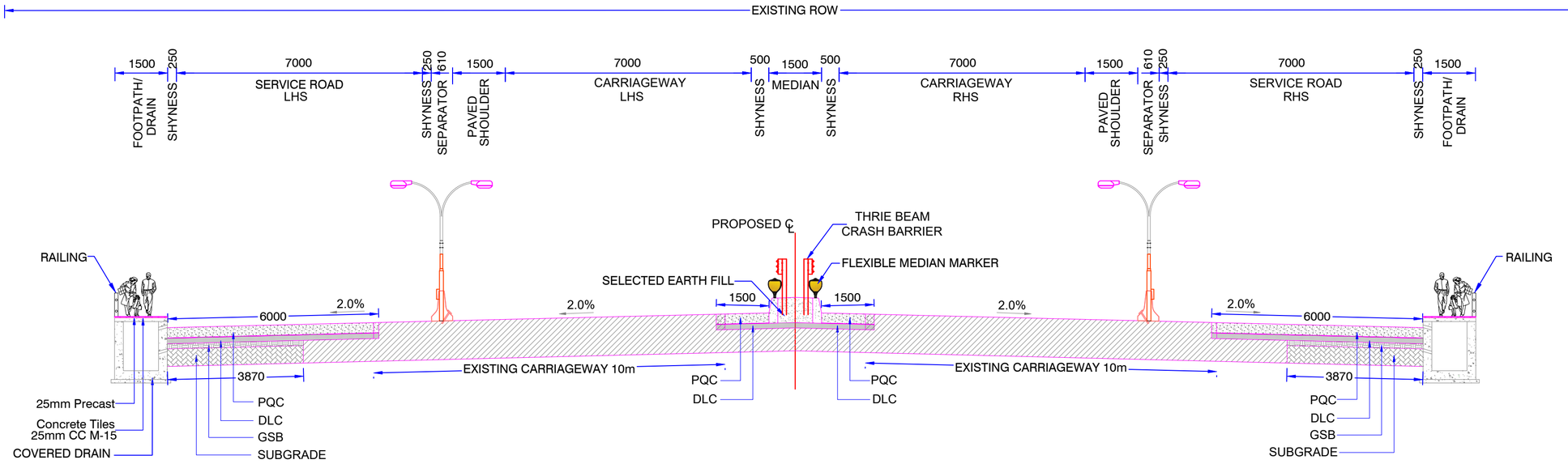
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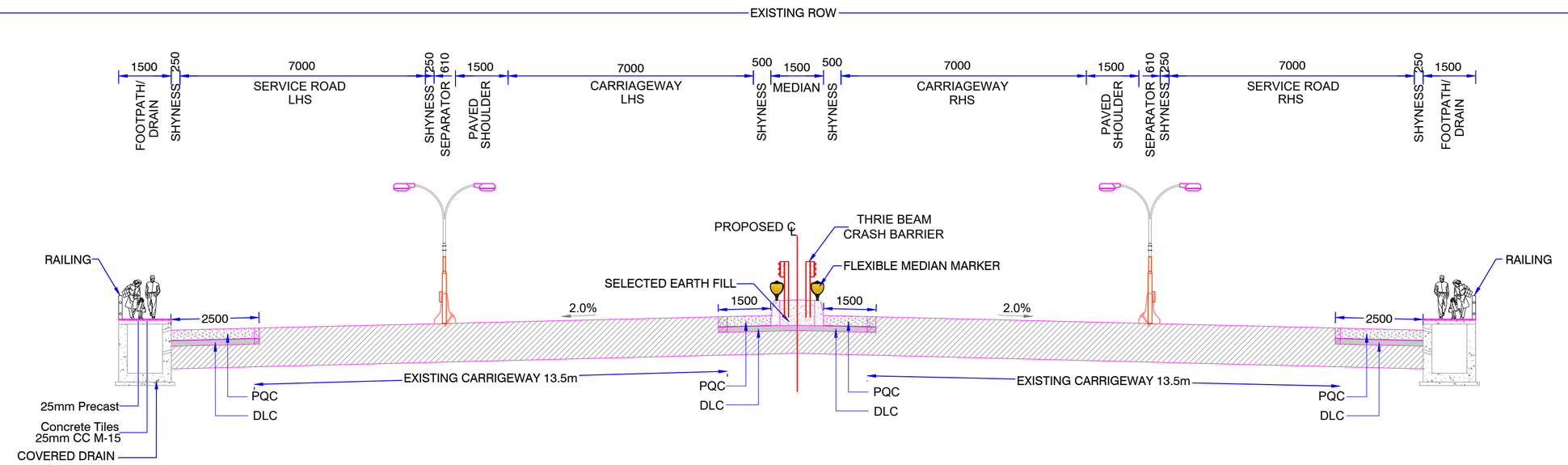
TITLE :

TYPICAL CROSS SECTIONS

DRG. NO.2667 / GOA / NH-66 / TCS / 02 | R0



TYPE -IV : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 4.0m MEDIAN)



TYPE -V : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 6-LANE)

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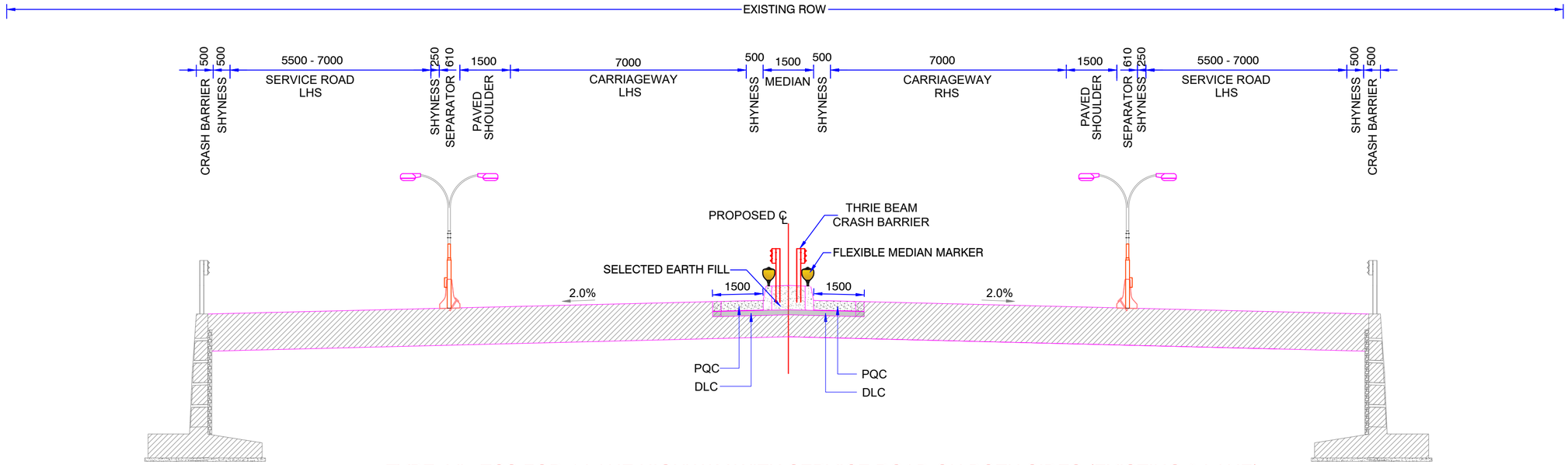
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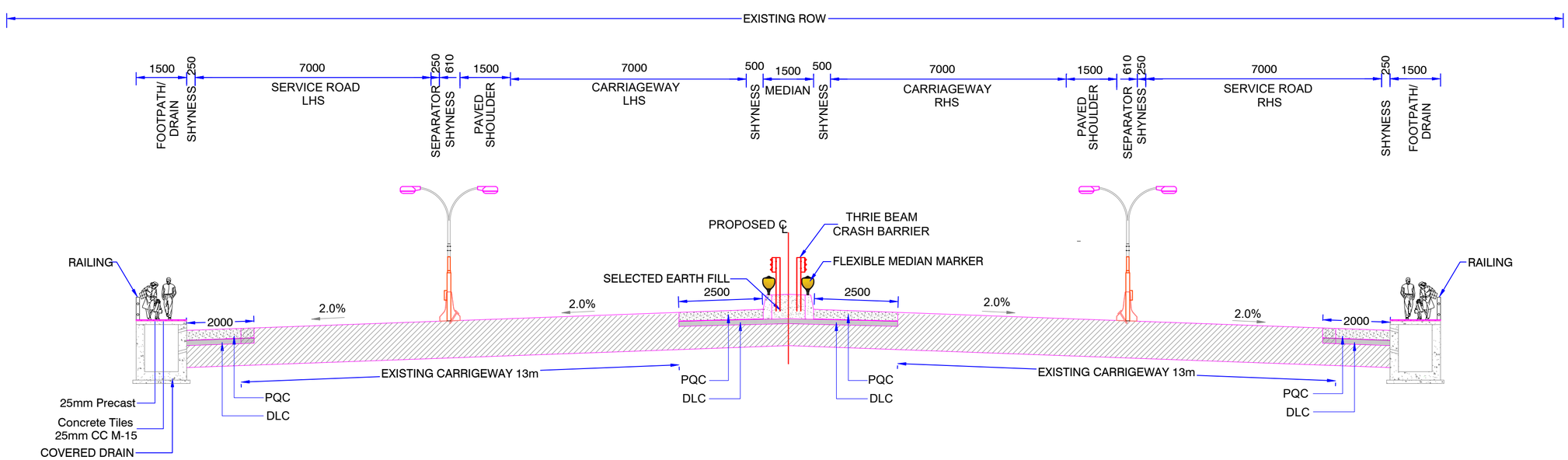
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TYPICAL CROSS SECTIONS

DRG. NO.2667 / GOA / NH-66 / TCS / 03 | R0



TYPE -VI : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 6-LANE)



TYPE -VII : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (MEDIAN OPENING APPROACH WITH 6.5m MEDIAN)

NOTE :
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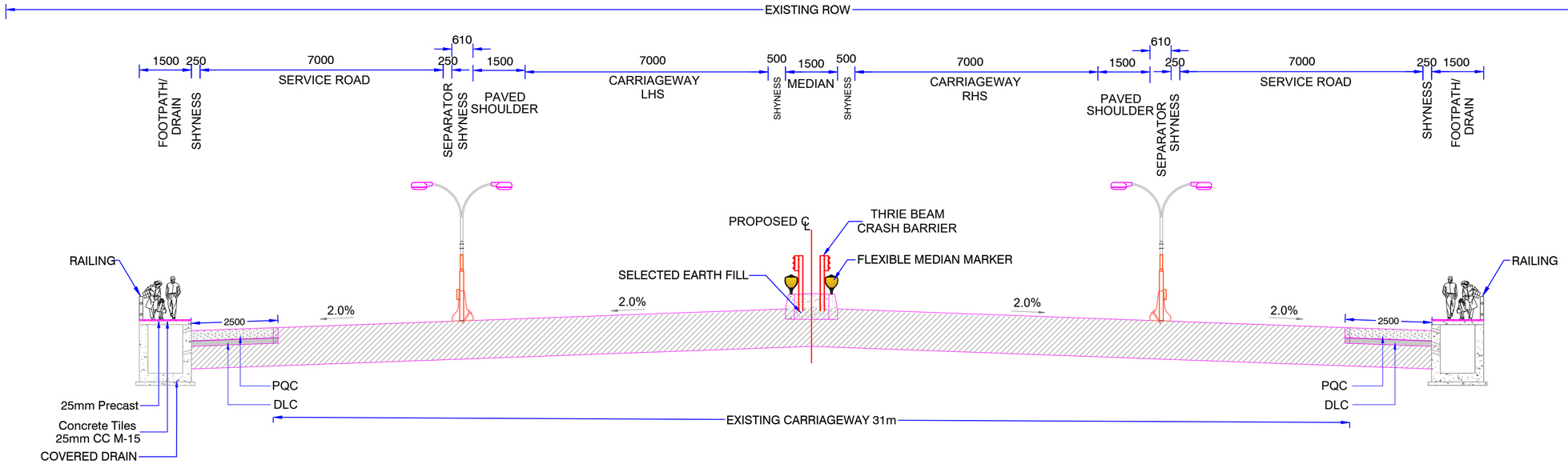
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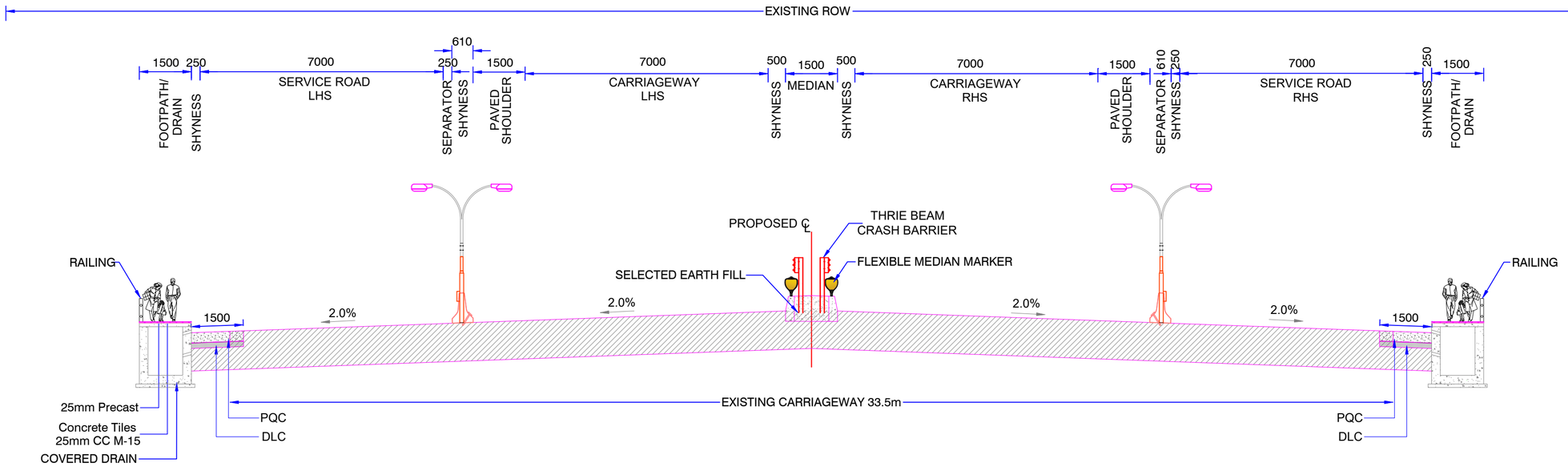
TITLE :

TYPICAL CROSS SECTIONS

DRG. NO.2667 / GOA / NH-66 / TCS / 04 | R0



TYPE -VIII : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN OPENING-CW 31m)



TYPE -IX : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING MEDIAN OPENING-CW 33.5m)

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CLIENT :

GOVERNMENT OF GOA

CONSULTANT :

Kaarvee

aarvee engineering consultants limited

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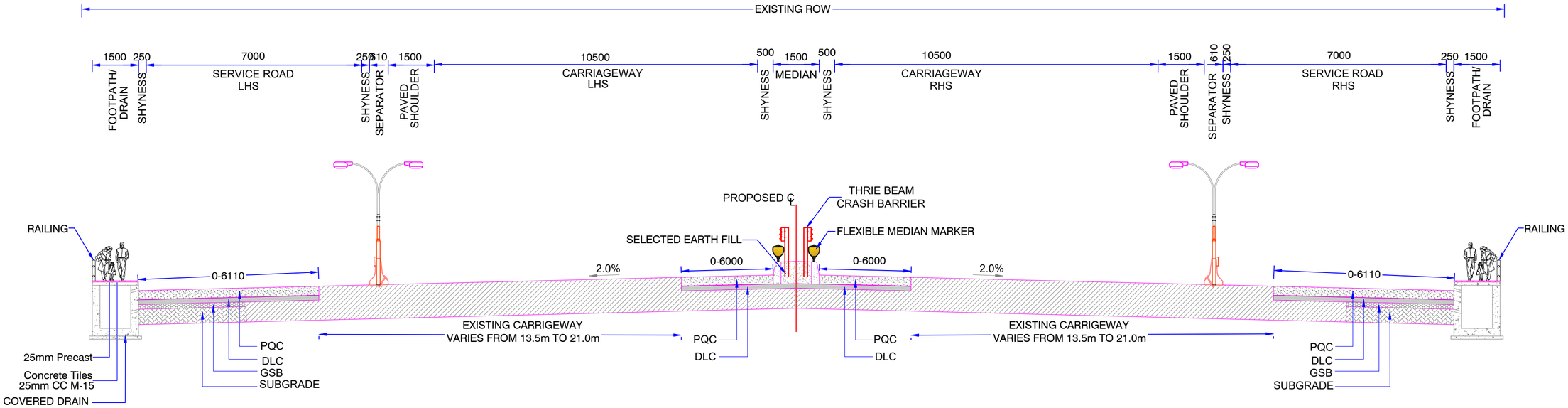
PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

TYPICAL CROSS SECTIONS

DRG. NO.2667 / GOA / NH-66 / TCS / 05 | R0



TYPE -X : TCS FOR 4-LANE HIGHWAY WITH SERVICE ROAD ON BOTH SIDES (EXISTING 6-LANE WITH MEDIAN VARYING FROM 1.5m to 13.5m)

NOTE :
ALL DIMENSIONS ARE IN MM

DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	G.KRISHNA	P.SRINIVAS RAO	APR-2026

REVISION NO.	DATE	DESCRIPTION	REVISED BY
R1	APR-2026	REVISED FEASIBILITY REPORT	-
R0	OCT-2024	INITIAL SUBMISSION	-

NOT TO SCALE

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CLIENT :

CONSULTANT :

aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

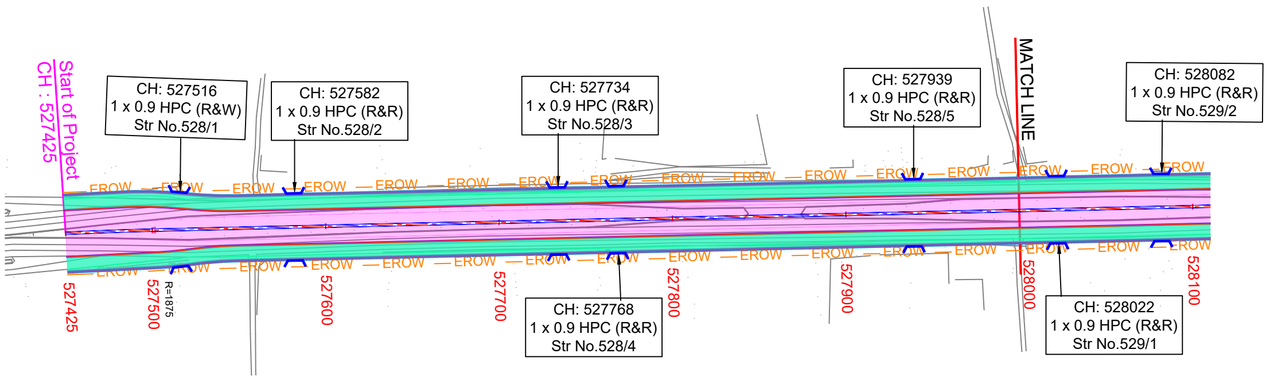
TYPICAL CROSS SECTIONS

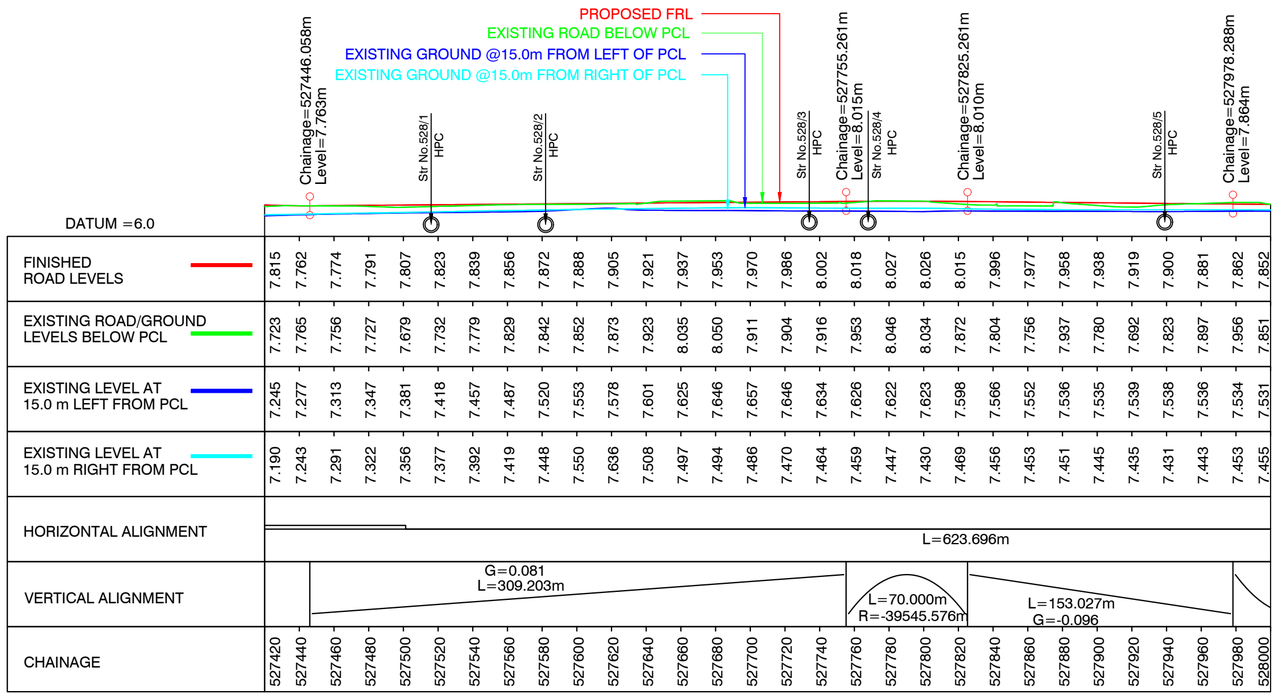
DRG. NO.2667 / GOA / NH-66 / TCS / 06 R0

PLAN & PROFILES
MAIN CARRIAGEWAY

PATRADEVI

POLLEM





DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

REVISION NO.	DATE	DESCRIPTION	REVISED BY
R2	JAN-2026	REVISED FEASIBILITY REPORT	-
R1	OCT-2024	INITIAL SUBMISSION	-

LEGEND :

- Proposed CL
- Proposed CW
- Existing ROW — EROW
- Culvert / Bridge
- MCW
- SR
- Separator
- Footpath Cum Drain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

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TITLE :

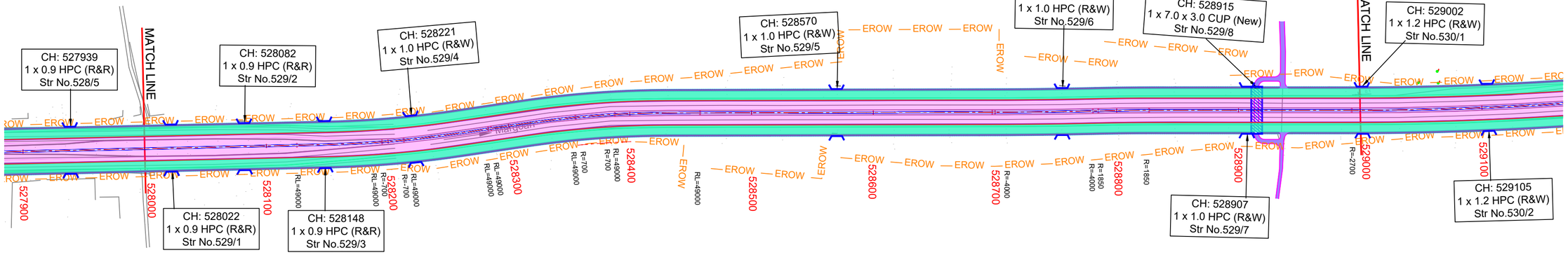
PLAN AND PROFILES OF MAIN CARRIAGEWAY

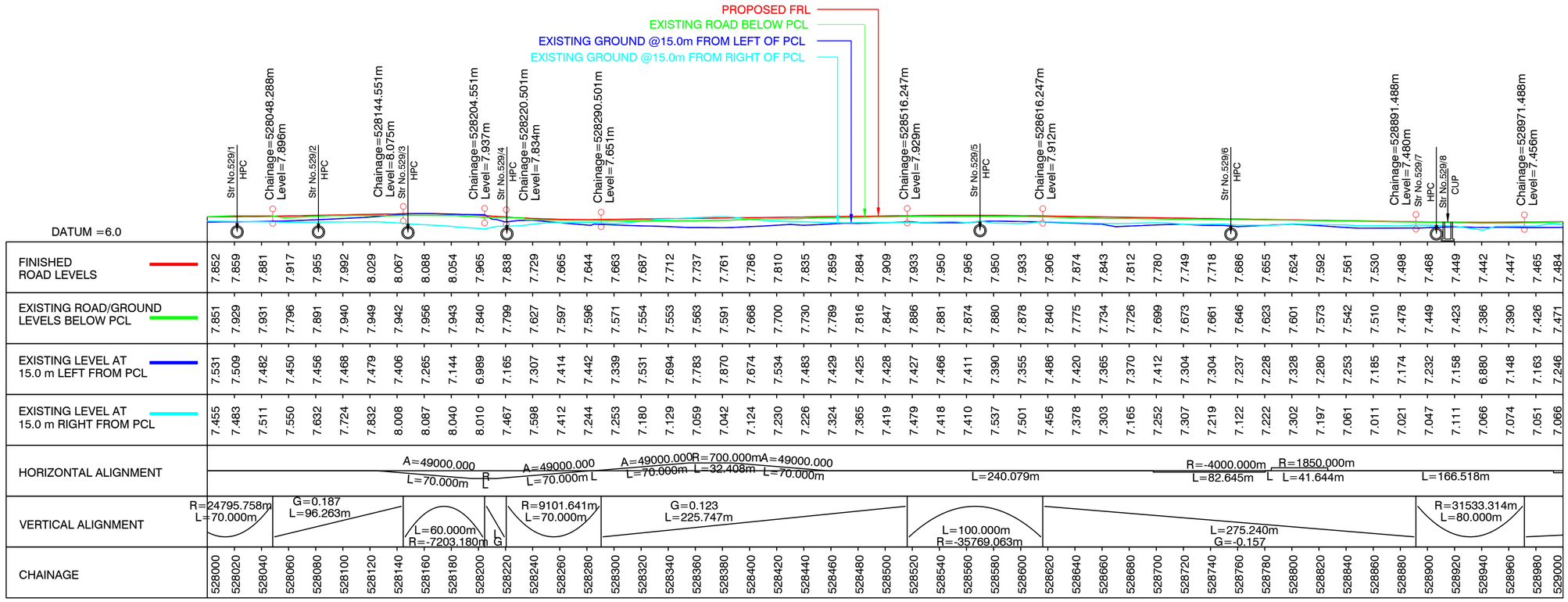
From Km. 527.425 to Km. 528.000

DRG. NO. 2667/ GOA / NH-66 / PP / MCW / 01 | R1

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POLLEM





DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

REVISION NO.	DATE	DESCRIPTION	REVISED BY
R2	JAN-2026	REVISED FEASIBILITY REPORT	-
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LEGEND :
- Proposed CL
- Proposed CW
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- Culvert / Bridge
- MCW
- SR
- Separator
- Footpath Cum Drain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

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PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

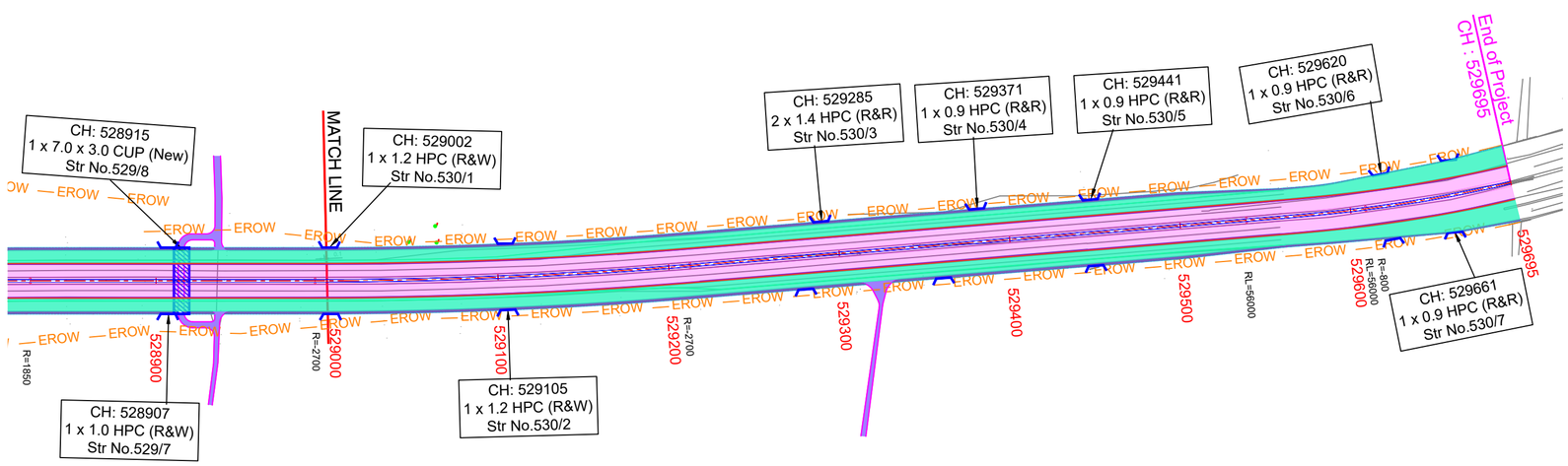
PLAN AND PROFILES OF MAIN CARRIAGEWAY

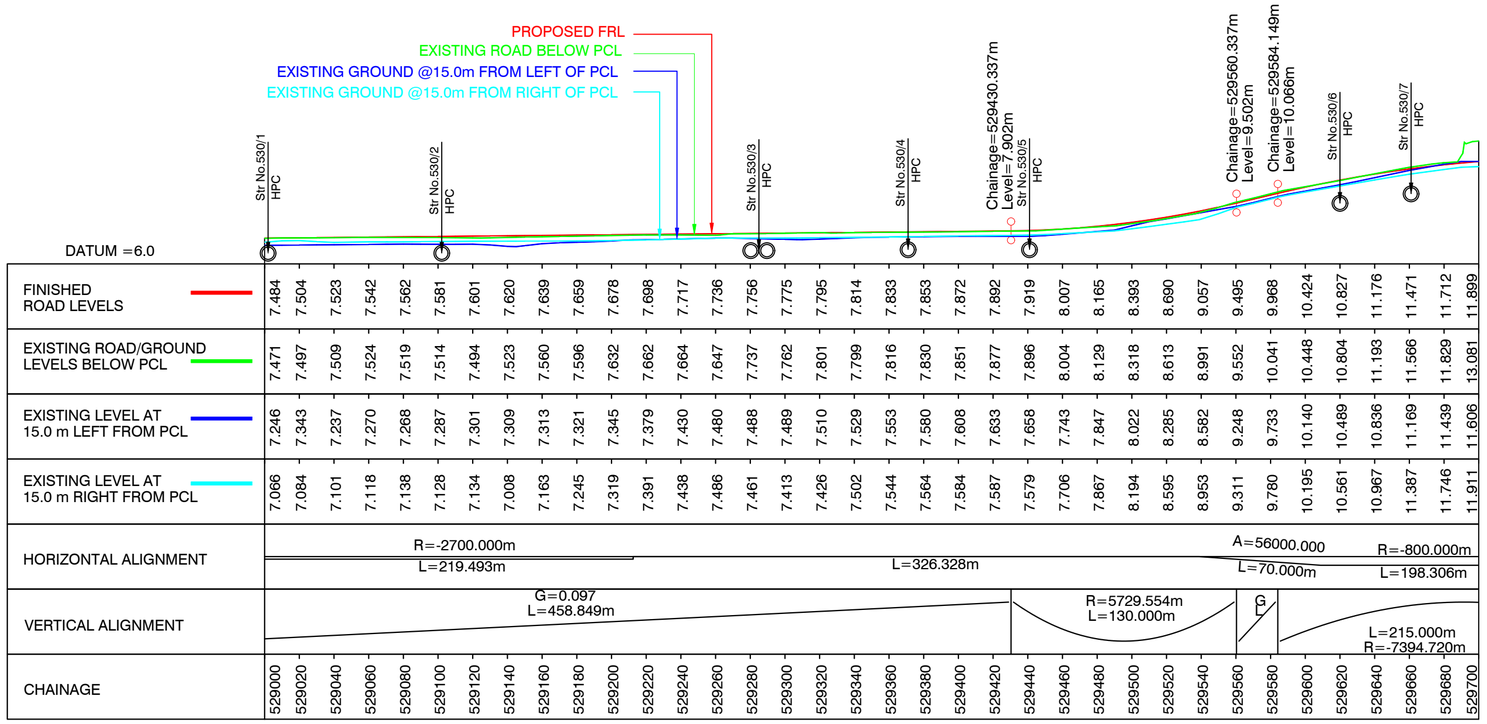
From Km. 528.000 to Km. 529.000

DRG. NO. 2667/ GOA / NH-66 / PP / MCW / 02 R1

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POLLEM





DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

REVISION NO.	DATE	DESCRIPTION	REVISED BY
R2	JAN-2026	REVISED FEASIBILITY REPORT	-
R1	OCT-2024	INITIAL SUBMISSION	-

LEGEND :

- Proposed CL
- Proposed CW
- Existing ROW — EROW —
- Culvert / Bridge
- MCW
- SR
- Separator
- Footpath Cum Drain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

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PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

PLAN AND PROFILES OF MAIN CARRIAGEWAY

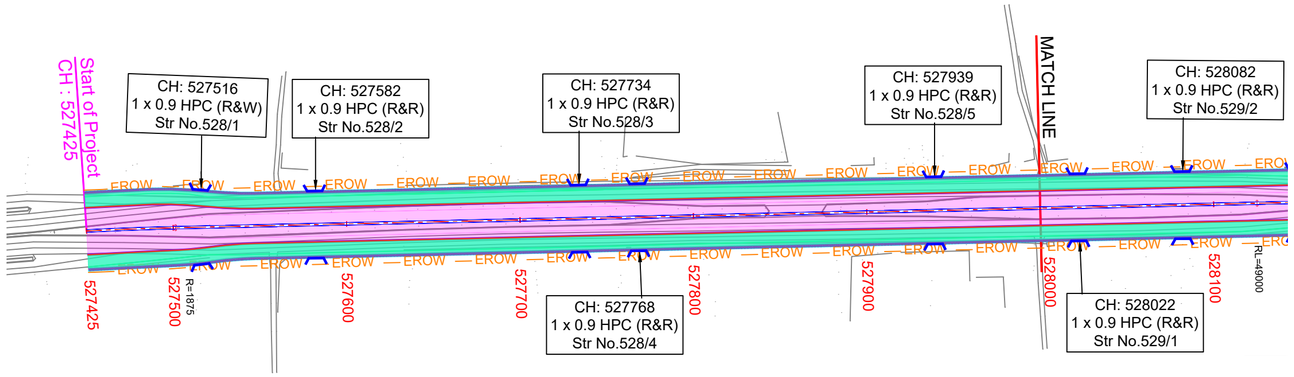
From Km. 529.000 to Km. 529.695

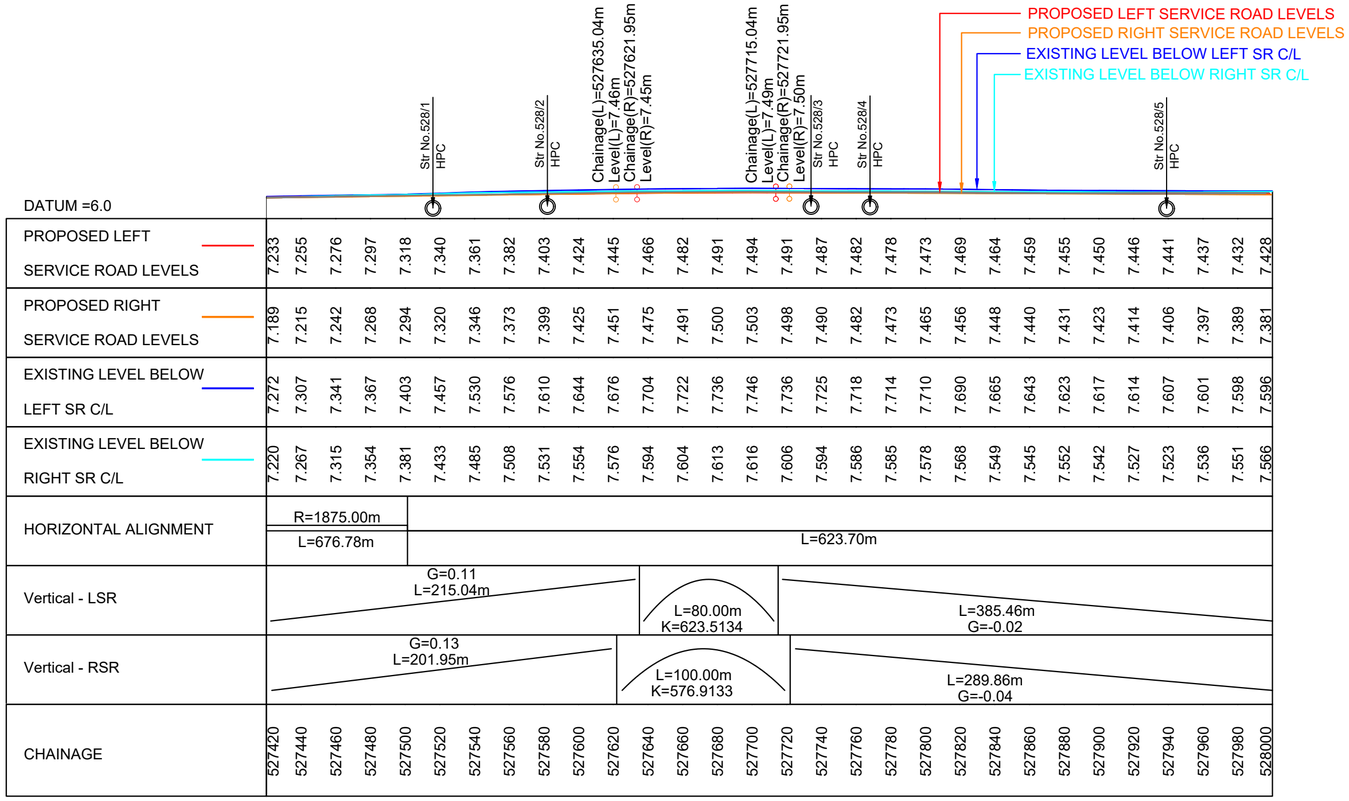
DRG. NO. 2667/ GOA / NH-66 / PP / MCW / 03 | R1

PLAN & PROFILES
SERVICE ROAD

PATRADEVI

POLLEM





DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

REVISION NO	DATE	DESCRIPTION	REVISED BY
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R1	OCT-2024	INITIAL SUBMISSION	-

LEGEND :
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- Proposed CW
- Existing ROW — EROW —
- Culvert / Bridge
- MCW
- SR
- Separator
- Footpath Cum Drain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

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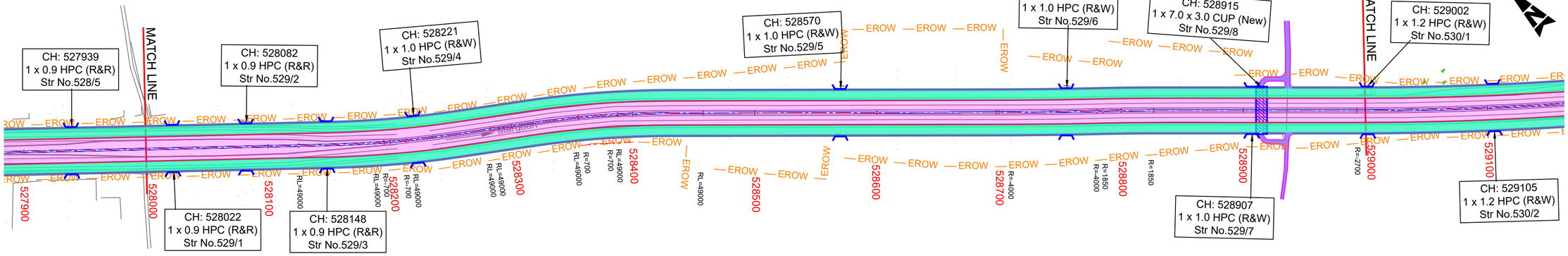
PLAN AND PROFILES OF SERVICE ROAD

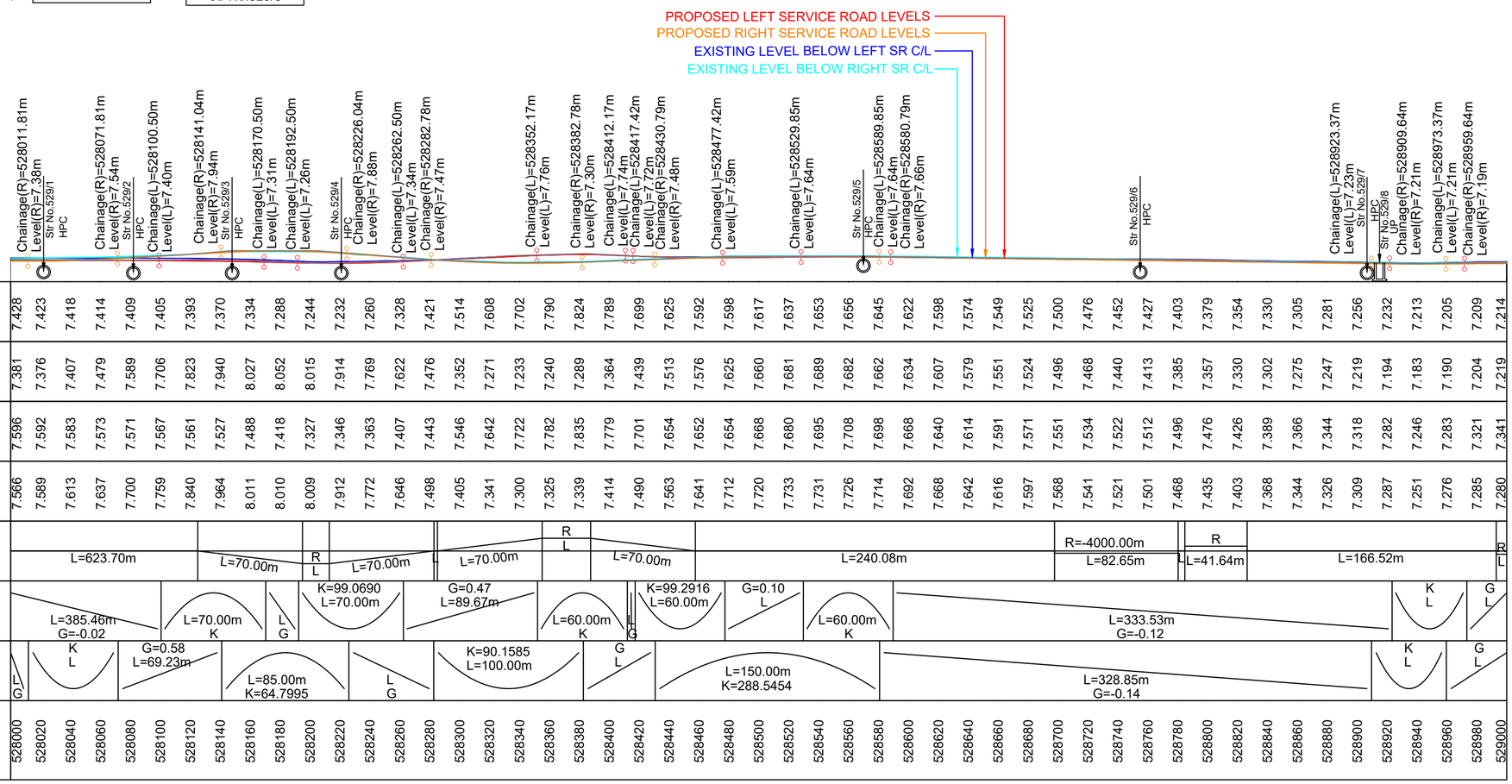
From Km. 527.425 to Km. 528.000

DRG. NO.2667/ GOA / NH-66 / PP / SR / 01 R1

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POLLEM





DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
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REVISION NO	DATE	DESCRIPTION	REVISED BY
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LEGEND :
- Proposed CL
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- Existing ROW — EROW —
- Culvert / Bridge
- MCW
- SR
- Separator
- Footpath Cum Drain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CLIENT :

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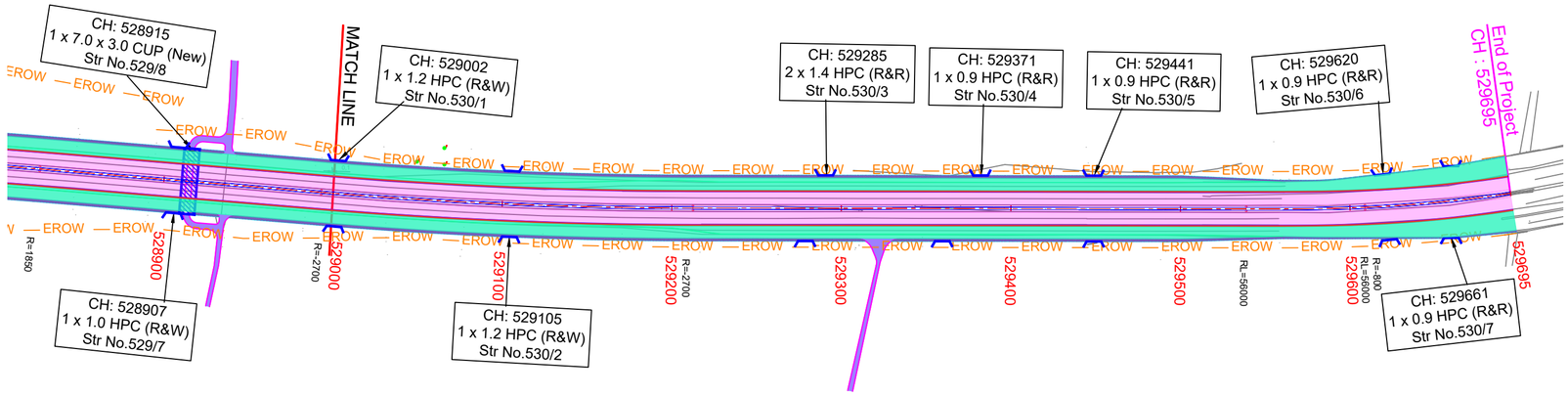
PLAN AND PROFILES OF SERVICE ROAD

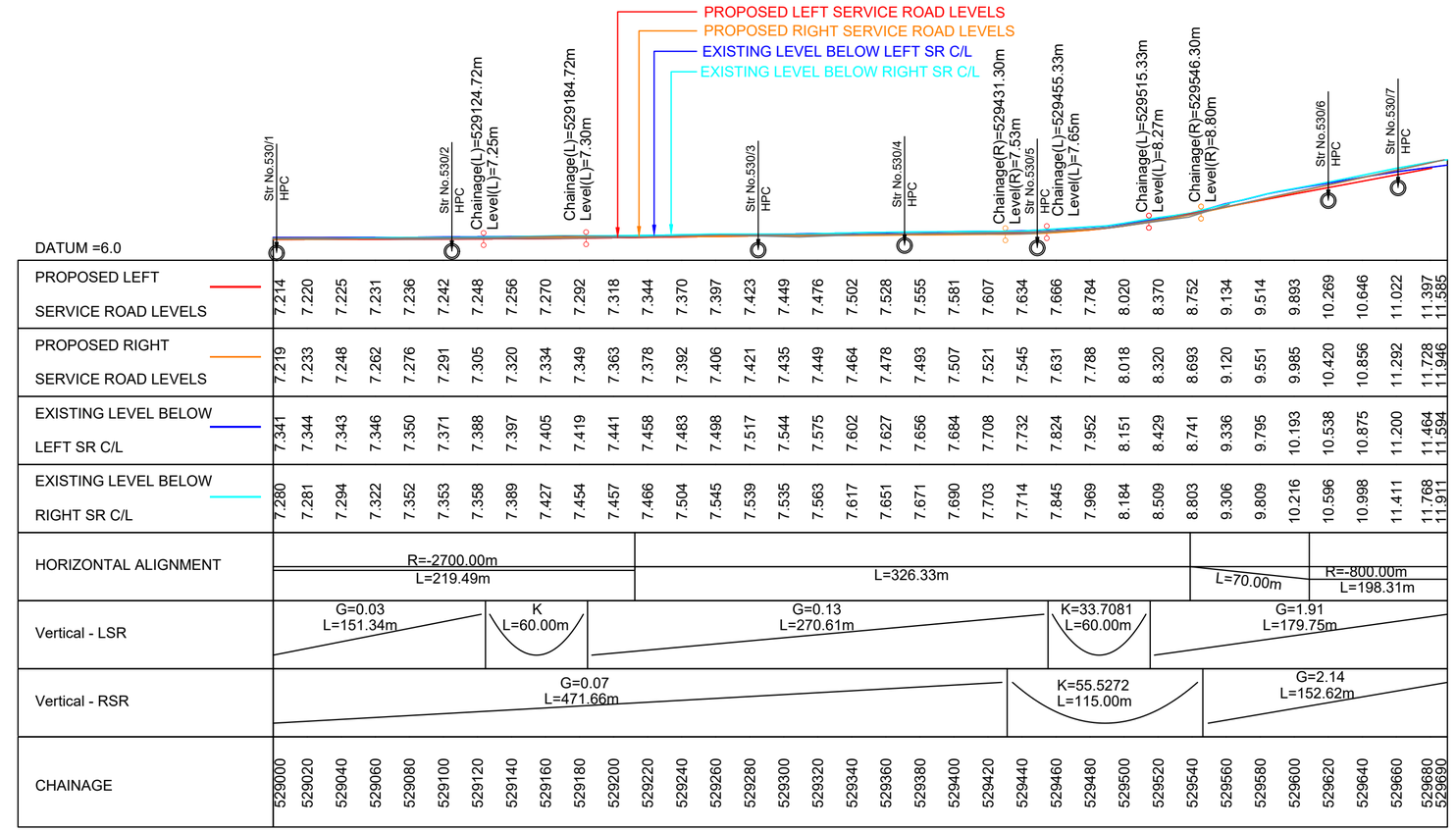
From Km. 528.000 to Km. 529.000

DRG. NO.2667/ GOA / NH-66 / PP / SR / 02 R1

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POLLEM



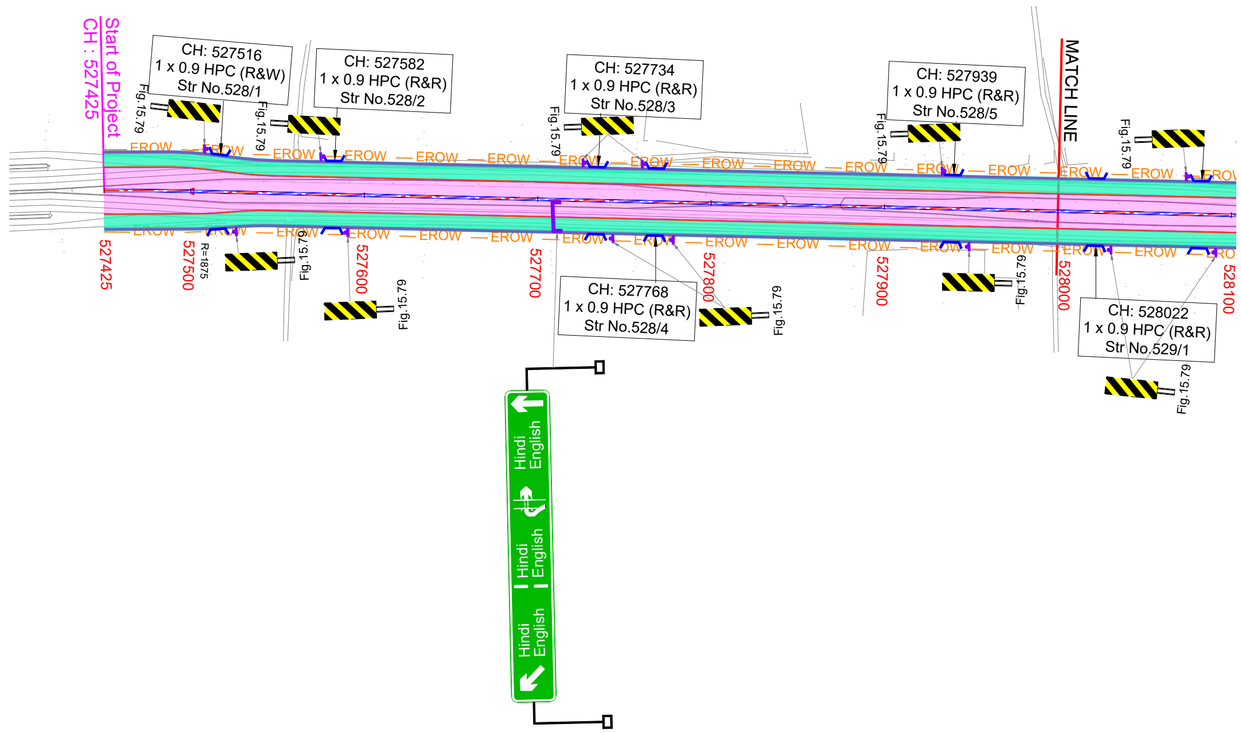


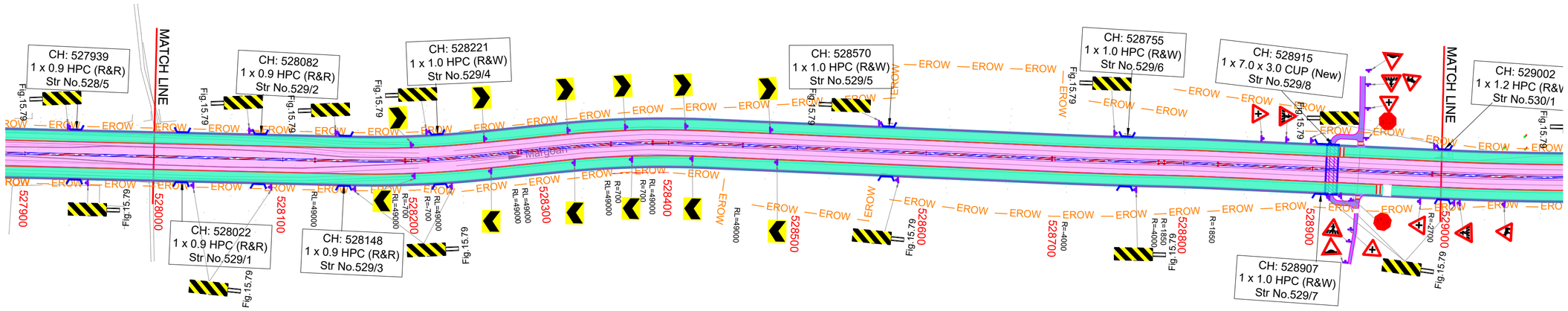
| | | |

SIGNAGE PLAN

PATRADEVI

POLLEM





DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

REVISION NO.	DATE	DESCRIPTION	REVISED BY
R2	JAN-2026	REVISED FEASIBILITY REPORT	-
R1	OCT-2024	INITIAL SUBMISSION	-

LEGEND :

- Proposed CL
- Proposed CW
- Existing ROW — EROW —
- Culvert / Bridge
- MCW
- SR
- Separator
- Footpath Cum Drain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CLIENT :

GOVERNMENT OF GOA

CONSULTANT :

Kaarvee
aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

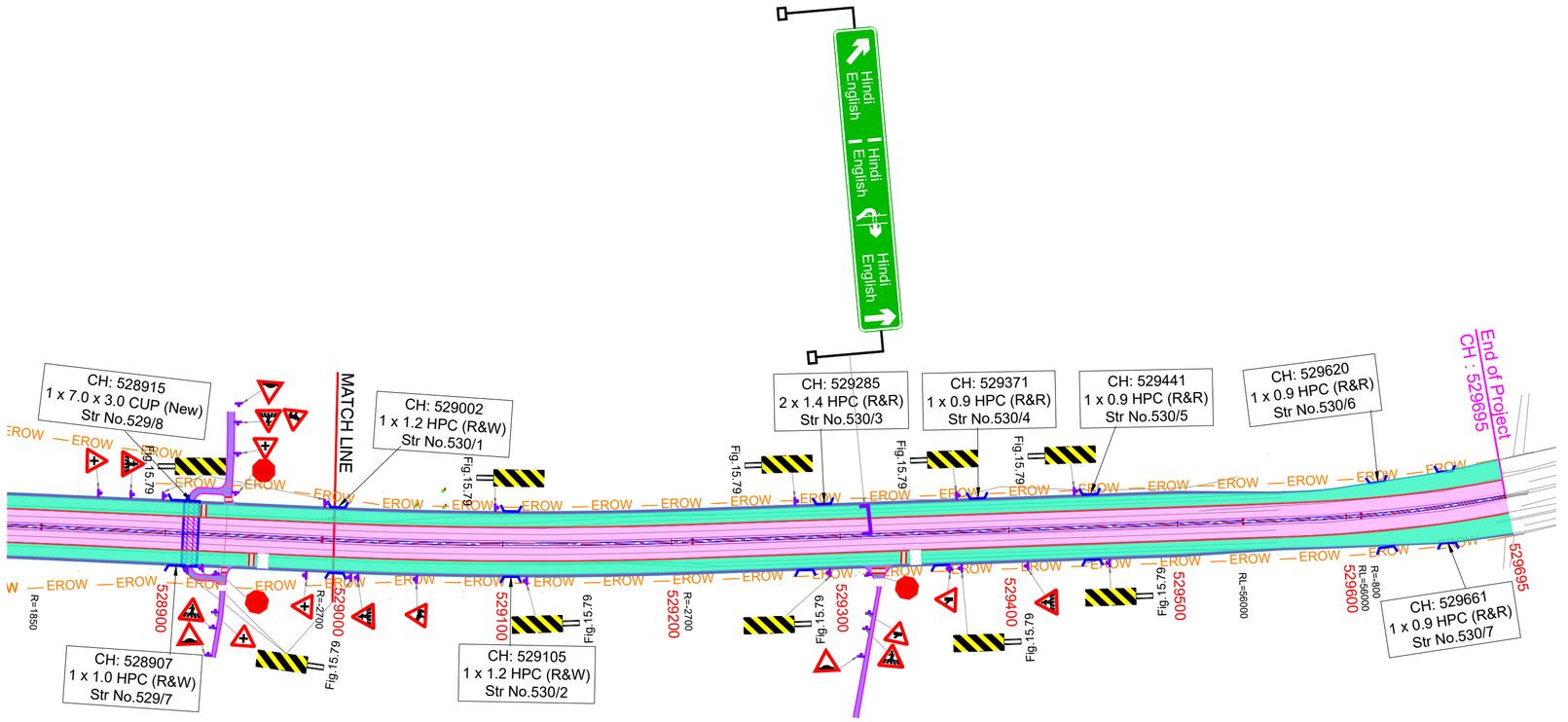
SIGNAGE PLAN

From Km. 527.425 to Km. 529.000

DRG. NO.2667/ GOA / NH-66 / SP / 01 | R1

PATRADEVI

POLLEM



DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	JAN-2026

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PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

SIGNAGE PLAN

From Km. 529.000 to Km. 529.695

DRG. NO. 2667/ GOA / NH-66 / SP / 02 | R1

JUNCTION LAYOUT



DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
G.KRISHNA	P.SATISH	P.SRINIVAS RAO	S.S.REDDY	APR-2026

REVISION NO	DATE	DESCRIPTION	REVISED BY
R2	APR-2026	REVISED FEASIBILITY REPORT	-
R1	OCT-2024	INITIAL SUBMISSION	-

LEGEND :

Proposed CL

Proposed CW

Table Top Crossing

Table Top Crossing with Pedestrain

SCALE :

0 25 50 75 100m
Horizontal 1:2500

0 2.5 5.0 7.5 10m
Vertical 1:250

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CLIENT :

CONSULTANT :

aarvee

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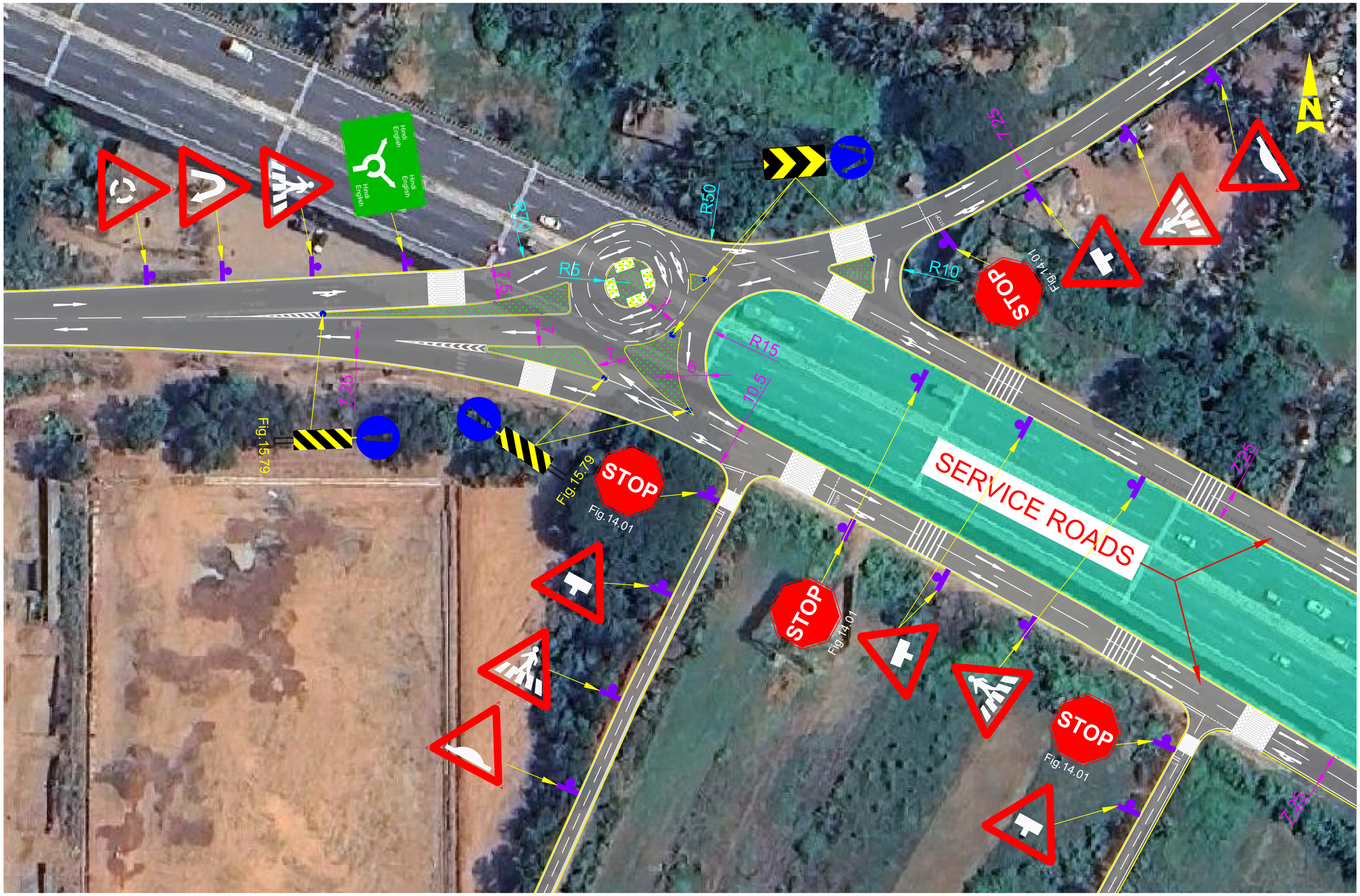
PROJECT :

CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT KM. 528.915 AND CONSTRUCTION OF SERVICE ROAD BETWEEN KM 527.425 TO KM. 529.695 ON NH - 66 IN THE STATE OF GOA

TITLE :

MAJOR AND MINOR JUNCTIONS

DRG. NO.2667/ GOA / NH-66 / JUN / 01 R1



DESIGNED BY	DRAWN BY	CHECKED BY	APPROVED BY	DATE
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REVISION NO	DATE	DESCRIPTION	REVISED BY
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LEGEND :

Proposed CL

Proposed CW

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Table Top Crossing with Pedestrain

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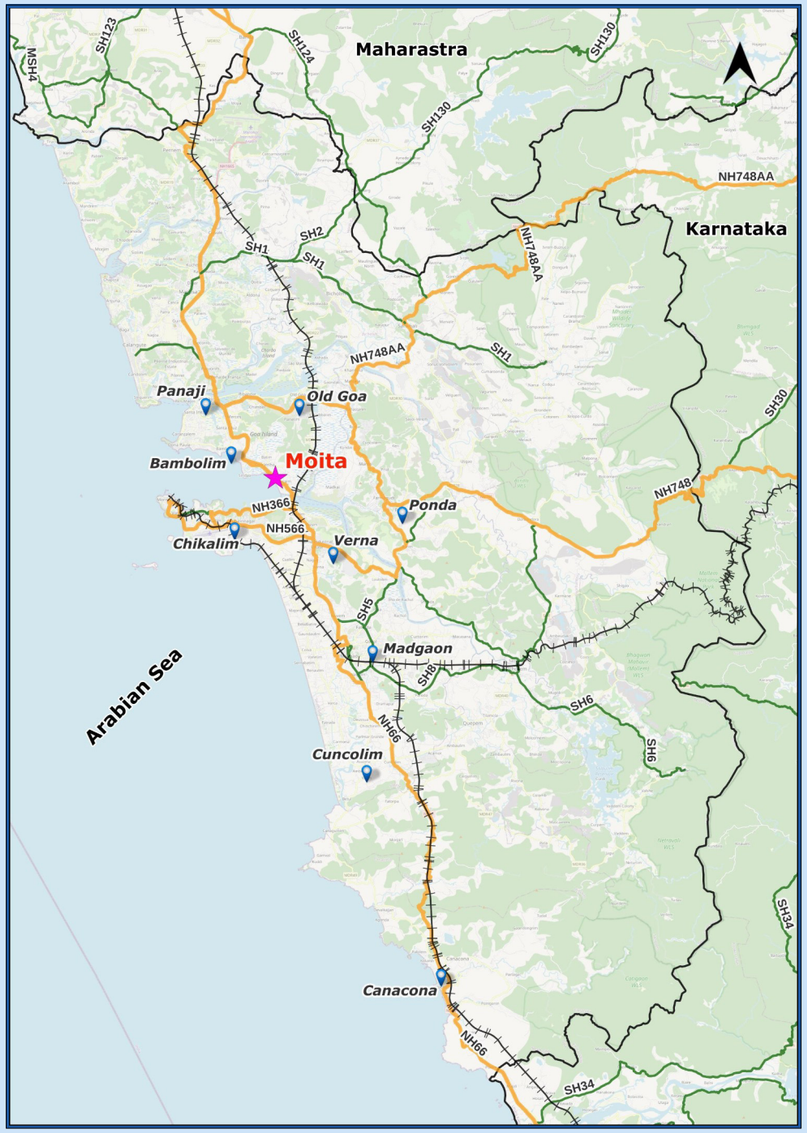
MAJOR AND MINOR JUNCTIONS

DRG. NO. 2667/ GOA / NH-66 / JUN / 02 | R1

GOVERNMENT OF GOA

PUBLIC WORKS DEPARTMENT (NATIONAL HIGHWAYS)

Construction of Cattle Underpass near Moita at Km. 528.915 and Construction of Service road between Km. 527.425 to Km. 529.695 on NH-66 in the state of Goa.









STRUCTURAL DRAWINGS

Consultant

aarvee

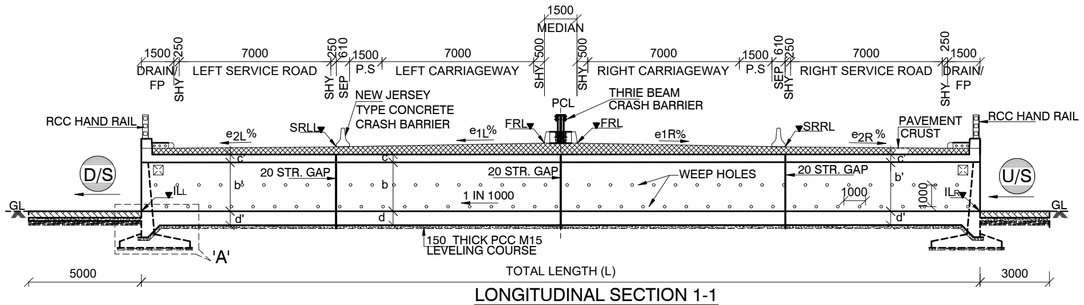
aarvee engineering consultants limited

8-2-5, Ravula Residency, Srinagar Colony Main Road, Hyderabad-82, Telangana, India.

Tel: +91-40-4848 3456, 2373 7633; Fax: +91-40-23736277

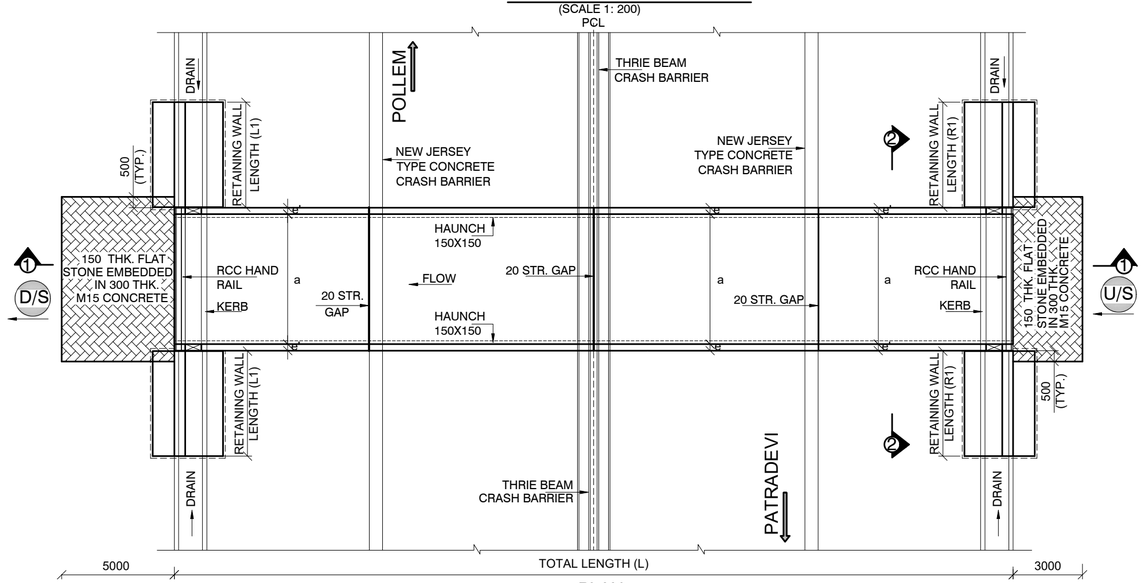
e-mail: aarvee@aarvee.net; web: www.aarvee.com

CATTLE UNDERPASS



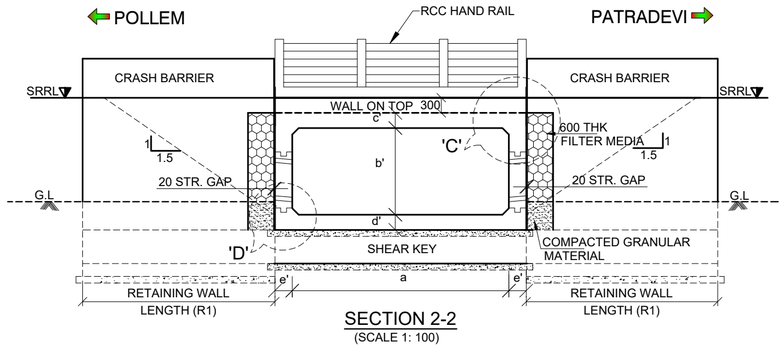
LONGITUDINAL SECTION 1-1

(SCALE 1: 200)



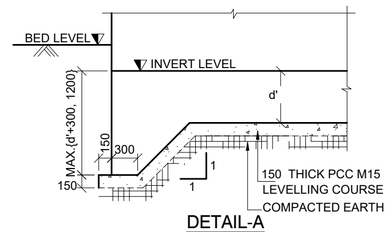
PLAN

(SCALE 1: 200)



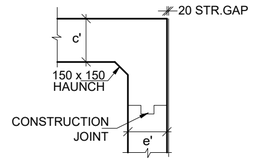
SECTION 2-2

(SCALE 1: 100)



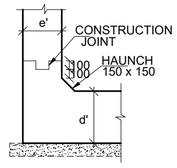
DETAIL-A (SHOWING DIMENSIONAL DETAILS OF SHEAR KEY)

(SCALE 1:50)



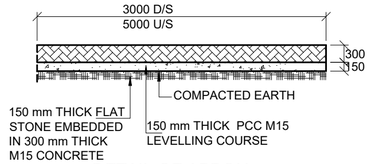
DETAIL-'C'

(SCALE 1: 50)



DETAIL-'D'

(SCALE 1: 50)



DETAIL OF APRON

(SCALE 1:75)

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES, UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE AS FOLLOWS :-

LEVELLING COURSE	M15
RCC BOX CULVERT	M30
RETAINING WALL	M30
CRASH BARRIER	M40
APPROACH SLAB	M30

5. MINIMUM CLEAR COVER TO ANY REINFORCEMENT SHALL BE AS FOLLOWS :-

NON EARTH FACE	-	45
EARTH FACE	-	75
CRASH BARRIER	-	45

6. DESIGN CRITERIA HAS BEEN FROM THE FOLLOWING CODES:
   a) IRC: 6-2017 c) IRC: 112-2020
   b) IRC: SP:13-2022 d) IRC: 78-2022
7. THE REINFORCEMENT SHALL BE BARS OF GRADE DESIGNATION Fe-500 CONFORMING TO LATEST IRC CODES / MORTH CIRCULARS.
8. BACK FILLING FOR SIDE WALL AND RETAINING WALLS SHALL CONFORM TO SPECIFICATION GIVEN AT APPENDIX-6 OF IRC : 78-2022.
9. THE PROPERTIES OF THE MATERIALS USED FOR BACK FILLING BEHIND SIDE WALL AND RETAINING WALLS SHALL CONFORM TO THE FOLLOWING
   $\emptyset \neq 28°$ & $\gamma_s = 20\ kN/m^3$
10. SOFT AND LOOSE PATCHES IN THE BEARING AREA ARE TO BE REPLACED BY COMPACTED GRANULAR FILLS WITH LAYERS NOT EXCEEDING 300 mm.
11. COMPRESSIBLE FILLER BOARD SHALL BE PROVIDED IN EXPANSION GAP BETWEEN SIDE WALLS AND RETAINING WALL & APPROACH SLAB AND SIDE WALL.
12. ANY DISCREPANCY NOTED SHOULD BE REPORTED TO THE ENGINEER INCHARGE IMMEDIATELY.
13. SAFE BEARING CAPACITY OF BOX CULVERT IS MENTIONED IN TABLE. THE SAME SHALL BE ENSURED BEFORE EXECUTION.
14. ALL THE LEVELS AND CAMBERS TO BE VERIFIED WITH RESPECT TO PLAN AND PROFILE DRAWINGS BEFORE STARTING UP OF EXECUTION.
15. BACK FILLING BEHIND WALLS SHALL BE DONE SIMULTANEOUSLY ON EITHER SIDE OF THE STRUCTURE WITH HEIGHT DIFFERENCE NOT MORE THAN 1.0 m.
16. WEEP HOLES OF 100 mm DIA SHALL BE PROVIDED AT 1000 mm C/C BOTH HORIZONTALLY AND VERTICALLY IN A STAGGERED MANNER IN SIDE WALLS OF BOX CELL AND RETAINING WALLS ABOVE 150 mm FROM GL OR LWL WHICHEVER IS HIGHER.
17. 600 mm THICK FILTER MEDIA SHALL BE PROVIDED BEHIND SIDE WALLS AND RETAINING WALLS AS PER IRC : 78 - 2022.
18. FOR DETAILS OF RETAINING WALL & MEDIAN WALL REFER SEPARATE DRAWING.
19. RETAINING WALL LENGTH & HEIGHT SHALL BE ADJUSTED TO SUIT SITE CONDITION.
20. BED SLOPE AND BED LEVELS SHALL MATCH WITH EXISTING SITE CONDITION.
21. FOR MISCELLANEOUS DETAILS OF CRASH BARRIER, APPROACH SLAB, HANDRAILS & DRAINAGE SPOUT REFER MISCELLANEOUS DRAWINGS.
22. THE FOUNDATION RECOMMENDATION IS AS PER THE GEOTECHNICAL INVESTIGATION DONE DURING FEASIBILITY STAGE. THE SAME SHALL BE ASCERTAINED AT SITE BY CONDUCTING SUITABLE SITE INVESTIGATIONS.

LEGENDS:

FRL	= FINISHED ROAD LEVEL	P.S	= PAVED SHOULDER
PCL	= PROPOSED CENTER LINE	SRLL	= SLIP ROAD LEFT LEVEL
IL	= INVERT LEVEL	SRRL	= SLIP ROAD RIGHT LEVEL
EQ	= EQUAL	THK.	= THICK
EXP.	= EXPANSION	TYP.	= TYPICAL
JT.	= JOINT	STR.	= STRUCTURE
F.P	= FOOTPATH	U/S	= UP STREAM
C.B	= CRASH BARRIER	D/S	= DOWN STREAM
SHY	= SHYNESS		= PAVEMENT CRUST AS PER DESIGN SPECIFICATION
SEP	= SEPERATOR		

DETAILS OF BOX CULVERTS

S. No.	Proposed Chainage (km)	Proposed TCS	Proposed Structure Type	Proposal Type	No of Spans	Span Length [a] (m)	Vent Height [b] (m)	Top Slab [c] (m)	Bottom Slab [d] (m)	Side Wall [e] (m)	Skew / Normal	MCW FRL (m)	Camber MCW (e_{1L})	Camber MCW (e_{1R})	Flow Direction	Invert Level (IL_L) (m)	Invert Level (IL_R) (m)	Height of Cushion MCW (m)		Service Road FRL (SRLL) (m)	Service Road FRL (SRLR) (m)	Service Road Camber (e_{2L})	Service Road Camber (e_{2R})	No. of Spans	Service Road Span (a) (m)	Service Road Vent Height (b') (m)	Service Road Top Slab [c'] (m)	Service Road Bottom Slab [d'] (m)	Service Road Side Wall [e'] (m)	Height of Cushion on Service Road (m)		Total Length (L) (m)	Retaining Wall Length L1 (m)	Retaining Wall Length R1 (m)	SBC (t/m^2)
1	528+915	IV	UP cum Box culvert	New Construction	1	7.00	3.00	0.450	0.450	0.450	Normal	7.453	-2.00%	-2.00%	L to R	3.300	3.339	0.300	0.300	7.238	7.200	-2.00%	-2.00%	1.00	7.0	3.0	0.450	0.450	0.450	0.300	0.300	38.720	5.660	5.660	12.0

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	OCT' - 2024
R1	REVISED AS PER NEW PROPOSAL	DEC' - 2025
R2	REVISED AS PER TCS MODIFICATION	JAN' - 2026
R3	REVISED AS PER CLIENT OBSERVATION	JAN' - 2026

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CONSULTANTS:
Kaarvee
aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

CLIENT:
GOVERNMENT OF GOA

DRAWN: KPU	
DESIGNED: SIBHI CHELVAN	
CHECKED: Y.PRAVEEN	
APPROVED: G. PRAVEEN	

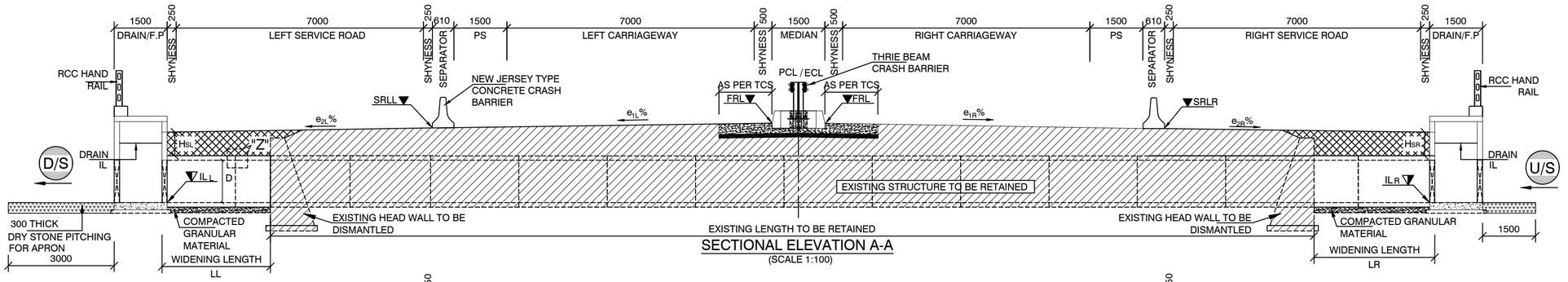
PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

DRAWING TITLE:
GENERAL ARRANGEMENT DRAWING OF UNDERPASS cum BOX CULVERT AT Km: 528+915

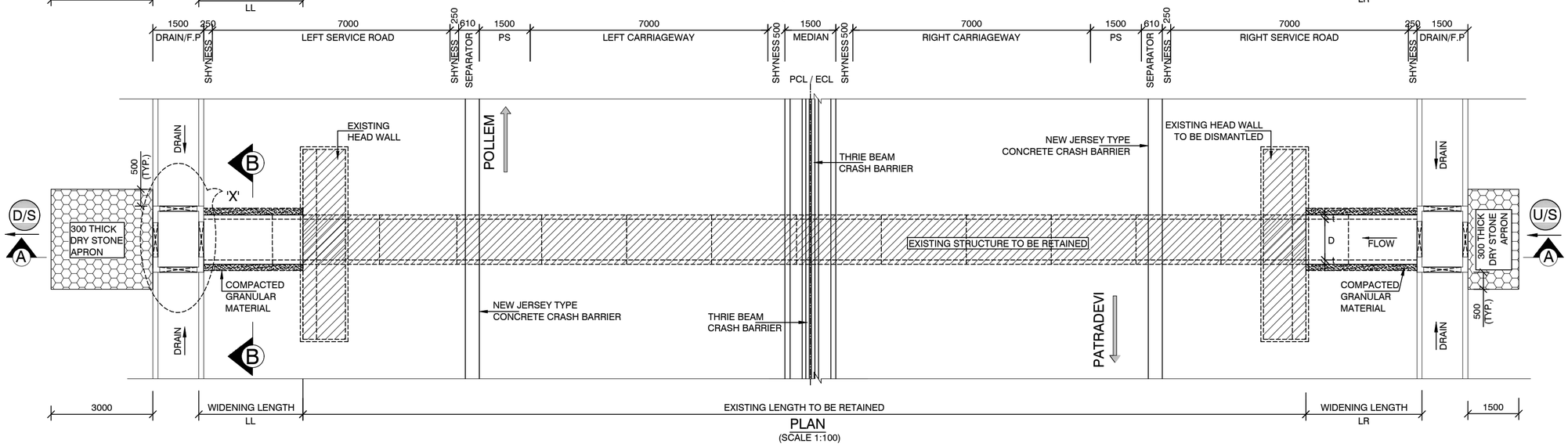
DRG. NO.: AA/2667/STR/UPcumBC/528915/001

SHEET NO: 1 OF 1

HUME PIPE CULVERTS



SECTIONAL ELEVATION A-A
(SCALE 1:100)



PLAN
(SCALE 1:100)

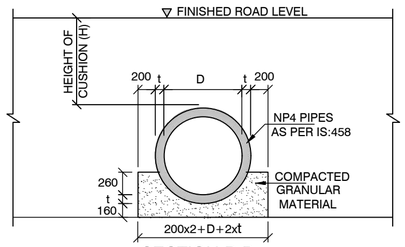
NOTES:

1. DIMENSIONS ARE NOT TO BE SCALED
   ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS UNLESS OTHERWISE NOTED.
2. CONSTRUCTION WORK, INCLUDING BACKFILL (SPECIFICATION NO. 2907) AND FLUSH JOINTS (SPECIFICATION NO. 2906) SHALL BE CARRIED OUT AS PER SECTION 2900 OF MORTH OR AS APPROVED BY THE ENGINEER.
3. DETAILS LIKE FRL, CAMBER, CARRIAGEWAY, MEDIAN, SHOULDERS, MEDIAN KERB AND PAVEMENT OVER PIPE SHALL BE VERIFIED WITH RELEVANT HIGHWAY DRAWINGS.
4. NALLA TRAINING SHALL BE DONE IF REQUIRED AND AS DIRECTED BY THE ENGINEER.
5. BEDDING FOR PIPE SHALL BE AS PER MORTH SPECIFICATION No. 2904.
6. ANY DESCREPANCY NOTED SHALL BE REPORTED TO THE DESIGN CONSULTANT IMMEDIATELY.
7. FURTHER DETAILING OF INTERNAL FLUSH JOINT SHALL BE AS GIVEN IN IS 458-2021 SECTION-6.3
8. DIAMETER & THICKNESS OF PIPE SHALL BE AS PER IS 458:2021

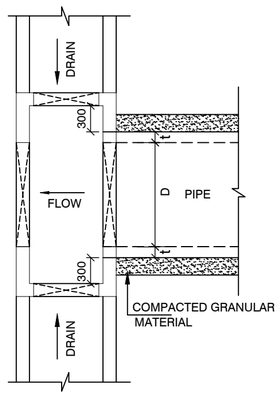
DIAMETER (D)	THICKNESS (t)
300	50
400	60
500	70
600	75
700	85
800	95
900	100
1000	115
1100	115
1200	125

LEGEND:

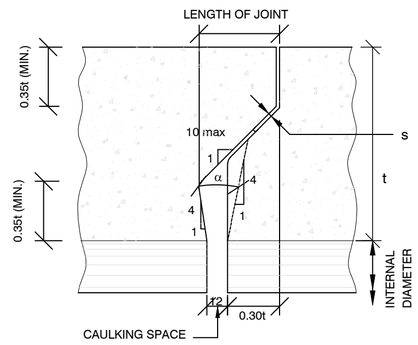
U/S = UP STREAM
D/S = DOWN STREAM
▽ = LEVEL
= EXISTING TO BE RETAINED
= PAVEMENT CRUST (AS PER DESIGN SPECIFICATIONS)
PS = PAVED SHOULDER
FRL = FINISHED ROAD LEVEL
ECL = EXISTING CENTER LINE.
PCL = PROPOSED CENTRE LINE
IL = INVERT LEVEL
SRLL = SERVICE ROAD LEVEL LEFT
SRLR = SERVICE ROAD LEVEL RIGHT
t = WALL THICKNESS
S = MIN. OF 0.002 OF INTERNAL DIA OR 2mm
α = INCLUDED ANGLE NOT MORE THAN 25° (ONLY FOR DESIGN PURPOSE NOT TO BE MEASURED)



SECTION:B-B
(IF EARTH CUSHION / CRUST (H) > 0.6 m < 4.0m)
(SCALE 1:50)



DETAIL: X
(SCALE 1:50)



DETAIL "Z"
(SCALE 1:25)
(TYPICAL DETAIL SHOWING INTERNAL FLUSH JOINTS FOR NEW PIPES)

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	DEC' 2025
R1	REVISED AS PER TCS MODIFICATION	JAN' 2026

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CONSULTANTS:

Kaarvee
aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

CLIENT:

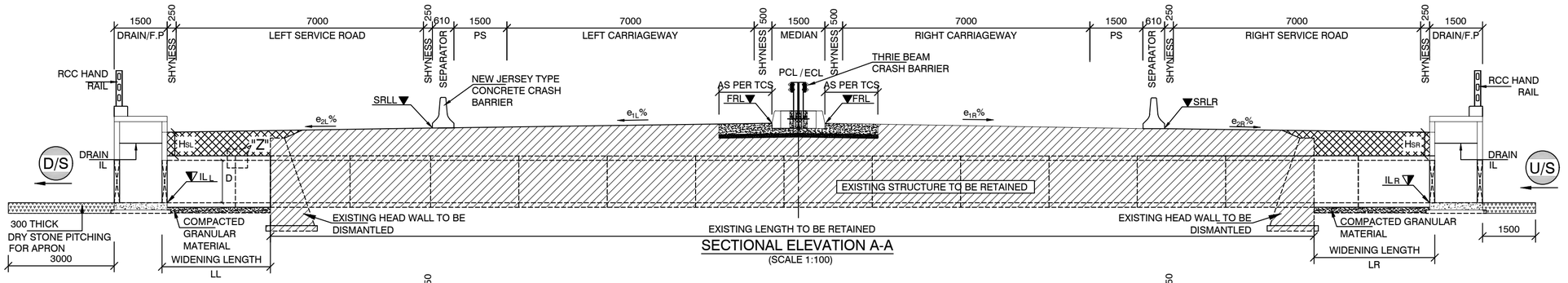
DRAWN: D.GOPAL RAO
DESIGNED: SIBHI CHELVAN
CHECKED: Y. PRAVEEN
APPROVED: G.PRAVEEN KUMAR

PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

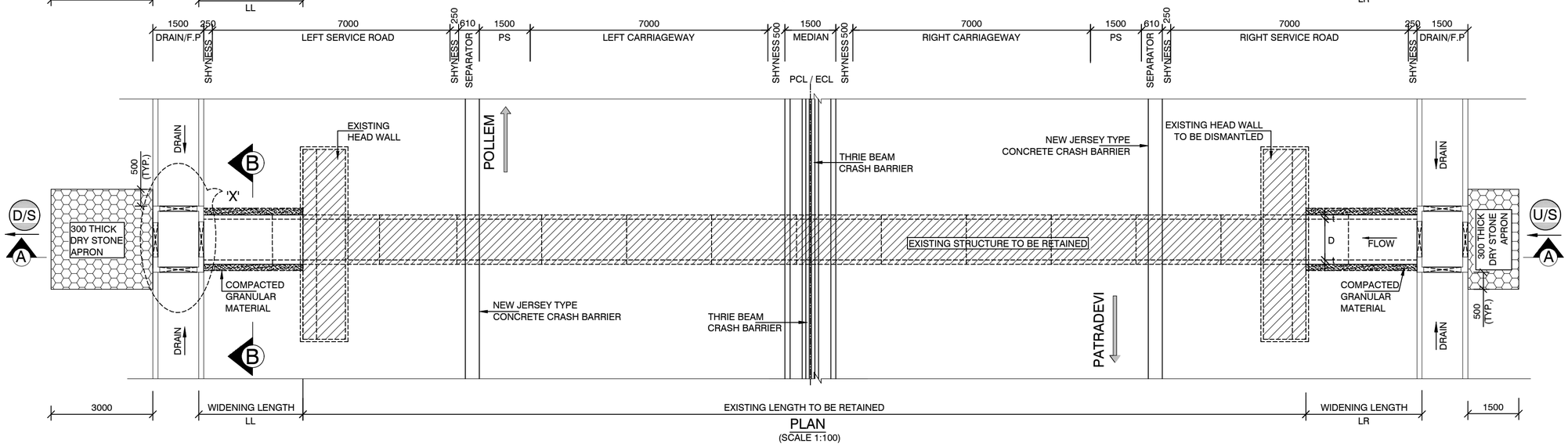
DRAWING TITLE:
TYPICAL ARRANGEMENT DRAWING FOR EXISTING SINGLE ROW HUME PIPE CULVERT TCS-IV (RETAINED & WIDENING)

DRG. NO.: AA/2667/NH66/STR/HPC/TYP-01/001

SHEET NO: 1 OF 1



SECTIONAL ELEVATION A-A
(SCALE 1:100)



PLAN
(SCALE 1:100)

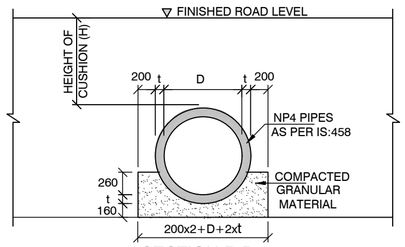
NOTES:

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7. FURTHER DETAILING OF INTERNAL FLUSH JOINT SHALL BE AS GIVEN IN IS 458-2021 SECTION-6.3
8. DIAMETER & THICKNESS OF PIPE SHALL BE AS PER IS 458:2021

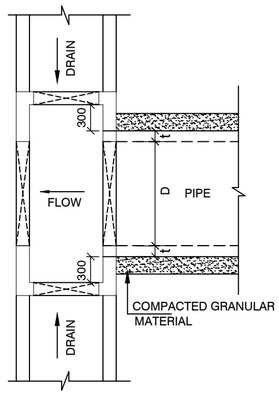
DIAMETER (D)	THICKNESS (t)
300	50
400	60
500	70
600	75
700	85
800	95
900	100
1000	115
1100	115
1200	125

LEGEND:

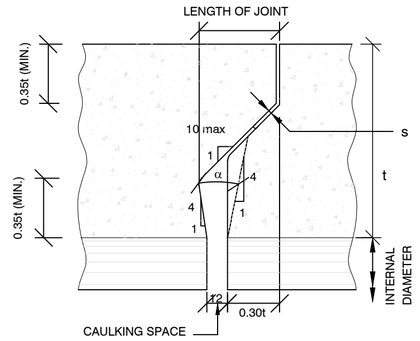
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t = WALL THICKNESS
S = MIN. OF 0.002 OF INTERNAL DIA OR 2mm
α = INCLUDED ANGLE NOT MORE THAN 25° (ONLY FOR DESIGN PURPOSE NOT TO BE MEASURED)



SECTION:B-B
(IF EARTH CUSHION / CRUST (H) > 0.6 m < 4.0m)
(SCALE 1:50)



DETAIL: X
(SCALE 1:50)



DETAIL "Z"
(SCALE 1:25)
(TYPICAL DETAIL SHOWING INTERNAL FLUSH JOINTS FOR NEW PIPES)

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	DEC' 2025
R1	REVISED AS PER TCS MODIFICATION	JAN' 2026

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CONSULTANTS:

Kaarvee
aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
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e-mail: aarvee@aarvee.net; web: www.aarvee.com

CLIENT:

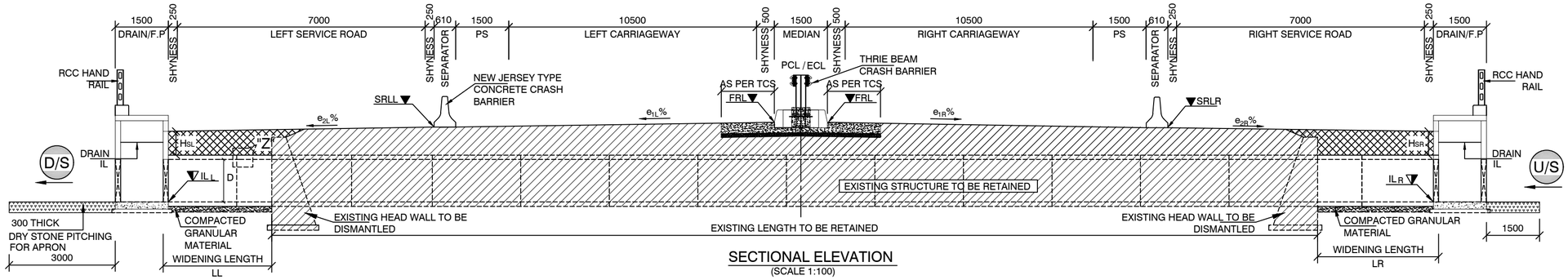
DRAWN: D.GOPAL RAO
DESIGNED: SIBHI CHELVAN
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APPROVED: G.PRAVEEN KUMAR

PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

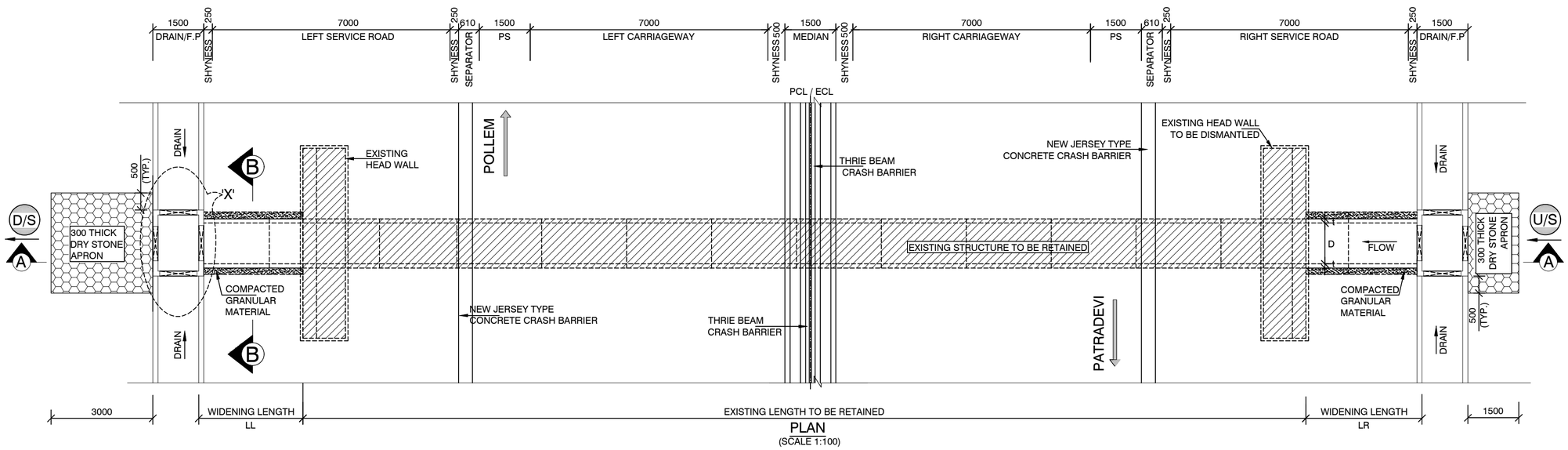
DRAWING TITLE:
TYPICAL ARRANGEMENT DRAWING FOR EXISTING SINGLE ROW HUME PIPE CULVERT TCS-III (RETAINED & WIDENING)

DRG. NO.: AA/2667/NH66/STR/HPC/TYP-02/001

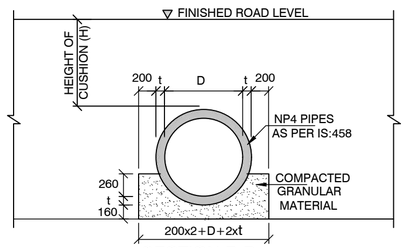
SHEET NO: 1 OF 1



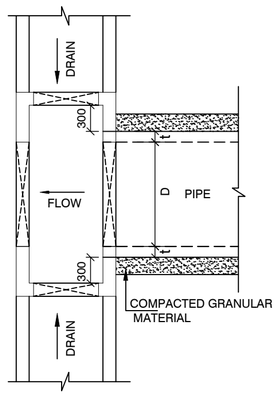
SECTIONAL ELEVATION
(SCALE 1:100)



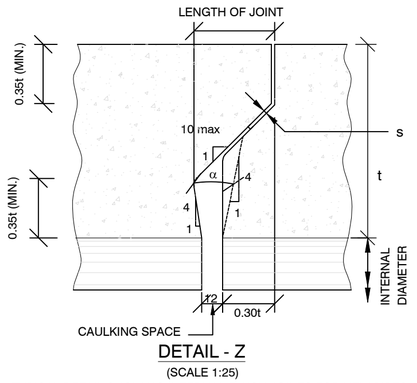
PLAN
(SCALE 1:100)



SECTION:B-B
(IF EARTH CUSHION / CRUST (H) > 0.6 m < 4.0m)
(SCALE 1:50)



DETAIL: X
(SCALE 1:50)



DETAIL - Z
(SCALE 1:25)
(TYPICAL DETAIL SHOWING INTERNAL FLUSH JOINTS FOR NEW PIPES)

NOTES:

1. DIMENSIONS ARE NOT TO BE SCALED
   ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS UNLESS OTHERWISE NOTED.
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4. NALLA TRAINING SHALL BE DONE IF REQUIRED AND AS DIRECTED BY THE ENGINEER.
5. BEDDING FOR PIPE SHALL BE AS PER MORTH SPECIFICATION No. 2904.
6. ANY DESCREPANCY NOTED SHALL BE REPORTED TO THE DESIGN CONSULTANT IMMEDIATELY.
7. FURTHER DETAILING OF INTERNAL FLUSH JOINT SHALL BE AS GIVEN IN IS 458-2021 SECTION-6.3
8. DIAMETER & THICKNESS OF PIPE SHALL BE AS PER IS 458:2021

DIAMETER (D)	THICKNESS (t)
300	50
400	60
500	70
600	75
700	85
800	95
900	100
1000	115
1100	115
1200	125

LEGEND:

- U/S = UP STREAM
- D/S = DOWN STREAM
- = LEVEL
- = EXISTING TO BE RETAINED
- = PAVEMENT CRUST (AS PER DESIGN SPECIFICATIONS)
- PS = PAVED SHOULDER
- FRL = FINISHED ROAD LEVEL
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- IL = INVERT LEVEL
- SRLL = SERVICE ROAD LEVEL LEFT
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- t = WALL THICKNESS
- S = MIN. OF 0.002 OF INTERNAL DIA OR 2mm
- α = INCLUDED ANGLE NOT MORE THAN 25° (ONLY FOR DESIGN PURPOSE NOT TO BE MEASURED)

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	DEC' 2025
R1	REVISED AS PER TCS MODIFICATION	JAN' 2026

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CONSULTANTS:
aarvee
aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

CLIENT:
GOVERNMENT OF GOA

DRAWN: D.GOPAL RAO
DESIGNED: SIBHI CHELVAN
CHECKED: Y. PRAVEEN
APPROVED: G.PRAVEEN KUMAR

PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

DRAWING TITLE:
TYPICAL ARRANGEMENT DRAWING FOR EXISTING SINGLE ROW HUME PIPE CULVERT TCS- X (RETAINED & WIDENING)

DRG. NO.: AA/2667/NH66/STR/HPC/TYP-03/001

SHEET NO: 1 OF 1

SCHEDULE OF HUME PIPE CULVERTS (RETAINING & WIDENING)

S. No.	Proposed Chainage (km)	Structrue type	Proposal type	Existing Span Arrangement		Proposed Span Arrangement		Proposed TCS	Skew/ Normal	PCL to ECL	Existing Length (m)	Camber for MCW		Camber for Service road		Proposed Finished Road Levels (m)					Min. Invert Levels (m)		Flow Direction	Proposed Slope	Height of cushion on MCW (m)		Height of cushion on SR (m)		Proposed Length of pipes (m)		Total No.of Pipes (Full) (2.50m)	Total No.of Pipes (Half) (1.250m)	Type of Bedding for MCW	Type of Bedding for Service road	Proposed Total Length L (m)	Remarks
				No. of Rows	Dia.(m) D	No. of Rows	Dia.(m) D					e_{1L}%	e_{1R}%	e_{2L}%	e_{2R}%	Existing MCW	Left Edge MCW	Right Edge MCW	Left Service Road	Right Service Road	IL_L	IL_R			H_L	H_R	H_{SL}	H_{SR}	L_L	L_R						
1	527+516	HPC	R&W	1	0.9	1	0.9	X	Normal	0.0	36.0	Retained	Retained	-2.00%	-2.00%	7.534	Retained	Retained	7.336	7.315	5.270	5.227	L to R	0.001	Retained	Retained	1.066	1.088	3.360	3.360	2	2	Retained	Granular	6.720	Main carraigeway – Retained and Service road – Retained & widening
2	528+221	HPC	R&W	1	1.0	1	1.0	IV	Normal	0.0	31.0	Retained	Retained	-2.00%	-2.00%	7.810	Retained	Retained	7.233	7.907	5.408	5.372	L to R	0.001	Retained	Retained	0.710	1.420	2.360	2.360	2	-	Retained	Granular	4.720	
3	528+570	HPC	R&W	1	1.0	1	1.0	IV	Normal	0.0	31.0	Retained	Retained	-2.00%	-2.00%	7.828	Retained	Retained	7.653	7.674	5.827	5.791	L to R	0.001	Retained	Retained	0.711	0.768	2.360	2.360	2	-	Retained	Granular	4.720	
4	528+755	HPC	R&W	1	1.0	1	1.0	IV	Normal	0.0	31.0	Retained	Retained	-2.00%	-2.00%	7.615	Retained	Retained	7.434	7.420	5.406	5.370	L to R	0.001	Retained	Retained	0.913	0.935	2.360	2.360	2	-	Retained	Granular	4.720	
5	528+907	HPC	R&W	1	1.0	1	1.0	IV	Normal	0.0	31.0	Retained	Retained	-2.00%	-2.00%	7.400	Retained	Retained	7.248	7.209	4.275	4.239	L to R	0.001	Retained	Retained	1.857	1.855	2.360	2.360	2	-	Retained	Granular	4.720	
6	529+002	HPC	R&W	1	1.0	1	1.0	IV	Normal	0.0	31.0	Retained	Retained	-2.00%	-2.00%	7.383	Retained	Retained	7.215	7.220	4.672	4.636	L to R	0.001	Retained	Retained	1.427	1.469	2.360	2.360	2	-	Retained	Granular	4.720	
7	529+105	HPC	R&W	1	1.0	1	1.0	III	Normal	0.0	31.0	Retained	Retained	-2.00%	-2.00%	7.385	Retained	Retained	7.244	7.295	5.156	5.120	L to R	0.001	Retained	Retained	0.973	1.060	2.360	2.360	2	-	Retained	Granular	4.720	

SCHEDULE OF HUME PIPE CULVERTS (RETAINING)

S.No.	Proposed Chainage (km)	Existing Structure type	Existing Span Arrangement		Existing (Skew / Normal)	Proposed TCS	Proposal
			No. of Rows	Dia. (m) D			
1	527+582	HPC	1.0	0.90	Normal	I	1. Existing Culvert is Retained with Rehabilitation works such as removing debris / garbage / vegetation, clearing flow obstructing blockages , Protection works (aprons), Safety barriers, etc. 2. The drain box's alignment needs to be adjusted appropriately to disperse water at the culvert location depending on the site conditions.
2	527+734	HPC	1.0	0.90	Normal	I	
3	527+768	HPC	1.0	0.90	Normal	II	
4	527+939	HPC	1.0	0.90	Normal	II	
5	528+022	HPC	1.0	0.90	Normal	I	
6	528+082	HPC	1.0	0.90	Normal	I	
7	528+148	HPC	1.0	0.90	Normal	II	
8	529+285	HPC	2.0	1.40	Left skew	V	
9	529+371	HPC	1.0	0.90	Right skew	V	
10	529+449	HPC	1.0	0.90	Normal	V	
11	529+620	HPC	1.0	0.90	Normal	VI	
12	529+661	HPC	1.0	0.90	Normal	VI	

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	DEC' 2025
R1	REVISED AS PER TCS MODIFICATION	JAN' 2026

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CONSULTANTS:
aarvee
aarvee engineering consultants limited
Ravula Residency, Srinagar Colony Main Rd., Hyderabad-82, India
Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

CLIENT:
GOVERNMENT OF GOA

DRAWN: D.GOPAL RAO
DESIGNED: SIBHI CHELVAN
CHECKED: Y. PRAVEEN
APPROVED: G.PRAVEEN KUMAR

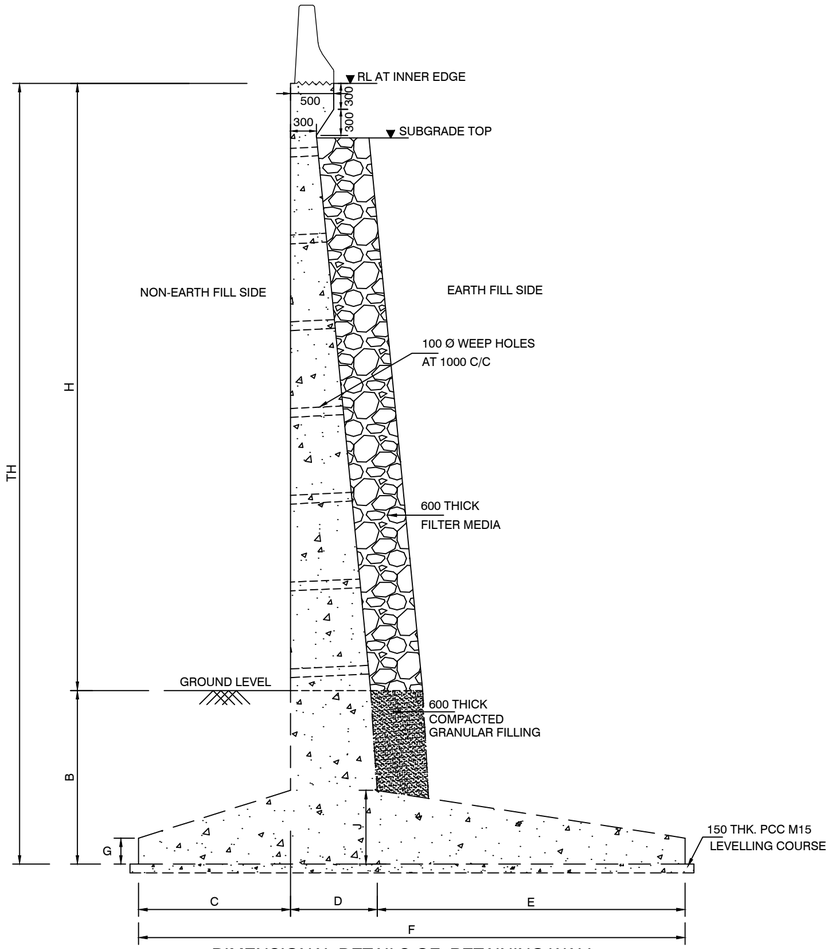
PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

DRAWING TITLE:
SCHEDULE OF HUME PIPE CULVERTS

DRG. NO.: AA/2667/NH66/STR/HPC/TAB/001

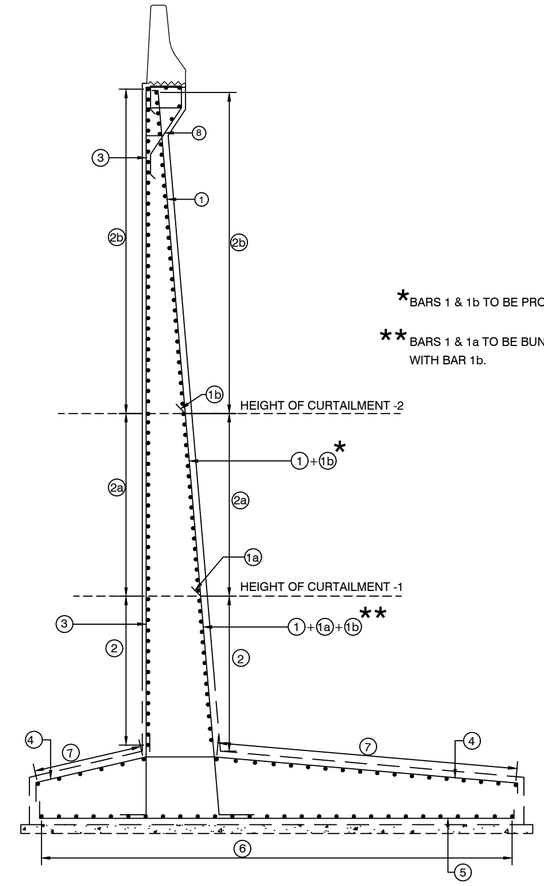
SHEET NO: 1 OF 1

MISCELLANEOUS DRAWINGS



DIMENSIONAL DETAILS OF RETAINING WALL

(SCALE 1:50)



*BARS 1 & 1b TO BE PROVIDED ALTERNATELY.

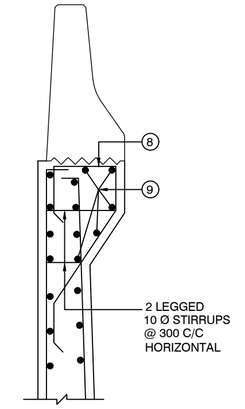
**BARS 1 & 1a TO BE BUNDLED AND PROVIDED ALTERNATELY WITH BAR 1b.

REINFORCEMENT DETAILS OF RETAINING WALL

(SCALE 1:50)

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES, UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE AS FOLLOWS :
   - LEVELLING COURSE ---------- M15
   - RCC RETAINING WALL ---------- M30
4. THE REINFORCEMENT SHALL BE BARS OF GRADE DESIGNATION Fe 500 CONFORMING TO LATEST IRC CODES / MORTH CIRCULARS.
5. MINIMUM CLEAR COVER TO ANY REINFORCEMENT SHALL BE AS FOLLOWS :-
   - EARTH FACE ---------- 75
   - NON EARTH FACE ---------- 50
6. 20mm EXPANSION GAP SHALL BE PROVIDED IN BETWEEN RETAINING WALL FOR EVERY 20m LENGTH.
7. CRASH BARRIER SHALL BE PROVIDED THROUGH OUT THE LENGTH OF THE RETAINING WALL IN CASE OF RETURN WALLS.



DETAILS OF BRACKET REINFORCEMENT

(SCALE 1 : 25)

Schedule of Sectional Dimensions

Height Above GL	Df Below GL	Total Height	SBC (kN/m²)	Length of Toe	Stem Bottom Thick	Length of Heel	Total Width	Raft Thickness (end)	Bottom raft Thickness At stem	Curtailment Height From bottom stem 1a	1b	Stem main reinforcement (Earth face) 1 Dia	1 spacing	1a Dia	1a spacing	1b Dia	1b spacing	Stem main reinforcement (Non Earth face) 3 Dia	3 spacing	Stem Distribution reinforcement 2 Dia	2 spacing	2a Dia	2a spacing	2b Dia	2b spacing	Raft Top 4 Dia	4 spacing	Raft Bottom 5 Dia	5 spacing	Raft Bottom Distribution 6 Dia	6 spacing	Raft Top Distribution 7 Dia	7 spacing	Bracket Reinforcement 8 Dia	8 spacing	9 Dia	9 No's
H	B	TH		C	D	E	F	G	J	-	-																										
2.0	1.5	3.5	130	0.5	0.45	1.8	2.75	0.4	1.0	-	-	12	160	-	-	-	-	12	180	8	220	8	220	-	-	16	150	16	150	8	170	8	170	12	160	8	5
3.0		4.5		0.7	0.5	2.6	3.8	0.4	1.2	2.40	-	12	160	12	160	-	-	12	160	8	190	8	190	-	-	16	120	16	120	8	140	8	140	12	160	8	5
4.0	2.0	6.0	150	1.3	0.7	2.6	4.6	0.4	1.20	1.60	3.00	12	160	12	160	12	160	12	130	10	160	10	160	10	190	16	120	16	120	10	140	10	140	12	160	8	5
4.5		6.5		1.5	0.7	2.8	5.0	0.4	1.30	2.00	4.00	12	160	12	160	12	160	12	110	10	160	10	160	10	160	16	110	16	110	10	140	10	140	12	160	8	5
5.0		7.0		1.7	0.8	2.9	5.40	0.4	1.30	2.50	4.20	16	170	12	170	12	170	16	180	10	160	10	160	10	160	16	110	16	110	10	160	10	160	12	170	8	5

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	DEC' - 2025

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

CONSULTANTS:

aarvee
aarvee engineering consultants limited
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Tel: +91-40-23737633; Fax: +91-40-23736277
e-mail: aarvee@aarvee.net; web: www.aarvee.com

CLIENT:

GOVERNMENT OF GOA

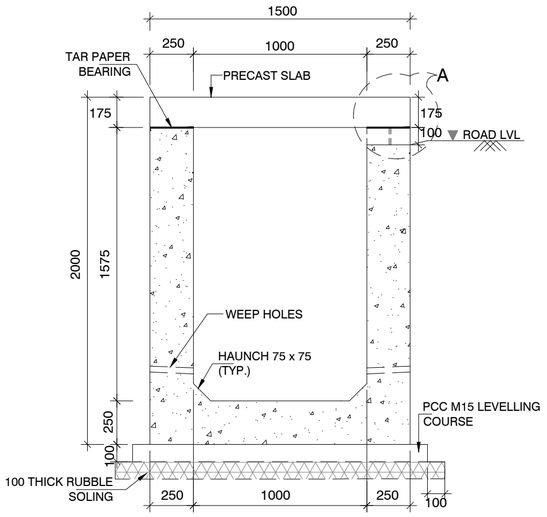
DRAWN: KPU
DESIGNED: SIBHI CHELVAN
CHECKED: Y.PRAVEEN
APPROVED: G. PRAVEEN

PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

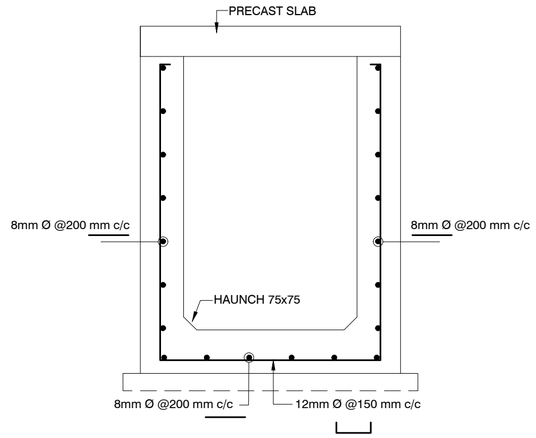
DRAWING TITLE:
TYPICAL DIMENSIONAL & REINFORCEMENT DETAILS OF RETAINING WALL

DRG. NO.: AA/2667/STR/RW/001

SHEET NO: 1 OF 1



CROSS SECTION OF DRAIN
(SHOWING DIMENSIONAL DETAILS)
(SCALE 1:25)



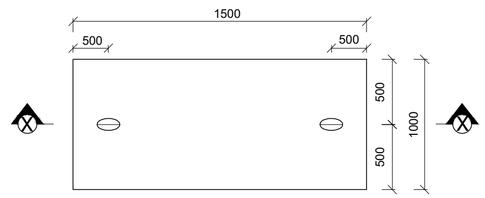
CROSS SECTION OF DRAIN
(SHOWING REINFORCEMENT DETAILS)
(SCALE 1:25)

NOTES :-

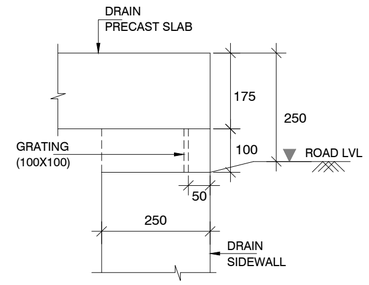
1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES, UNLESS OTHERWISE SPECIFIED.
2. DIMENSIONS ARE NOT TO BE SCALED. ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE AS FOLLOWS :-
   a) LEVELLING COURSE ---- M15
   b) RAFT AND SIDE WALLS ---- M30
   c) PRECAST SLABS ---- M30
4. THE REINFORCEMENT SHALL BE BARS OF GRADE DESIGNATION Fe 500 CONFORMING TO LATEST IRC CODES / MORTH CIRCULARS
5. MINIMUM CLEAR COVER TO REINFORCEMENT SHALL BE AS FOLLOWS :-
   a) EARTH FACE -------- 75 mm
   b) NON EARTH FACE -------- 45 mm
6. 20 mm EXPANSION GAP SHALL BE PROVIDED FOR EVERY 20.00 mt. LENGTH OF DRAIN.
7. WATER STOPPER SHALL BE PROVIDED IN EXPANSION GAPS.
8. ALL DIMENSIONS ARE TO BE VERIFIED AT SITE BEFORE EXECUTION OF WORK.
9. WIDTH AND HEIGHT OF DRAIN MAY BE VARIES AS PER SITE CONDITION.
10. WEEP HOLES OF 100 mm DIA SHALL BE PROVIDED AT 1000 mm C/C BOTH HORIZONTALLY AND VERTICALLY IN A STAGGERED MANNER IN SIDE WALLS OF DRAIN ABOVE 150 mm FROM RAFT LEVEL.

IMPORTANT NOTE :-

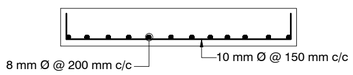
1. 100 X 100 mm SIZE GRATING SHALL BE PROVIDED IN SIDE WALL ON ROAD SIDE AT 5.00 m SPACING TO DRAIN OFF RAIN WATER AT ROAD LEVEL.



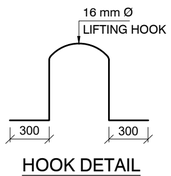
PLAN
(DIMENSIONAL DETAILS OF PRECAST SLAB)



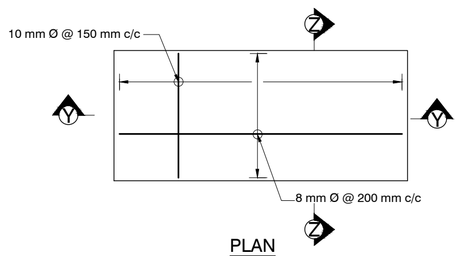
TYPICAL DETAIL 'A'
(SCALE 1:10)



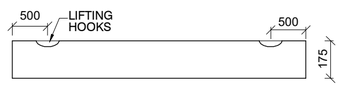
SECTION Z-Z



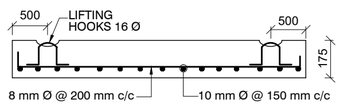
HOOK DETAIL



PLAN
(REINFORCEMENT DETAILS OF PRECAST SLAB)



SECTION X-X



SECTION Y-Y

REV	DESCRIPTION	DATE
R0	INITIAL SUBMISSION	DEC' - 2025
R1	REVISED AS PER CLIENT REQUIREMENT	APR' - 2026

SCALES:
AS MENTIONED

SCALES SHOWN ARE FOR AN A2 SIZE ORIGINAL DRAWING

Signature Not Verified
Digitally signed by GAJANAN RAMESH DESAI
Date: 2026.04.28 13:56:47 IST
Location: eProcure-EPROC

CONSULTANTS:
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CLIENT:

DRAWN: KPU
DESIGNED: SIBHI CHELVAN
CHECKED: G. PRAVEEN
APPROVED: G. PRAVEEN

PROJECT:
CONSTRUCTION OF CATTLE UNDERPASS NEAR MOITA AT Km : 528915 INCLUDING APPROACHES AND CONSTRUCTION OF SERVICE ROAD BETWEEN Km: 527425 to Km: 529695 ON NH-66 IN THE STATE OF GOA

DRAWING TITLE:
DIMENSIONAL & REINFORCEMENT DETAILS OF COVERED DRAIN

DRG. NO.: AA/2667/STR/DRAIN/001

SHEET NO: 1 OF 1