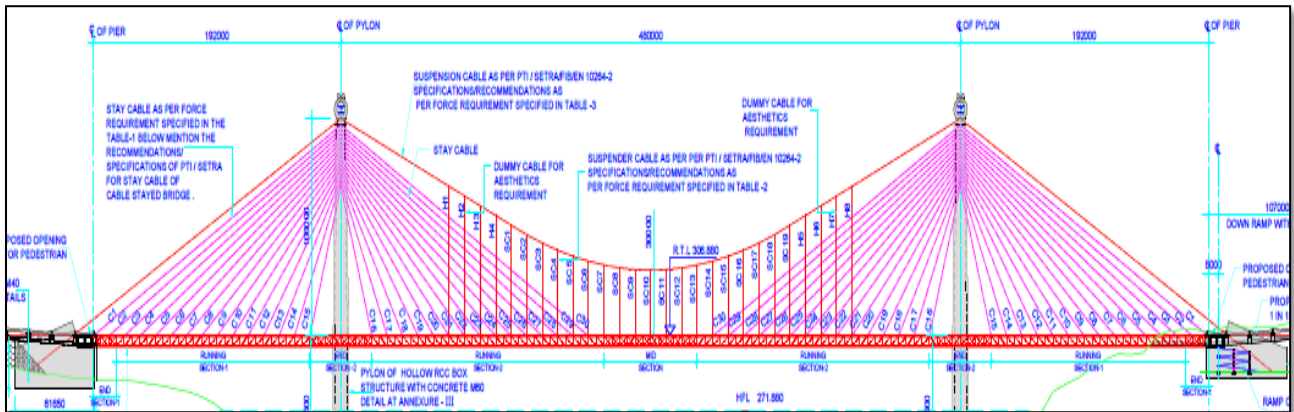


Ministry of Road Transport and Highways

Regional Office, Hyderabad



UP-GRADATION TO 2/4 LANE WITH PAVED SHOULDERS CONFIGURATION OF NEWLY DECLARED NH 167K STARTING FROM ITS JUNCTION WITH NH-167 NEAR KALWAKURTHY CONNECTING NAGARKURNOOL, KOLLAPUR, RAMPUR IN THE STATE OF TELANGANA, MANDUGULA, SIVAPURAM, KARIVENA AND TERMINATING AT ITS JUNCTION WITH NH 40 NEAR NANDYAL IN THE STATE OF ANDHRA PRADESH FOR A LENGTH OF 185.90 KMS (APPROX) INCLUDING FOUR LANE MAJOR BRIDGE ACROSS RIVER KRISHNA.

Detailed Project Report (Pkg. 2)

Iconic Krishna River Bridge

Package -2- Construction of Iconic Hybrid Cable Stayed and Suspension Bridge Across Krishna River On NH -167K (Design Chainage 87+360 To 88+437 In The State Of Telangana And Andhra Pradesh Under EPC Mode Under NH(O)

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1. EXECUTIVE SUMMARY

1.1 GENERAL

The R&B Department-NH wing, Hyderabad, Telangana State has entrusted the assignment of “Project Management Consultancy for Up-gradation to 2/4/6 lane with paved shoulders configuration of newly declared NH 167K starting from its junction with NH 167 near Kalwakurthy connecting Nagarkurnool, Kollapur, Rampur in the state of Telangana, Mandugula, Sivapuram, Karivena and terminating at its junction with NH 40 near Nandyala in the state of Andhra Pradesh including a major bridge

1.2 SCOPE OF CONSULTANCY SERVICES

Since the project is important highway and ambitious project of the Ministry, our objective is to prepare DPR including Pre-construction activities and Project Management Consultancy including maintenance of completed project as per conditions/ specifications mentioned in the agreement and as per discussions and guidelines issued by the authority time to time in the scheduled period.

The scope of services includes –

- Project Preparation includes Feasibility Study and DPR – Project Planning, Mobilization, Alignment Finalization, Preliminary Surveys, Land Acquisition, utility identification, detailed design, preparation of DPR with drawings, strip plan, preparation of bid documents with technical schedules.
- Pre-construction Activities – Land Acquisition Process, obtain utility estimates & required clearances
- Construction Activity and maintenance – Review & approval of design, supervision, review the progress of work, Quality assurance and monitoring, clearances from different agencies

Broadly the scope of services shall comprise, but not limited to, the following:

- Traffic surveys and demand assessment

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- Engineering surveys and Investigations
- Location and layout of Toll Plazas, Truck lay-bys, Bus Bays and Bus Shelters
- Preparation of Designs for road, (Pavement/Geometric Design)
- Designs of all structure viz., Minor & Major Bridges, VUPs, PUPs, ROB/RUBs, Grade Separators, Over Passes for (Old and New number of Major/Minor bridges)
- Preparation of BOQ and Cost Estimates including its Rate Analysis
- Final Detailed Project Report and final drawings.
- Preparation of all types of Bid documents, Schedules required for the EPC Agreement.
- Preparation of Drawings for all Road furniture and all Safety features

1.3 STATUS OF WORK

The work order for providing consultancy service was received on 28th June 2021. The chronology of events is mentioned below

- ❖ **Date of LOA – 28.06.2021**
- ❖ **Bank Guarantee submitted through letter on 09.07.2021**
- ❖ **Agreement done on date – 30.07.2021**
- ❖ **Inception Report submitted on 17.08.2021**
- ❖ **Site visits done on- 06.07.2021 & 12.07.2021**
- ❖ **Traffic Surveys and Soil investigations started on 31.08.2021**
- ❖ **Lidar surveys started on 01.09.2021**
- ❖ **FWD and NSV surveys started on 6th December,2021**
- ❖ **Geotechnical investigations started on 5th January,2022**
- ❖ **Alignment Report for approval submitted on 19th January,2022**
- ❖ **Approval for Alignment received on 21.01.2022**
- ❖ **SFC has sanctioned pkg. 1 on 31.03.2022.**
- ❖ **Schedules for pkg. 1 are submitted on 10.07.2022.**
- ❖ **Demarcation of ROW is completed for pkg. 1.**

Now submitting Draft Detailed Project Report for pkg. 2, on the Iconic Krishna River Bridge.

Package -2- Construction of Iconic Hybrid Cable Stayed and Suspension Bridge Across Krishna River On NH -167K (Design Chainage 87+360 To 88+437 In The State Of Telangana And Andhra Pradesh Under EPC Mode Under NH(O))

1.4 SOCIO-ECONOMIC PROFILE

NH 167K is a major National Highway that runs through the state of Telangana and Andhra Pradesh. The project corridor connects Nagarkurnool district in Telangana and Kurnool district in Andhra Pradesh. A major bridge across River Krishna near Somasila connects both the states. The total project has been divided into the following packages:

- Package -1: Starting of Kalwakurthy bypass to the end of Kollapur Bypass (Km 0.000 to Km 79.100)
- Package -2: Iconic Krishna River Bridge from 87+360 to 88+437
- Package -3: Approached of Iconic Krishna River Bridge from 79+100 to 87+360 and 88+437 to 93+837.
- Package -4: End of Bridge Approaches to Nandyal (NH 40) – 93+897 to 124+700 and 141+900 to 173+700.
- Package -5: Nallamalla Forest Area – 124+700 to 141+900.

The present report is for preparation of Detailed Project Report for Package -2 i.e Iconic Krishna River Bridge from 87+360 to 88+437.

Nagarkurnool district is located in the southern region of Telangana. Also the Nagarkurnool is the district headquarters. It was part of the Mahbubnagar district prior to re-organisation of districts in the state. The district shares boundaries with Nalgonda, Rangareddy, Mahabubnagar, Wanaparthy districts and with the state boundary of Andhra Pradesh with Nandyala, Palnadu and Ongole districts.

Nagarkurnool is located at latitude 16° 28' 59.88" N; longitude 78° 19' 59.88" E. It has an average elevation of 458 meters (1503 feet). It is settled in the central Deccan Plateau and northern part of Nallamalla Hills made up of granite rocks and hill formations. Most of the region is occupied by Deccan thorn scrub forests and Central Deccan Plateau dry deciduous forests towards the southern region of the district. The region falls under semi-arid climate which left the region barren making the cultivation dependent on seasonal rainfall. Krishna river flows from southern border of district and additionally the district has many interlinked chains of lakes and ponds that drain into "Dindi" river. Located in the semi-arid region of Telangana, Nagarkurnool has a predominantly hot and dry climate. Summer starts in March, and peak in May with average high temperatures in the 42 °C (108 °F) range. The monsoon arrives in June

and lasts until September with about 550 mm (22 in) of precipitation. A dry, mild winter starts in October and lasts until early February, when there is little humidity and average temperatures in the 22–23 °C (72–73 °F) range. Many hill rocks and lakes are located throughout district.

Kurnool is located at latitude 15° 48' 42.6" N; longitude 77° 58' 11.14" E. It has an average elevation of 273 meters (898 feet). It is settled in the central Deccan Plateau and northern part of Nallamalla Hills made up of granite rocks and hill formations. Most of the region is occupied by Deccan thorn scrub forests and Central Deccan Plateau dry deciduous forests towards the southern region of the district. The region falls under semi-arid climate which left the region barren making the cultivation dependent on seasonal rainfall. Tungabhadra and Krishna rivers merges and flows from northern border of district and additionally the district has many interlinked chains of lakes and ponds. Located in the semi-arid region of Telangana, Nagarkurnool has a predominantly hot and dry climate. Summer starts in March, and peak in May with average high temperatures in the 42 °C (108 °F) range. The monsoon arrives in June and lasts until September with about 550 mm (22 in) of precipitation. A dry, mild winter starts in October and lasts until early February, when there is little humidity and average temperatures in the 22–23 °C (72–73 °F) range. Many hill rocks and lakes are located throughout district.

Climate, Terrain and Geology, Rivers/ Streams/ Water Courses, Seasons, Area and Population, Economy etc. are discussed in **Chapter 3**.

1.5 ENGINEERING SURVEYS AND INVESTIGATIONS

Relevant reports and data, development plans concerning to the proposed project and the project influence area was collected from concerned Departments and studied. Reconnaissance Survey, Road Inventory and Condition Survey of Bridges & other Structures and Culverts have done. From the road inventory data, the following is inferred:

- The proposed alignment is a green field corridor connecting both states through the proposed bridge across Krishna River.
- The proposed right of way is 45m as per site requirements.

Package -2- Construction of Iconic Hybrid Cable Stayed and Suspension Bridge Across Krishna River On NH -167K (Design Chainage 87+360 To 88+437 In The State Of Telangana And Andhra Pradesh Under EPC Mode Under NH(O))

- The proposed alignment is passing through various towns and habitations where few lengths are passing through commercial establishments. Except at the town locations, the existing land use is agriculture along both sides of the project stretch. In addition, the alignment is passing through the forest at many locations; total length of the forest in the complete project stretch is 8.35 KM which includes 3.5 KM in Telangana and 4.8 KM in Andhra Pradesh.
- The existing CD works are of different types like pipe culverts, minor bridges, slab culverts and major bridges are observed. Low-level causeways are also observed at many locations in the total project alignment, which needs to be reconstructed as a minor / major bridge considering the waterway and HFL of the stream. Due to low-level causeways, the road is sub-merged during the rainy season and
- In Telangana state, the MS pipeline of “Mission Bhagiratha” for water supply is observed on one/both sides of the alignment within the existing ROW. Shifting of this utility may be difficult considering cost & time factors. We are proposing a new alignment such as to avoid its shifting.
- The existing alignment is passing / connecting to several villages/ towns/ habitations. The width of ROW again reduces in the habituated areas. In urban development, there may be an encroachment on the ROW.
- The alignment passing through the following villages/habitations – Malleswaram, Sangameswaram, and Kapileswaram villages.
- Topographical Survey of the Project Road has been completed as per requirements of TOR.
- Other investigation ie Traffic Surveys, Soil investigations, FWD, NSV & Geotechnical Investigations etc. has also been completed.

Inventory, Condition Survey of Road, Culverts, Bridges & Structures and Site Surveys/Investigations are discussed in **Chapter 4**.

1.6 DESIGN STANDARDS

All the components of the Project Road has been designed as per provisions of latest MORTH/IRC Codes and practices, NHAI Circulars, AASHTO and Engineering Practices. Standards for Highway and Bridge/Structures components are detailed in **Chapter 4**.

Package -2- Construction of Iconic Hybrid Cable Stayed and Suspension Bridge Across Krishna River On NH -167K (Design Chainage 87+360 To 88+437 In The State Of Telangana And Andhra Pradesh Under EPC Mode Under NH(O)

1.7 TRAFFIC SURVEYS AND ANALYSIS

Primary Traffic Surveys

Various Traffic surveys as per the TOR has been conducted at Kalwakurthy, Nagarkurnool and Kollapur along the project road.

The following surveys were carried out in consultation with the client.

Sl. No.	Type of Survey	Section Name	Location & Chinage	Survey Date	
				From	To
1.	Classified Traffic Volume Count Survey	Kalwakurthy to Nagarkurnool Road	Kalwakurthy (Km 6.80)	25.08.2021	31.08.2021
		Nagarkurnool to Kollapur Road	Peddakothapalli(Km 17.8)	23.08.2021	29.08.2021
		Kollapur to Pebbair Road	Ramapuram (Km 1.60)	29.08.2021	04.09.2021
		Hyderabad to Kurnool Road	Addakal Toll Plaza	26.08.2021	01.09.2021
2.	Origin-Destination Survey & Willingness to Pay Survey	Kalwakurthy to Jadcherla Road	Kalwakurthy	07.09.2021	08.09.2021
		Devarkonda to Boothpur Road	Vnkatapuram	01.09.2021	02.09.2021
		Hyderabad to Kurnool Road	Addakal Toll Plaza	02.09.2021	03.09.2021
3.	Axle Load Survey	Kalwakurthy to Nagarkurnool Road	Kalwakurthy (Km 6.80)	31.08.2021	01.09.2021
		Nagarkurnool to Kollapur Road	Peddakothapalli(Km 17.8)	27.08.2021	28.08.2021

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Sl. No.	Type of Survey	Section Name	Location & Chinage	Survey Date	
				From	To
4.	Turning Movement Count Survey	NH 167K & NH 167	Kalwakurthy	02.09.2021	03.09.2021
		NH 167K & SH-20	Nagarkurnool	02.09.2021	03.09.2021
		NH 167K & Wanaparthy Road	Kollapur	04.09.2021	05.09.2021
5.	Speed & Delay Survey	Along the Project Road		08.09.2021	09.09.2021

Secondary Data

In addition to the above primary surveys, the following data/information was also collected from various authorities.

- ❖ Registered motor vehicles data for the Project Influencing districts/ states.
- ❖ Fuel sales data along the project road.
- ❖ Net State Domestic Product of Telangana, Andhra Pradesh and Karnataka.
- ❖ Net District Domestic Product (NDDP), per-capita income etc. for influencing area (PIA).

Average Daily Traffic (ADT)

Daily traffic volume by vehicle type and direction is added separately and averaged to determine the Average Daily Traffic (ADT). The traffic given below includes non-tollable traffic as well. ADT, observed at the two survey locations, in vehicles and in PCUs, are presented in below table 1.1.

Table 1.1: Average Daily Traffic (ADT) on the Project Corridor

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Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
Car/ Jeep/Van	1446	1176	560
Two-wheeler	2798	3036	2066
Auto Rikshaw	165	248	208
Minibus	3	5	2
School Bus	1	3	0
Bus (Govt)	108	165	87
Bus (Pvt)	5	2	2
LCV (4 Tyre)	200	210	98
LCV (6 Tyre)	67	47	20
2-Axle	22	29	8
3-Axle	33	23	10
4-Axle and 6 Axle	48	51	11
7 Axle Above	0	0	10
Tractor	15	13	14
Tractor with Trailer	16	31	19
Cycle	17	1	6
Cycle Rickshaw	0	0	1
Animal cart	1	0	0
Others	20	10	1
Total in Numbers	4963	5049	3121
Total In PCUS	4202	4312	2457

Traffic Survey's findings, analysis and projections are discussed in **Chapter 6**.

Typical Cross Sections

Typical Cross Sections generally comply by the stipulations in IRC: SP: 73-2018 "Standards for Two Laning of Highways with Paved Shoulders". To suit the site requirement different types of Typical Cross Sections designed and proposed for the project road and are presented in **Annexure I**.

Proposal for Bypasses, Realignments

Realignments proposed for the package where the existing alignment is passing with poor geometrics and development of existing geometrics are not feasible due to constraints like lesser ROW, Forest land and social issues.

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The consultants were studied three alignment options including the existing alignment **and finalized one best alignment after various site visits, detailed discussions and subsequent presentations with R&B NH Division/ MoRTH officials at various stages.** Take off and merging point from the existing road are finalized considering various aspects like expected future development, angle of intersection, crossing of major streams/ railway line crossings etc. Tentative alignment of bypass is developed considering proposed length, terrain condition, natural water bodies, forest and habitation etc.

Pavement Design

Design of New Flexible Pavements

The pavement design based on pavement section comprising conventional base/ sub-base materials for a total design period of 15 years and design CBR 10%, designed as per IRC: 37-2012 with bituminous surfacing using VG-40 or equivalent modified bitumen as per the design catalogue. The proposed composition is shown in **Table 1.4**.

Table 1.4: Pavement Composition for New Construction

Homogeneous Section	Location		Adopted Design Traffic (MSA)	Pavement Crust Thickness			
	From Km	To Km		BC	DBM	WMM	GSB
HS1	0+000	36+000	45	40	100	250	200
HS2	36+000	75+000	45	40	100	250	200
HS3	75+000	93+500	45	40	100	250	200

HS1 : Kalwakurthy to Nagarkurnool

HS2 : Nagarkurnool to Kollapur bypass End

HS3 : Kollapur bypass End to Bridge East Approach end

Major Bridges, Minor Bridges And VUP

There are 35 bridges in total on project road. Out of which 34 are minor bridges and 1 Major bridges. The condition of the bridges is fair to good and the bridges are generally constructed of RCC. The length of the bridges varies from 6.00 m to 290.00 m. Their

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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location, span arrangement and length and type of structure of Minor and Major Bridges shown below in table no. 1.5.

Table 1.5: Details of Minor Bridges on Project Road

Sr. No.	Description		Design Chainage	Proposed Configuration	Proposed Width	Proposal
	Type	Water Body	Km.	Nos. x Span	m	
1	MNB	Stream	80+900	1 x 8.00	12.00	New Bridge
2	MNB	Stream	90+320	1 x 10.00	12.00	New Bridge
3	MNB	Stream	91+700	1 x 8.00	12.00	New Bridge

1.8 PRELIMINARY COST ESTIMATES & IMPLEMENTATION SCHEDULE

Based on the above, costing has been estimated and are presented in below Table 1.7.

Table 1.7: Estimated Project Cost

Project Cost Summary			
Sr. No.	Particulars	Amount In Rs.	Amount In Cr.
A	Civil Construction Cost		
1	Foundation	43,81,02,122.38	43.81
2	Substructure	1,34,69,32,053.53	134.69
3	Superstructure	4,00,87,52,286.73	400.88
4	Stay Cable & Suspension Cable	2,00,24,33,160.00	200.24
5	Exit ramps, Approaches, Drain, BHMS, Illumination etc.	36,48,01,634.56	36.48
	Total Estimated Civil Cost (Excl. GST):	8,16,10,21,258.00	816.10

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	GST @ 18% of A	1,46,89,83,826.00	146.90
B	Total Estimated Cost (Incl. GST):	9,63,00,05,084.00	963.00
	Contingencies @1 % of A	8,16,10,213.00	8.16
	Agency Charges 3 % of A	24,48,30,638.00	24.48
	Price Escalation @ 5 % on A	40,80,51,063.00	40.81
	Maintenance @ 3.75 % on B(For 10 years)	36,11,25,191.00	36.11
C	Preconstruction Cost & other Cost		
	Cost towards Forest Clearance (LS)	10,00,00,000.00	10.00
D	Total Project Cost	10,82,56,22,189.00	1,082.56

Implementation Schedule and Packaging

The length of Project stretch is 1.077 Km (incl. Iconic Bridge) and cost is 1082.56 Crores including GST, therefore it recommended that project road should be undertaken as single package on EPC Mode.

2 PROJECT DESCRIPTION

2.1 Introduction

The alignment is passing through two states Telangana and Andhra Pradesh. Both the states are separated by the River Krishna. The project includes preparation of DPR and Project Management Consultancy for up-gradation of 2/4/6 lane with paved shoulders configuration of newly declared NH 167 K from its junction with NH 167 near Kalwakurthy connecting Nagarkurnool, Kollapur, Rampur in the state of Telangana, Mandugula, Sivapuram, Karivena and terminating at its junction with NH 40 near Nandyala in the state of Andhra Pradesh including a major bridge across river Krishna. The alignment is passing through Nagarkurnool District in Telengana, Kurnool & Nandyala districts of the Andhra Pradesh respectively.

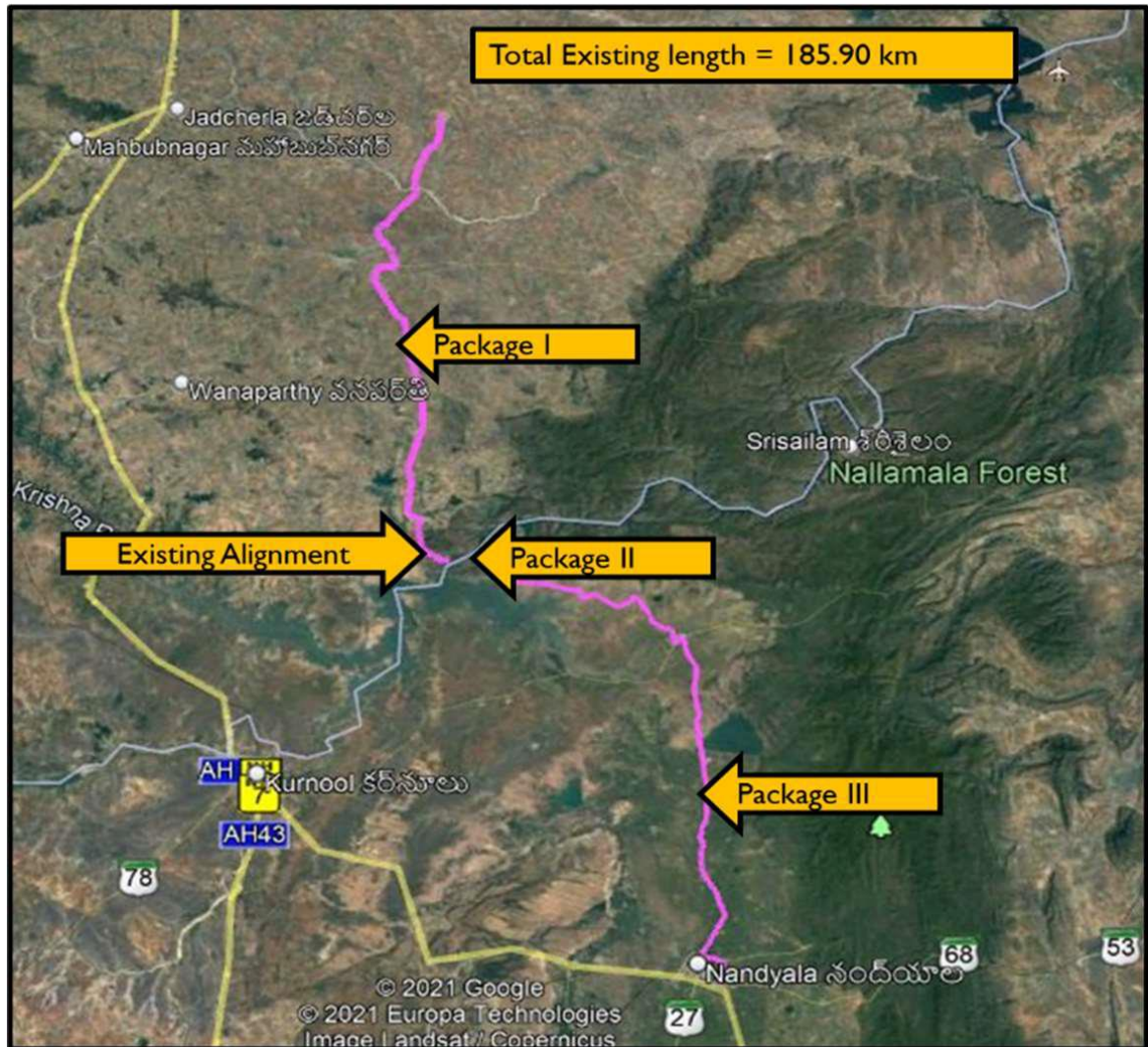
The NH-167K passing through both the states were not connected due to the lack of bridge on backwater of Srisailem dam on river Krishna near Somasila. There is a famous temple – Sangameshwaram in Andhra Pradesh i.e on the other side of River Krishna. The area is surrounded by high hills and has reserved forest. The width of the valley is about from 500 M 2000 M. The normal depth of water is about 30 – 35 M in the valley. The population on the banks of Krishna River on the Andhra side is very rare/scattered due to the hilly region and Sri Sailam Tiger Reserved Forest.

There is no connectivity between the two states across Krishna River and there was long pending demand for a bridge from the local peoples. The proposed NH 167 K will be the shortest link between NH167 and NH 40 in the two states. Hence Ministry of Road Transport and Highways has decided to construct a major high-level ICONIC river bridge on Krishna River, to develop as a tourist location and improvement/widening of newly declared NH 167K.

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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2.2 Status of Work

Agreement for providing consultancy service was executed on 30th July, 2021.

The Inception Report and Quality Assurance Plan has already been submitted vide Consultant's letter dated 17.08.2021 detailing Consultant's Methodology and Work Plan and Traffic Survey Proposals. As per requirements of work, all the Traffic and other Engineering Surveys and investigation, namely Classified Traffic Volume Count, Origin Destination survey, Turning Movement, , Axle Load, Speed and Delay surveys, Topographical survey with Lidar, Road/Bridge inventory, FWD, NSV, Sub Soil investigations and Geotechnical

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investigations have been completed. Present stage of submission is “**Detailed Project Report**”.

2.3 Current Submission

The current submission is the detailed project report, the purpose of which, is to define the design criteria to be used in the design of hybrid-cable stayed bridge across Krishna River in the State of Telangana.

This document forms the basis of analysis, design and detailing for structural components of the hybrid-cable stayed bridge across Krishna River, which includes superstructure, substructure & foundation. The design hypothesis is based on the IRC and other relevant Indian and International codes.

This report contains 7 chapters:

Chapter – 1	:	Executive Summary
Chapter – 2	:	Project Description
Chapter – 3	:	Socio Economic Profile
Chapter – 4	:	Engineering Surveys and Investigations
Chapter – 5	:	Geometric Standards & Designs
Chapter – 6	:	Traffic Survey details and Analysis
Chapter – 7	:	Improvement Proposals

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3 SOCIO-ECONOMIC PROFILE

3. About the state

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

The districts in which the study corridor passes through are the primary Project influence area. Given the above, the major economic characteristics are addressed at the project district level, which is Nagarkurnool in the state of Telangana, Kurnool and Nandyala districts in the state of Andhra Pradesh.

All statistics used to study the past economic performance of the PIA are based on secondary official sources of information. The base data required was collected from the Directorate of Economics and Statistics, Govt. of Andhra Pradesh.

3.1 Demographic Profile of Telangana

The state of Telangana was formed on the 2nd of June, 2014, and it is the youngest state in the Indian Union. It is a land-locked state located in the southern Indian peninsula on the Deccan Plateau, with Hyderabad as its capital. The region lies between 15°50'10" N and 19° 55'4" N latitudes and 77°14'8" E and 81°19'16" E longitudes. It is bordered by Maharashtra on the North and North-West, Chhattisgarh on the East and North-East, Karnataka on the West, and Andhra Pradesh on the South and South-East. Telangana is ranked 12th in the country in terms of population and ranked 11th in terms of area. The region is majorly drained by Godavari and Krishna rivers with 79% and 69% catchment areas respectively. The most commonly spoken language in the state is Telugu. The other languages used are Urdu, Hindi and English.

The total Geographical area of the state is 1, 12, 077 Square Kilometers. There are 33 districts in Telangana. Revenue Divisions: There are 74 revenue divisions, 594 revenue mandals, and 10,909 revenue villages in the state. Local Bodies: The state has 12,769

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Gram Panchayats; 129 municipalities and 13 municipal corporations. Legislative Divisions: There are 119 assembly constituencies and 17 parliamentary constituencies in the state.

Key Highlights

Total Population

The total population of Telangana as of 2011 was 3, 50, 03, 674. This was nearly 2.89% of the population of India in 2011. According to the projections of the National Commission on Population, Ministry of Health & Family Welfare, Government of India, the population of Telangana in the years 2021 and 2031 would be 3, 77, 25, 000 and 3, 92, 07, 000 respectively. This is 2.77% and 2.66% of the total population of the country in 2021 and 2031 respectively. The state's share in the national population is estimated to decrease by 0.23 percentage points between 2011 and 2031.

Gender-wise population

Of the total population in Telangana in 2011 1, 73, 92, 041 are females and 1, 76, -11, 633 are males. The share of females and males in the total population of the state is 49.69% and 50.31% respectively. The sex ratio (the number of females per thousand males) of the state is 988. The sex ratio among the districts varies from 950 to 1046 with a median value of 996. Three districts; Suryapet, Mahabubabad and Hanumakonda; have a sex ratio of 996. Rangareddy, with a sex ratio of 950, has the lowest sex ratio in the state. Nirmal, with a sex ratio of 1046, ranks highest among the districts in terms of the sex ratio.

Urban and Rural Population

The urban and rural population of Telangana are 1, 36, 08, 665 and 2, 13, 95, 009 respectively. The share of the urban and rural population out of the total population in the state is 38.88% and 61.12% respectively. Hyderabad and Medchal Malkajgiri are the most urbanized districts in the state, with 100% and 91.47% of their populations, respectively, residing in urban areas. Mulugu has the highest share of rural population at 96.10% followed by Narayanpet at 92.63%.

Social Groups

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The total SC and ST populations of Telangana are 54, 08, 800 and 31, 77, 940 respectively. The two social groups account for 15.45% and 9.08% of the state's total population respectively.

Mancherial has the highest share of SC population out of the total district population at 24.72% followed by Jayashankar Bhupalpally at 22.08%. The districts with the least share of SCs out of the total district population are Hyderabad and Medchal-Malkajgiri at 6.28% and 9.42% respectively. In the entire state, the maximum number of persons from the SC community reside in Rangareddy district, and the least number in Mulugu district.

Literacy

The total literacy rate of the state is 66.54%. The literacy rate among females and males respectively is 57.99% and 75.04%. The literacy rate among the rural population is 57.30% whereas among the urban population this is 81.09%

Child Sex Ratio

There are 38, 99, 166 children (0-6 years) in the state of which 18, 81, 231 are females and 20, 17, 935 are males. The child sex ratio (0-6 years) in the state is 932. The child sex ratio (CSR) among the districts varies from 903 to 971 with a median value of 934.

Wanaparthy and Mahbubabad, with a CSR of 903, have the lowest child sex ratio in the state, whereas Mulugu, with a CSR of 971, has the highest child sex ratio in the state

Table 3.1 gives the population characteristics of the state of Telangana between 2001 and 2011 for all the census years.

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Table 3.1: Population Characteristics – Telangana

Sl. No.	Item	Unit	2001	2011
1	Total Population	Lakhs	309.87	350.03
2	Growth rate over the previous census	Percentage	18.77	13.58
3	Density of Population	Persons per sq. Km.	270	312
4	No. of Households	Lakhs	65.24	83.04
5	Male Population	Lakhs		176.12
6	Female Population	Lakhs		173.92
7	Rural Population	Lakhs		213.95
8	Urban Population	Lakhs	98.53	136.08
9	Urban Population as a percentage of total Population	Percentage	31.8	38.88
10	Literacy rate – Total Population	Percentage	58	66.54
11	Workers – Total	Lakhs		163.41
	Workers – Agriculture	Lakhs		31.51
	Workers – Non-agriculture	Lakhs		131.9

Source:Socio Economic Profile,2020-21,Telangana.

Urbanization is very predominant in Telangana and there are a large number of towns in the project district of Mahaboobnagar as per 2011 census. Now these towns are part of Nagarkurnool district. **Table 3.2** gives the district-wise towns and their population.

Table 3.2: Population of Towns and Cities-2011 census

Sl. No.	Name of the Town / City / Urban Agglomeration	Civic Status of Town / City	Population 2011
(1)	(2)	(3)	(5)
I. Nagarkurnool District			

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Sl. No.	Name of the Town / City / Urban Agglomeration	Civic Status of Town / City	Population 2011
(1)	(2)	(3)	(5)
1.	Kalwakurthy	M.P.	28, 060
2.	Tadooru	M.P.	26, 157
3	Nagarkurnool	M.P	26, 801
4	Peddakothapalli	P	5, 407
5	Kollapur	P	4, 732

Note: M.P – Major Panchayat, M- Municipal Corporation, P – Panchayat

Source: Directorate of Census Operations, Andhra Pradesh, Hyderabad.

3.3 Economic Profile of the State

Agriculture

The agriculture sector is the backbone of the rural economy in Telangana. 4 key sub-sectors constitute the 'Agriculture & Allied Sectors' – Crops, Livestock, Forestry and Logging, and Fishing and Aquaculture. The sector is a principal source of employment for around 55% of the population in the state. Since state formation, the contribution of the 'Agriculture and Allied Sectors' to Telangana's Gross State Value Added at current prices has consistently improved from 16.3% in 2014-15 to 20.5% in 2020-21(PE). There was a 142% increase in the Gross Value Added by the sector between 2014-15 and 2020-21.

Industry

The industrial sector contributes 19% to the state's Gross State Value Added (GSVA). The manufacturing sector contributes 9.3% to the state's GSVA – accounting for about half of the industrial sector GSVA. The state has made considerable progress in improving its Ease of Doing Business ranking, moving up from rank 13 in 2015 to consistently maintaining a position in the top 3 ranked states thereafter.

The growth of the industrial sector in the state has generally outpaced the growth of the sector at the all-India level (see Figure 5.2). The state has witnessed steady growth

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across all sub-sectors, with mining and quarrying consistently contributing more to the industrial growth of the state in comparison to the sub-sector's all-India growth contribution.

Initiatives such as TS-iPASS have created a favorable investment climate in the state.

Since the formation of the state, 13,379 MSMEs have registered under TS-iPASS with an investment of Rs. 18, 465 crore and creation of 2, 43, 556 jobs; 889 large firms have registered through TS-iPASS over the same period, with an investment of Rs. 1, 88, 881 crore and generation of 12, 14, 462 jobs. There is also rapid growth in emerging sectors such as electronics, which has attracted Rs. 7, 500 crore worth of investment in the last two years.

Pharmaceutical Sector

The state's pharmaceutical sector has made significant contributions to the COVID-19 response. It has manufactured and supplied life-saving drugs in bulk quantities including Remdesivir and Favipiravir used to treat COVID-19 patients. One of the first RTPCR test kits approved by the Indian Council of Medical Research (ICMR) was from Hyderabad and since then, a number of companies have developed additional RT-PCR kits, rapid test kits, viral transport mediums, reagents and technology-based diagnostics solutions.

Importantly, the first indigenously developed vaccine for COVID-19, Covaxin, comes from Bharat Biotech, a Hyderabad-based company. Other companies from the state like Biological E and Dr. Reddy's are also engaged in the development and manufacture of COVID-19 vaccine.

Spread across 19,000 acres, Hyderabad Pharma City is the world's largest pharmaceutical industrial park. In December 2019, the Government of India granted National Investment Manufacturing Zone (NIMZ) status to the project. It is expected that the project will attract around Rs. 71,000 crore in investment and generate 5.6 lakh jobs.

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Electronics

The state is home to several global companies specializing in electronics manufacturing, such as Intel, Micron, Qualcomm, Nvidia, Motorola, AMD, CDAC, Apple, Oppo, One Plus and Micromax. Encouragingly, a number of companies, such as Micromax, Radiant, HFCL and HSIL, have made repeat investments in the state. The state has attracted over Rs. 7,500 crore worth of investment, with employment generation potential of over 20,000, in the last two years under its Electronics Policy 2016.

The state has two electronics manufacturing clusters near Hyderabad (E-city at Raviryal and Maheshwaram Science Park). They are spread in an area of 912 acres and 30 units have been established so far, and are a key part of the state's approach to make Hyderabad the hub of Electronic System Design Manufacturing (ESDM). Two new industrial clusters are designated as the Electric Vehicle Cluster and the New Energy Park to promote electric vehicle and energy storage systems manufacturing in Divitipally (in Mahabubnagar district) and Chandanavelly (in Rangareddy district).

Mining

The state has a rich variety of minerals suitable for mining; 76,974 hectares of land has been leased for mining and quarrying activities. Major minerals by production value include coal, gravel, granite, limestone (used in cement), sand, laterite and quartz.

In terms of number of units, major industries include granite cutting and polishing (36%), stone crushing (23%), brick kilns (12%), stone slabs or napaslab (9%) and concrete ready mix (6%). In 2020-21, the top districts (and mineral resources) in terms of mineral revenue collection are: Siddipet (granite, quartz, sand), Karimnagar (granite, laterite, sand), Suryapet (limestone, granite, stone metal), and Mahabubnagar (road metal, quartz, feldspar).

The Government helps utilize this natural endowment in a sustainable and eco-friendly manner in line with the National Mineral Policy, 2019. It processes mineral concession applications, grants leases for minor minerals, approves mine plans, inspects mines, curbs illicit mining, collects mineral revenues an

Handloom, Textiles and Handicrafts

The Government is implementing various schemes for the development of both the handloom and power loom sectors, including the Nethanna ku Cheyutha (Thrift Fund Scheme), Chenetha Mithra (Wage Compensation Linked Input Subsidy), Powerloom Weavers Thrift Fund Scheme, and the loan waiver scheme. The Government has surveyed and issued geo-tagged numbers to 17,573 handloom weavers and 38,262 powerloom workers in the state.

The state is best known for the production of long staple cotton, which is highly regarded globally. The Government has formulated the Telangana Textile and Apparel Policy (T-TAP) 2017-22 and has invested in infrastructure to make the state a hub for the textile industry—with a focus on spinning, weaving, knitting, processing and garment manufacturing. The Kakatiya Mega Textile Park (KMTP) is being established to develop Warangal as a textile hub. The foundation stone of the park was laid in October 2017, and the park spans 2,000 acres covering the entire value chain—from ginning to garment making.

The state houses many artisanal clusters that produce items such as furniture, toys, silver filigree, brass and bangles. Two prominent regions include Nirmal and Karimnagar. Nirmal is known for its distinct furniture and toys. For instance, in 2009, Nirmal painted furniture received Geographical Indication rights, which are given to products that have a specific geographical origin. In addition, a large variety of toys and paintings are produced by local Naqash artisans in Nirmal.

Exports

In 2019-20, the state exported a total of Rs. 1.8 lakh crore, 28.8% of which was goods exports and the remaining 71.1% services exports. In terms of total goods exports, the state started from Rs. 35,444 crore in 2015-16 and reached Rs. 52,170 crore in 2019-20, with a strong compounded annual growth rate of 10.2% per annum over this period. The top three destinations of goods exported from the state include the USA, China and Russia. The state ranks 6th in export preparedness (2nd among landlocked states), according to NITI Aayog's Export Performance Index Report 2020 (see Figure 5.14). It ranks 5th on the Logistics Ease Across Different States (LEADS) index, and 2nd among landlocked states.

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Pharmaceutical products are the largest exported items from the state, accounting for approximately one-third of all exports. The state is also successfully diversifying its export basket, with rapid growth in sectors such as plastic and paper products.

Table 3.4: Gross State Domestic Product by Sectors at Constant (2011-12) Prices (Rs. In crores)

S.No.	Industry	2020-21(PE)	% of total
1	Primary Sector	1,19,477	18.5
2	Secondary Sector	1,14,933	17.8
3	Tertiary Sector	3,44,269	63.7
4	Total Gross State Domestic Product	6,44,599	100.0

Source: Statistical Abstract- 2021, Telangana.

Trends in GSDP growth rate

In Telangana, the tertiary sector has been consistently the greatest contributor to the GSDP at 64 % in 2020-21, followed by the primary sector at 19% and finally, the secondary sector at 18 %.

Table 3.5: GROSS STATE DOMESTIC PRODUCT OF TELANGANA AT CONSTANT PRICES (2011-12) (RS. IN CRORES)

S.No	Year	Primary	Secondary	Tertiary	Total	Per Capita Income (RS)
1	2011-12	65,676	92,778	1,77,597	3,59,434	91,121
2	2012-13	71,355	81,925	1,92,596	3,70,113	92,732
3	2013-14	72,616	82,240	2,09,440	3,89,957	96,039
4	2014-15	68,415	78,231	2,36,427	4,16,332	1,01,424
5	2015-16	65,708	94,944	2,63,191	4,64,542	1,12,267
6	2016-17	72,463	95,034	2,92,042	5,07,946	1,21,512
7	2017-18 (TRE)	80,395	1,06,133	3,14,214	5,57,410	1,31,503

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8	2018-19 (SRE)	89,357	1,19,963	3,39,068	6,12,148	1,47,787
9	2019-20 (FRE)	1,06,555	1,17,397	3,58,372	6,48,595	1,55,221
10	2020-21(PE)	1,19,477	1,14,933	3,44,269	6,44,599	1,53,298

Table 3.6: GROSS STATE DOMESTIC PRODUCT OF TELANGANA AT CURRENT PRICES (RS. IN CRORES)

S.No	Year	Primary	Secondary	Tertiary	Total	Per Capita Income(RS)
1	2011-12	65,676	92,778	1,77,597	3,59,434	91,121
2	2012-13	80,049	84,906	2,10,308	4,01,594	1,01,007
3	2013-14	89,016	90,440	2,42,273	4,51,580	1,12,162
4	2014-15	90,828	89,660	2,86,011	5,05,849	1,24,104
5	2015-16	92,834	1,07,860	3,29,641	5,77,902	1,40,840
6	2016-17	1,08,666	1,09,608	3,81,912	6,58,325	1,59,395
7	2017-18 (TRE)	1,24,623	1,27,556	4,27,998	7,50,050	1,79,358
8	2018-19 (SRE)	1,47,775	1,48,977	4,82,845	8,60,078	2,10,563
9	2019-20 (FRE)	1,85,677	1,49,210	5,36,857	9,57,207	2,33,325
10	2020-21(PE)	2,16,285	1,47,922	5,33,231	9,80,407	2,37,632

Source: - Statistical Abstract,2021, Telangana..

The agriculture and allied sector in the state grew by 14.3% at constant prices in 2020-21(compared to the 3.6% agriculture growth rate at the national level).

The contribution of the secondary sector to Telangana's GSVA has been 16.5% and 19.9% at current and constant prices respectively.

The tertiary sector remains the dominant sector in the state's economy, contributing for 59.4% of state GSVA in 2020-21 at current prices and 59.5% of state's GSVA in 2020-21 at constant prices.

3.4 Socio-Economic Profile of Project Road Influence Area

3.4.1 Nagarkurnool

Nagarkurnool District is located in the southern region of Telangana State at a distance of about 130 Kms from the Capital City of Hyderabad. It is situated at a distance of 40 Kms Jadcherla i.e., Hyderabad - Bengaluru National High Way -44) The District Head Quarters i.e, Nagarkurnool Town is located between 16.48333 N latitude and 78.3333 E Longitude.

River Krishna flows through the District at Kollapur. There are 4 Major irrigation projects in the district. The district also has 2022 minor irrigation tanks. In addition Govt. of Telangana has accorded sanctions for restoration of 122 lakes under Mission Kakatiya Phase-I and 413 lakes under Mission Kakatiya Phase-II. Due to this there is good scope for increase in irrigated areas and also encouragement for fisheries sector in the district.

The district has large rural population. The main source of income for this rural population is agriculture and other allied activities like cattle rearing, fishing, poultry etc.

The District has 38 branches of Nationalized Banks, 5 branches of Private Banks, 25 Regional Rural Bank branches and 5 Cooperative bank branches. The Lead Bank in the District is Andhra Bank.

Due to increasing in the water resources available from MGKLI scheme and Mission Kakatiya there is also increasing in fish production. The district has 136 fish tanks with water spread area of 13918 hectares. There are 148 fisherman co-operative societies. Govt. has released 50 lakhs seed into tanks/reservoirs. The estimated production for the year 2016-17 is 7380 tonnes of fish and 150 tonnes of prawns. There is good potential for fish processing, fish feed and cold storage activities in the district.

The forests in this district are known to contain timber trees like bijasal (pterocarpus marsupium), Nalla maddi (terminalia tomentosa), Eppa (Hardwickia binata), ebony, teak, babul (Acacia arabica), mango and tamarind. The forest consists of brushwood,

tarvar (cassia auriculata) and other plants used for fuel. Important rivers Krishna flow through the district.

The principal food grain crops in Nagarkurnool district are rice, jowar, bajra and ragi while, the principle commercial crops are groundnut, castor, chillies and tobacco. Red-gram is the major pulse crop.

FACT SHEET OF NAGARKURNOOL DISTRICT

Demographic Profile

Area of the District	:	6,924 sq. Kms.
Population (2001 Census)	:	8, 61, 766
Male population	:	4, 37, 986
Female population	:	4, 23, 780
Density of population	:	124 persons per sq. Km.
Sex ratio	:	968 (Females per 1000 males)
No. of Mandals	:	16

Climate

Maximum temperature	:	42 °C
Minimum temperature	:	22-23 °C
Actual Rainfall	:	550 mm

Land and human resources utilization

Forest	:	2, 498.49 Sq.Kms
Agriculture	:	2, 44, 232 Hectares
Gross irrigated area	:	49, 269 Hectares

Social Infrastructure

Hospitals	:	01
Public Health Centres	:	24
Doctors	:	33
Hospital Beds	:	330

Education

High Schools	:	237
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Junior Colleges	:	59
Degree Colleges	:	24
Post Graduate Centres	:	1
Engineering Colleges	:	0
Medical Colleges	:	0
Polytechnical Colleges	:	0
Colleges of Education	:	7

Source : District Hand Book, Mahabubnagar

RESOURCES

Agro resources

Paddy, Castor, Pulses, Jowar, Maize, Ground Nut are the major crops grown in the District. Crop – wise details with area and production are indicated.

Table 3.7: AREAIN HECTARE OF MAIN CROPS

S.No	Crop	Area (in ,000 ha)
1	Paddy	12,752
2	Jowar	2685
3	Maize	67304
4	Red gram	5126
5	Maize	72
6	Chillies	346
7	Groundnut	19158
8	Bengal gram	224
9	Red gram	58
10	Cotton	83274

Source: Directorate of Statistics and Economics, Hyderabad.

Cropping area is increasing with availability of water from MGKLI Scheme and Mission Kakatiya scheme. Due to this many agro based industries can be set up in the District like Cotton Ginning mills and spinning mills, Rice Mills, Ground Nut Decorticators, Poultry and cattle feed units.

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Horticulture

The total area under Horticulture in the District is 21451 hectares.

Forest

Forests occupy an area of 2,498 Sq.Kms covering 36.8% of the total geographical area. Area under forest cover spread over Nagarkurnool and Achampet Divisions, with forest wealth such as Teak wood, Bamboo, Tamarind, Rosa grass, Beedi leaves ,Neem seeds, medicinal plants etc..

Minerals

The district is endowed with Minerals like Quartz, Feldspar, Laterite, Limestone, Barytes, emiprecious Stones as Major Minerals and Stone & Metal, Black Granite, Limestone Slabs, Fullers Earth, Gravel as Minor Minerals. Brief description of each Major Mineral is given below.

Feldspar & Quartz

The Mineral finds use in Ceramic Industries. It is occurring in the district as Pocket deposits, there are 37 no of Mining Leases including both Feldspar and Quartz

Quartz

The Mineral finds its use in Glass and Ferro Silicon Industries. It is occurring as associated Mineral with Feldspar. Part of the deposits is falling in the Forest area. Though there are many deposits of Quartz available in the Nagarkurnool District the consuming industries are located in Hyderabad from where the industries are acquiring the nearest Quartz deposits which are available in Ranga Reddy District.

Black Granite

The Mineral Limestone is available in Bijinepally, Kollapur, Nagarkurnool, Peddakothapally, Tadoor, Telkapally & Vangoor Mandal. There are about 7 mining leases given by the Mining department

Barytes

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The Mineral Barytes is available in Kollapur Reserve Forest area. The Mineral cannot be mined in Forest area unless and until the Forest department grants the permission.

LIVE STOCK RESERVES

The livestock population of the district is as follows:

Cattle	:	2, 39, 523
Buffaloes	:	1, 06, 373
Sheep	:	6, 62, 717
Goat	:	1, 95, 745
Others	:	25090
Poultry	:	18, 90, 760
Total	:	31, 20, 208

The sheep population in the district is 3rd highest in Telangana state after Nalgonda and Wanaparthy Districts.

Dairy development

Many farmers in the district particularly the small and marginal farmers are taking up this activity as a subsidiary occupation for complementing the insecure rain fed agriculture in the district. Dairy farm is an important allied agro activity suitable in this predominantly rural economy of the district. Total no. of Collection Centers are 215, total number of Milk producers Benefiting are 10555 and total chilling capacity of functioning units is 71500 lits per day

INFRASTRUCTURE

Communications

The District is well connected by Road ways. National High way No.167 NH-765 and NH-167K are passing through the district. The District has a 213 Km of National Highway besides 146 Km of State Highways and 3078 Km Z.P. Roads. The International AirPort at Shamshabad has connected the District by Air with the rest of the World.

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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National Highway	:	213	Km
State Highway	:	146	Km
Major District Roads	:	643	Km
Other District Roads	:	346	Km
Z.P. Roads	:	3078	Km

Table 3.8: Motor Vehicles of different classes

S.No.	Type of Vehicle	2020-21
1	Stage Carriages	0
2	Goods Vehicles	4055
3	Cars/Jeeps	885
4	Jeeps	1386
5	Taxies/cabs	27
8	Two wheelers	9819
9	Total Transport Vehicles	4195
10	Total non Transport Vehicles	12669
11	Total Vehicles	16864

Power

There is surplus power available in the district for industrial purposes. Further Express Feeders have been setup to cater the industrial needs. There are 75 Substations with domestic connections 123314, industrial 1477 and agricultural connection 61106.

EXISTING INDUSTRIAL ESTATES/ INDUSTRIAL DEVELOPMENT AREAS

There is one Industrial Park in the District located at Palem. The total area of the Industrial Park is 32 acres.

Industrial Scenario

The district is having 2 Large and Medium Industries and 290 micro enterprises in the sectors of Cotton and Granite cutting.

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OPPORTUNITIES BASED ON RESOURCES AND DEMAND

The proposed International Air Port at Shamshabad of Ranga Reddy district enhances the prospects for establishment of Export Oriented Units in the District. The district offers scope for establishment of industries based on resources and demand based are as indicated.

Nagarkurnool District has potential for many industries depending on the availability of resources as follows:

S.No	Type of Industrial activity	Potential area
1	Cotton Ginning & Pressing Units Raw Rice and Parboiled Rice Mills	Nagarkurnool, Kalwakurthy, Kollapur
2	Mineral Based Units	Veldanda, Vangoor, Telkapally
3	Ground Nut Decorticators Oil Expeller Units	Achampet, Bijnepally
4	Fish Processing Units Cold Storages	Kollapur, Bijnepally
5	Milk Chilling Dairy Products	Nagarkurnool, Kalwakurthy
6	Solar Power Plants	Kalwakurthy, Achampet, Telkapally, Veldanda
7	Stone Crushers and hot mix plants	Kollapur, Thimmajipet, Nagarkurnool

Granite polishing

Good quality of pink and black granite is available in the district. 70 Quarry Leases for Minor Minerals are existing in the district. Due to the increasing demand for granite which is being extensively used for construction purposes. There is good scope for 2 to 3 units to come up at Amangal, Pebbair, Veldanda, Vangoor and Telkapally. Due to major irrigation projects under construction like Palamuru-Rangareddy lift irrigation scheme, and MGKLI scheme, construction-based industries like Stone crushers and Hot mix plants are having good scope in the district.

4. ENGINEERING SURVEYS AND INVESTIGATIONS

4.1 Introduction

The Chapter primarily discuss about Package-2 for Iconic Krishna River Bridge from Km. 87/360 to 88/437. Also, this chapter deals with the Engineering Surveys and Investigations carried out during the study. Alignment study, Topographical surveys and other field investigations like Traffic Surveys, Road and Bridge inventory, FWD, NSV and Sub Soil investigations have been discussed in this chapter.

4.2 Collection of Secondary Data

All relevant reports and data, development plans concerning to the proposed project and the project influence area was collected directly or with the help of the Client from concerned Departments of Government of Andhra Pradesh. Existing details of project road i.e. culvert and bridge details were collected from PWD Department.

4.3 Study of the Existing Alignment

4.3.1 Alignment of NH 167K

The project is the preparation of Detailed Project Report, Pre-construction activity and Project supervision of upgradation to 2/4 lane with paved shoulders configuration of newly declared NH 167K starting from its junction with NH 167 near Kalwakurthy connecting Nagarkurnool, Kollapur, Rampur in the state of Telangana., Madugula, Atmakuru, Velugodu, Nandyalaa for a length of 185.00 Kms including a four-lane major bridge across river Krishna. There is no connectivity in between Telangana and Andhra Pradesh states due to the lack of bridge on Krishna River.

Existing two/ intermediate/ single lane road, an old state highway in Andhra & Telangana which is connected to NH 167 near Kalwakurthy and NH 40 in Andhra Pradesh near Nandyalaa is important, shortest link. Currently, the roads have no connectivity due to the lack of a bridge on the Krishna River. People on one of the banks of the Krishna River have to travel more than 80 Kms to reach another bank of the river. The lack of connectivity between the two states is one of the reasons for the

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slow development/progress of the area. Hence, it is decided to construct a 4-lane major bridge and its approaches on Krishna River connecting to National Highways through proposed widening & improvement of NH 167K from Kalwakurthy – Nagarkurnool - Kollapur in the state of Telangana and Atmakuru, Nandyalaa in the state of Andhra Pradesh. Due to the lack of a National Highway network in the area and no thorough connectivity due to the major Krishna River, the area is not developed. Since the location at Somasila and Sangameshwaram are having historic and pilgrimage places on both banks of the river, tourism can also be developed.

Package-02 Proposed major bridge constructed over the Krishana River between the state Telangana and Andhra Pradesh. The start points of proposed Bridge near Somsila in the state of Telangana at km. 87+360. The end point of proposed bridge near Kapileswaram in the state of Andhra Pradesh at Km. 88+437. The alignment is follows green field and forest area. The total length of package is 1.077 Km. The span arrangement of Bridge is 192+480+192m.

However, as per the techno-feasibility & pertaining to cutting – filling sections, an appropriate solution was selected, for which detailed study i.e., plan & profile etc. are prepared and presented in the respective volumes.



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4.3.2 Terrain

The project bridge from Km. 87+390 to Km. 93.500 passes through plain and rolling terrain.

4.3.3 Curvature

The alignment of the bridge has no curvilinear portions.

4.3.4 Religious structures

There are no major religious structures along the Bridge.

4.4 Bypass and Realignment Proposal

The alignment of bridge is passing through the green field alignment. Hence there is no requirement of bypass and realignment proposal.

4.5 Intersections

No Major and Minor Bituminous existing junctions are found on along the project road.

4.5.2 Proposed Cross Section

The proposed Bridge cross section is 4 Lane carriageway with paved shoulders at Bridge and Bridge approach.

For second level 12.9 m walkway consisting of 6m glass walkway at center and 3.45 m side walkway on either side are proposed (refer TCS).

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4.5.3 Land Use and Roadside Environments

The entire stretch of the bridge passes through forest/ green field area.

4.5.4 Existing Right of Way (ROW)

The Bridge is passing through green field alignment. However, in view future development 45 to 60 m ROW is being proposed.

4.5.5 Bridges and Cross Drainage Works

The preliminary assessed summary of structures along the project road is presented in Table 4.5.

Table 4. 1: Summary of Structures

Sl. No.	Type of Structure	Number of Structure
1	Major Bridge	1

Table 4.6: Details of Minor Bridges on Project Road

Sr. No.	Description		Design Chainage	Configuration
	Type	Water Body	Km.	Nos. x Span
1	Hybrid Suspension and Cable stay Bridge	Stream (Krishana River)	87+898	1 x 192 + 1 x 480 + 1 x 192

4.6 Road Inventory Surveys

The proposed bridge alignment passing through the green field alignment. Hence no road inventory is required.

4.6.2 Railway Crossings

There are no Rail-Road crossings along the package stretch (Km. 87+390 to Km. 88+370).

4.7 Pavement Condition Survey

Not applicable for the project stretch since the alignment is a green field alignment.

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4.8 Topography Survey

Topographic survey using Total Station –

Total Station and through closed traverse distributed linearly running between two nearest Primary Control Stations ensuring accuracy in the order of 1 in 10,000 as per IRC. The errors within permissible limits were distributed in rational manner to establish the accurate and effective horizontal control grid.



Total Station



Drone Fitted with Lidar

Topographic survey using Drone –

Mapping & Survey grade drone systems can take significantly higher resolution images than current satellite or manned aircraft. Drones are equipped with high resolution camera and sensors that allow for easy and quick capture of aerial data.

The Drones may be remotely controlled or can fly autonomously through software-controlled flight plans in their embedded systems working in conjunction with on-board sensors and GPS

Collected data is then transformed into Orthomosaics, point clouds and 3D models (DSM & DTM,) for analysis.

The output files that can be manipulated in popular CAD and GIS programs such as AutoCAD-3D, Global Mappers and others. The geo-referenced aerial maps can have sub centimeter resolution. Millions of data points can be collected within a short period of

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time. Underbrush, creeks, rivers, rocks and extreme topography impedes site inspections.

Drones minimize the risk to ground crews. All this leads to cost efficiency, a quicker decision process and safety. The bottom line, aerial data is easily transformed into actionable information.



Figure 4-1: SOP in Drone Surveying

Some of the photographs as shown below



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Bathymetric Survey for Krishna River Bridge –

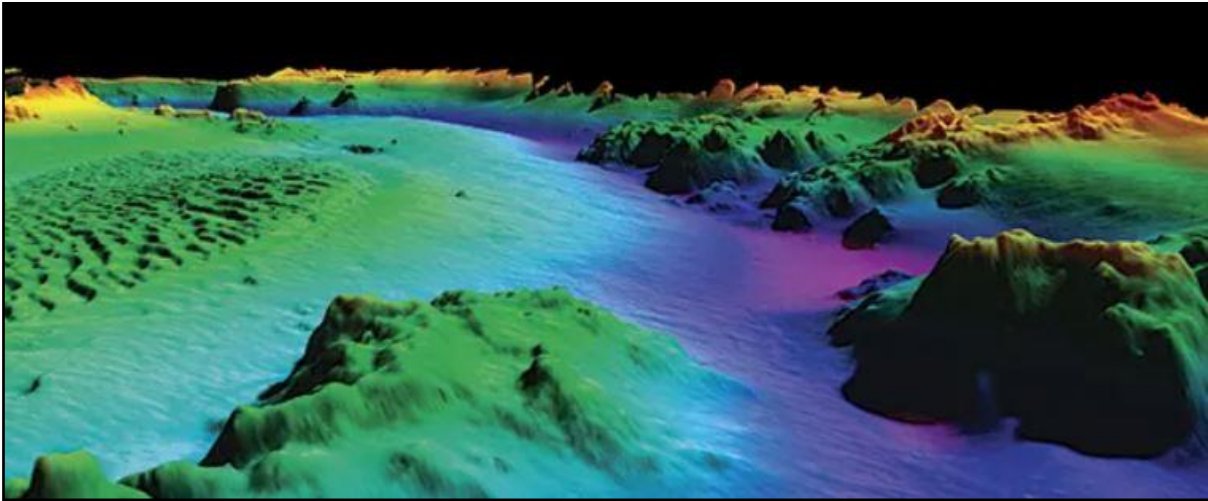
Bathymetric Survey is the measurement of underwater Depth for lakes, Oceans and other major water bodies by using an echo-sounder to provide safety to surface and subsurface navigation. From this survey we can get seafloor beds as contour lines which are called depth contours or isobaths. LiDAR technology may also be used for preparing Bathymetric maps.

The bathymetry survey of the river around the bridge piers is to be done using modern Acoustic Depth-sounding Instruments (ADCP) with Survey Line planning and border editor mounted to a floating raft with built in Geodetic Parameters & Utilities. After the field data-acquisition process is complete, post-processing and integration of data is necessary in order to glean physically-relevant information.

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The generated final files are contours, plotting sheets, and output for CAD, fly-through views, 2D/3D Models for visualizing, cross sections and volumes calculations.

4.9 Pavement, Sub grade Soil and OGL Investigations



4.9.1. Objective

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

The main objective of pavement investigations for alignment is to evaluate the strength, condition of the sub-grade for the native/sub-grade soil for the Existing Project Road. These characteristics are intended for designing overlay for the intended MSA, and for designing new pavement for the project road with enhanced durability benefits.

4.9.2. Various Tests and Test Standards

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

- Dynamic Cone Penetration Test (DCPT)
- Field Moisture Content (FMC) and Field Dry Density (FDD)

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- Pavement Crust Measurement
- Laboratory Testing of Sub-grade Soils

After the collection of representative samples, various laboratory tests as given in Table 4.7.

Table 4.7: Type of Lab Tests and Test Methods

Sl. No	Name of the Test	Test Method
1	Moisture Content at field	IS 2720, Part-2
2	Grain Size Analysis	IS 2720, Part-4
3	Atterberg Limits	IS 2720, Part-5
4	MDD & OMC Modified Proctor Compaction (Heavy Compaction)	IS 2720, Part-8
5	California Bearing Ratio Test (CBR)	IS 2720, Part-16
6	Free Swelling Index (FSI)	IS 2720, Part-40

4.9.4. Quarry and Construction Materials Investigations

4.9.4.1. Objective and Scope of Work

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

- Identification of potential sources of borrow pit soils indicating places and the status of quarries whether in operation or new sources along with identification of naturally available granular material (GSB) if any
- Potential sources of stone quarries
- Availability of sand
- Availability of Fly ash/Pond ash

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- Bituminous and Steel

The investigations of the materials were mainly concentrated on the above guidelines and were initially restricted along the respective road alignments and nearby sources adjoining road sections. When suitable information was not available, the reconnaissance extended towards further more kilometers where potential sources were found and where access was not a major constraint.

4.9.4.2. Survey Methodology

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

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

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

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

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

4.9.4.3. Various Tests and Test Standards

The following tests were performed on soils, aggregates, sand as per relevant Indian standard codes as presented in the Table 4.14 below.

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Table 4.14: Type of Tests and Test Methods

Sl. No	Name of the Test	Test Method
Soil		
1	Moisture Content at field	IS 2720, Part-2
2	Grain Size Analysis	IS 2720, Part-4
3	Atterberg Limits	IS 2720, Part-5
4	MDD & OMC Modified Proctor Compaction (Heavy Compaction)	IS 2720, Part-8
5	California Bearing Ratio Test (CBR)	IS 2720, Part-16
6	Free Swelling Index(FSI)	IS 2720, Part-40
Aggregates		
1	Flakiness Index and Elongation Index	IS 2386, Part-1
2	Specific Gravity and Water Absorption	IS 2386, Part-3
3	Aggregate Impact Value	IS 2386, Part-4 or IS:5640
4	Stripping Value	IS : 6241 or AASHTO T:182
5	Soundness in Sodium Sulphate and Magnesium Sulphate	IS:2386 ,Part-5 or IS:383
Sand		
1	Gradation	IS: 383
2	Fineness Modulus	IS: 383

4.9.4.4. Borrow Areas

A summary description of borrow area indicating their Location with respect to project chainages, approximate distance from the source of nearest point on the project and owner ship details are given below table 4.15.

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Table 4.15: Description of Soil Borrow Sources

S N o	Road Name	Chain age of Propo sed Align ment (km)	Side	Co-ordinates		Location Village Name /	Lead from Propo sed Alignm ent (km)	Type of Land	Area (Acr es)	Appro x. Quant ity (m3)
1	Kalwa kurthy to Somasila Section of NH-167K	54.000 (BA-4)	LHS	16.278 316	78.360 833	Pedda kothapally	0.040	-	5	6167.4 00
2		59.000 (BA-3)	LHS	16.231 457	78.352 404	Sathapur	0.550	-	2	2466.9 60
3		72.600 (BA-1)	RHS	16.147 259	78.237 132	Ennam betla	9.000	Govt. Land	6	7400.8 80
4		81.700 (BA-2)	LHS	16.061 974	78.310 953	Somasila	0.000	Forest Land	-	-

It has been concluded that borrow areas are available within the reasonable lead along the Project alignment.

Representative samples have been collected and tested in the laboratory. The following tests were conducted on the samples collected from borrow areas for assessment of their suitability. The laboratory test results are given in Table 4.16.

Classification (Grain Size Analysis and Atterberg Limits)

Compaction Characteristics: Moisture-Density relationships (Heavy compaction)

Soaked CBR and Free Swelling Index (FSI)

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Table 4.16: Laboratory Test Results of Borrow area Soil

Kalwakurthy Connecting Nagar kurnool, Kollapur, Rampur Section _Borrow Area Summary Results																					
Sl. No.	Location (km)	Side (LH S / RH S)	Gradation: Percent by weight retained the sieve (IS:2720 Part- IV)				Clay and Silt Content (%)	Atterberg Limits (IS:2720 Part - V)			Soil Classification	Modified Proctor Test (IS:2720 Part - VIII)		Dry Density (g/cc)			Soaked CBR (%) at 3 Energy Levels			4 Days Soaked CBR	FSI (%)
			4.75 mm	2.00 mm	425 micron	75 micron		(LL) %	(PL) %	(PI) %		OM C (%)	MD D (gm/cc)	10 blows	30 blows	65 blows	10 blows	30 blows	65 blows		
BA-1	BA-1 (72+600)	RHS	16.05	29.60	34.30	8.35	11.70	20.13	NP	NP	SM	8.000	2.031	1.79	1.94	2.07	5.94	10.51	18.28	12.00	5.00
BA-2	BA-2 (81+700)	LHS	6.40	11.65	27.55	12.25	42.15	25.17	18.45	6.72	SM	8.650	1.968	1.77	1.89	2.01	5.28	12.05	18.53	13.00	12.50
BA-3	BA-3 (59+000)	LHS	26.00	35.80	30.00	7.70	0.50	24.99	NP	NP	SM	8.950	1.928	1.75	1.86	1.99	5.88	11.68	18.08	11.00	0.00
BA-4	BA-4 (54+000)	LHS	6.80	19.05	50.80	8.35	15.00	24.34	NP	NP	SM	8.040	2.040	1.88	1.99	2.08	5.94	10.21	15.76	10.00	6.25

Based on laboratory test results of borrow soil test, the available borrow soil CBR is 10%, 11%,12% & 13.00%.

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A few photographs of borrow area sources are depicted below. Lead chart for borrow areas is also included.



Picture 1: Borrow Area-1 at Km 72.600



Picture 2: Borrow Area-2 at Km 81.700

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Picture 3: Borrow Area-4 at Km 54.000

4.9.4.5. Coarse Aggregate

The objective of this investigation is to identify, inspect and evaluate the aggregate sources, which would supply for the pavement and concrete, quality aggregate for the road construction. During the site visit, aggregate quarries are observed along the alignment. Existing and known quarries/crushing plants and other potential extraction sources of quarry areas in the project vicinity have been inspected. The summary of estimated available quantities of aggregates and ownership details are given at Table 4.16.

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Table 4.16: Details of Coarse Aggregate Crusher Location

S. No	Road Name	Ch (km)	Side	Co-ordinates (GPS)		Location / Village Name	Lead (km)	Contact Person		Cost of the material at crusher (Rs)/unit					Clearance authority	Existing Details (whether approved or not)	Remarks
								Name	Number	6 m m	10 m m	20 m m	40 m m	Stone Dust			
1	Kalwakurthy -Somasila _NH-167 K	72.600	RHS	16.123369	78.299344	Ennambetla	13 (from Kollapur)	B. Srinivas Reddy	94410 88814	Not under operation					R & B	Yes	BSR Crusher
2	Kalwakurthy - Somasila _NH-167 K	37.000	LHS	16.434574	78.350890	Vana patta	0.5	B. Srinivas Reddy	94410 88814	1800	1800	2000	1800	2200	R & B	Yes	Sri Uma Maheshwara Super Constructions

From the inspected sources, representative samples have been collected and tested in the laboratory for various engineering properties of the aggregates as per the specification's requirements. From this investigation it has been concluded that good quality aggregate sources with sufficient quantity are available along the expressway with a reasonable lead. The laboratory test results are given in Table 4.17 below

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Test results of the Coarse Aggregate Samples of the project road									
Sl. No.	Location and Name of Quarry (km)	Size (mm)	Specific Gravity	Water Absorption (%)	Aggregate Impact Value (%)	Loss Angeles	Combined Flakiness Index & Elongation Index (%)	Stripping Value	Remarks
1	Sri Uma Maheshwara Super Constructions at 37.000	40	2.77	0.43	28.89	24.72	27.1		
		20	2.74	0.35	28.33	26.04	29.34	95 -100	
		10	2.81	0.48	28.25	27.5	30.94	95 -100	
2	BSR Crusher at Km 72.600	40	2.79	0.25	23.07	25.7	37.02		
		20	2.82	0.2	23.51	27.8	36.94	95 -100	
		12	2.81	0.35	22.84	27.02	39.62	95 -100	

Test results of the Fine Aggregate samples of the project road											
Sl. No.	Location of River & Source (km)	Gradation: Percentage of Passing the sieve (IS:2720 Part-IV)							Silt Content (%)	Fineness Modulus	Sand Laying in Zone as per IS: 383
		10.0 mm	4.75 mm	2.36 mm	1.18 mm	600 micron	300 micron	150 micron			
1	Sri Uma Maheshwara Super Constructions at 37.000	100	97.24	91.79	80.78	53.53	13.59	3.91	0.7	3.58	Zone-2
2	BSR Crusher at Km 72.600	100	99.94	99.84	99.73	98.41	33.89	12.42	4.27	2.52	Zone-4

Table 4.17: Test Result of Coarse Aggregates

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BSR Crusher at Km 72.600



Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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Sri Uma Maheshwara Super Constructions at Km 37.000

4.9.4.6. Fine Aggregate – Sources and Tests

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

For plain and reinforced cement concrete (PCC and RCC) or pre-stressed concrete (PSC) works, fine aggregate shall consists of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attach the embedded steel. Motorized sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine

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aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386 (Parts I to VIII). The contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Sand/fine aggregate for structural concrete shall conform to the following grading requirements:

Table 4.19: Grading Requirement of Sand

IS Sieve Size	Percent by Weight Passing the Sieve		
	Zone I	Zone II	Zone III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
236 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 microns	15-34	35-59	60-79
300 microns	5-20	8-30	12.40
150 microns	0-10	0-10	0-10

During the site reconnaissance, two sand sources have been identified nearer to the project vicinity. While, the fineness moduli of sand is 3.01, sand sources are nearer to Zone IV as per IS 383. Silt content of both the two sources has been found within limit. Thus, identified sources of sand can be considered suitable for use in concrete works after proper screening and processing.

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Manufactured Materials

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

a) Bitumen

Bitumen is available from refinery at Vizag and Chennai.

b) Cement

Cement is produced in Assam can be procured directly from manufacturers or from their local authorized agents at NagarKurnool.

c) Steel

Structural steel, reinforcement steel (HYSD, TMT), HT strand, etc. are manufactured indigenously in India by reputed companies and can be procured directly from manufacturers or from their local authorized agents at NagarKurnool.

4.10 Sub Grade Soil and Material Investigations

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

- Dynamic Cone Penetration Test (DCPT)
- Field Moisture Content (FMC) and Field Dry Density (FDD)
- Pavement Crust Measurement
- Laboratory Testing of Sub-grade Soils

After the collection of representative samples, various laboratory tests are given Table 4.9 below

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Table 4. 22: Type of Lab Tests and Test Methods

Sl. No	Name of the Test	Test Method
1	Moisture Content at field	IS 2720, Part-2
2	Grain Size Analysis	IS 2720, Part-4
3	Atterberg Limits	IS 2720, Part-5
4	MDD & OMC Modified Proctor Compaction (Heavy Compaction)	IS 2720, Part-8
5	California Bearing Ratio Test (CBR)	IS 2720, Part-16
6	Free Swelling Index (FSI)	IS 2720, Part-40

4.10.1 DCP test (TRL Method) to compute field CBR

Dynamic Cone Penetration test according to TRL method was conducted to assess the in-situ CBR at and below sub-grade level. The benefits of using DCPT are sub-grade strength can be evaluated in quick succession and large amount of data can be calculated in a short time. The test was conducted at large pits along the existing pavement edge of the road. TRL's DCP apparatus consists of a hardened steel cone (60° cone angle) 20 mm in diameter, which is driven by a weight of 8 Kg with a drop height of 575 mm. A schematic diagram of DCPT instrument has been shown in Figure 4.10.

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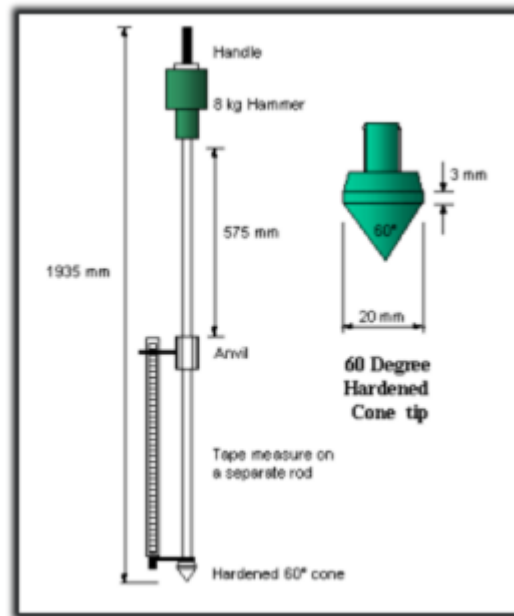


Figure 4- 1: Schematic Diagram of DCP Instrument

The CBR value was calculated for different soil layers encountered from the graph of penetration versus number of blows. The depth of penetration is measured after each blow, the output of the DCP test is in mm/blow. The penetration for each blow has been noted down in the field data sheet and the field CBR from DCPT test has been calculated using correlation between CBR and PI (Penetration Index). The correlations between CBR and PI are given in the Table 4.23 below.

Table 4.23: Correlations between CBR and PI

Author	Correlation	Field or Laboratory based Study	Material Tested
Kleyn (1975)	$\text{Log (CBR)} = 2.62 - 1.27 \log (\text{PI})$	Laboratory	Unknown
Harison (1987)	$\text{Log (CBR)} = 2.56 - 1.16 \log (\text{PI})$	Laboratory	Cohesive
Harison (1987)	$\text{Log (CBR)} = 3.03 - 1.54 \log (\text{PI})$	Laboratory	Granular
Livneh et. Al. (1994)	$\text{Log (CBR)} = 2.46 - 1.12 \log (\text{PI})$	Field and Laboratory	Granular and Cohesive

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Author	Correlation	Field or Laboratory based Study	Material Tested
Ese et. Al. (1994)	$\text{Log (CBR)}=2.44-1.07\log (\text{PI})$	Field and Laboratory	Aggregate base course (ABC)
NCDOT (1998)	$\text{Log (CBR)}=2.60-1.07\log (\text{PI})$	Field and Laboratory	ABC and Cohesive
Coonse (1999)	$\text{Log (CBR)}=2.53-1.14\log (\text{PI})$	Laboratory	Piedmont residual soil
Gabr (2000)	$\text{Lo(CBR)}=1.40-0.55\log (\text{PI})$	Field and Laboratory	gate base course (ABC)

The correlation for cohesive soil has been used to convert the DCPT into CBR. For the existing sub- grade soil is appraised as cohesive soil by visual means, CBR has been calculated by formulas given by Kleyn (1975) and Livneh et al (1994) and Harrison (1987) formula to compare the CBR values. We can see the field CBR values ranges mostly from 5 to 15.

The sub soil investigations report is attached to this report separately.

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5. GEOMETRIC DESIGN STANDARDS

5.1 General

This chapter describes the detailed design standards for Geometric Design.

5.2 Geometric Design Standards

5.2.1 Design Standards

Geometric Design Standards have been extracted from IRC SP 73-2018 (Geometric Standards for Rural Highways) Standards conforming to design speeds 100KMPH, 80KMPH and 65KMPH for plain and rolling terrain for given in **Table 5.1**.

Table 5.1: Geometric Design Standards for the Project Corridor

S. No	Description	Standards
1	Design Speed I.Ruling II.Minimum	100 KMPH 80 KMPH
2	Proposed ROW	45m/60m
3	Carriageway	
a)	Width per lane	3.5m
b)	Rate of taper	1 in 15
4	Paved shoulder	
a)	At Bridge	1.5m
b)	At Approach to bridges	1.5m
5	Horizontal Radius of curvature	
a)	Radius beyond which no super elevation is required (100/80 KMPH)	2000m/1200m
b)	Desirable minimum radius (100/80 KMPH)	400m/250m
6	Camber/Cross fall	
a)	Bituminous concrete surfacing including paved shoulder	2.5%
b)	Cement concrete surfacing	2.0%

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S. No	Description	Standards
c)	Earthen shoulder	3.0%
d)	Reverse cross slope of outer side earthen shoulders on super elevation	0.5% (min)
7	Super elevation	
a)	For radius of curvature more than desirable minimum (400m)	5%
b)	For radius of curvature less than desirable minimum (400m)	7%
8	Sight Distance	
a)	Desirable (100/80Kmph)-ISD	360m/260m
b)	Minimum (100/80Kmph)-SSD	180m/130m
9	Vertical Alignment	
a)	Minimum length of vertical curve	60m/50m
b)	Minimum k -value	
	i) Summit Curve (100/80 KMPH) 1. New carriageway/ Bypass/ Realignment/ Reconstruction Existing Carriageway	135/60 73.6/32.6
	ii) Valley Curve (100/80 KMPH)	41.5/25.3
c)	Maximum grade change not requiring vertical curve	≤0.5%/≤0.6%
10	Gradient	
a)	Ruling Gradient	2.5%
b)	Limiting Gradient	3.3%
c)	Minimum	0.3%
d)	For approaches to PUPs/ VUPs/ ROB/ FLYOVERS/ OVERPASS	Max 2.5%
11	Median Opening	
a)	Length of Median Opening	No median Opening
b)	Taper Length	Min 1 in 50
13	Embankment Side Slope	
		2H:1V

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S. No	Description	Standards
14	Safety barriers	
	Recommended barrier will be provided based on site requirement and as specified in Concessionaire Agreement	
17	Landscaping	
a)	In addition to tree plantation along the project road, landscaping will be done for median, interchanges, at service area and entry/exit ramps as per CA.	

5.3 Horizontal Alignment

The Project corridor is proposed to be improved as per the improvement proposals detailed above.

5.3.1 Radius of Horizontal Curves

The Radius required for horizontal curves shall be calculated from the following formulae:

$$R = \frac{V^2}{127(e + f)}$$

Where,

R = Radius in meters

V = Vehicle speed in Km/hour

e = Super-elevation ratio in meter/meter

f = Coefficient of side friction between vehicle tyres and the pavement (taken as 0.15)

Based on the above equation and the maximum permissible values of super elevation taken as 5.0%, for a speed of 100 Km/h, minimum radius is 400 m.

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According to the IRC: SP 73-2018 design standards, the desirable (ruling) radii of horizontal curves are 400m and 250 m, for plain/rolling terrains, corresponding to design speeds of 100Km/h and 80Km/h.

On new roads, horizontal curves should be designed to have the largest practical radius generally more than the above values corresponding to design speed. The Consultants recommend providing higher radii for smooth curvatures to accommodate possibility of higher speeds in future. This is because improvements in horizontal geometry are likely to prove very costly if taken up in future. Hence the radii proposed are as follows which also correspond to the maximum super-elevation values of 5.0%.

Table 5. 2: Adopted Horizontal Radii

Speed (Km/h)	Desirable Minimum (m)	Absolute Minimum (m)
100	400	250

5.3.2 Transition (Spiral) Curves

A transition curve, transition spiral, or spiral easement is a mathematically calculated Euler spiral fitted between a straight and a circular curve on a section of highway. In plan (i.e., the horizontal curve) the start of the transition is at infinite radius and at the end of the transition it has the same radius of curvature as the adjoining circular curve, thus forming a very broad spiral. At the same time in the vertical plane, the outside of the curve is gradually raised until the full super elevation is reached.

A spiral easement is used to smooth the change in centripetal acceleration experienced by a road vehicle and the users approaching the horizontal circular curve and to prevent abrupt forces and discomfort. Without such an easement the centripetal force would change abruptly, with very undesirable results, at the tangent point where the straight track meets the curve.

Minimum length of the transition curve will be determined from the following considerations and the largest of the three values will be adopted for design.

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- 1. Rate of change of centrifugal acceleration, the length of transition curve is given by:**

$$L_s = \frac{0.215V^3}{CR}$$

Where,

L_s = Length of transition in meters

V = Speed in Km/hr

R = Radius of circular curve in meters

$C = 80/(75+V)$ (Subject to a maximum of 0.8 and minimum of 0.5)

- 2. Based on Rate of change of super-elevation, the minimum length of transition is given by:**

$$L_s = eNW$$

Where,

L_s = Length of transition in meters

W = width of carriageway

N = Rate of change of super elevation

(Not steeper than 1 in 150 for roads in plain & rolling terrain)

e = super elevation ratio in meter/ meter

- 3. Based on Empirical Formula, the minimum length of transition is given by:**

$$L_s = 2.7 \frac{V^2}{R}$$

The IRC: SP73-2018 design standards suggest 130 m and 90 m transition curve lengths for circular curves of radii 360 m and 230 m (design speeds of 100 Km/h and 80 Km/h).

The Consultants propose maximum transition curve lengths of 120 m and 90 m for design speeds of 100 Km/h and 80 Km/h respectively. No transition curve will be required for a horizontal radius of 2000m or more for a design speed of 100 Km/h.

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5.3.3 Super elevation

Super elevation is tilting the roadway to help offset centripetal forces developed as the vehicle goes around a curve along with friction that keep a vehicle from going off the road. Super-elevation required on horizontal curves shall be calculated from the following formulae:

$$e = \frac{V^2}{225R}$$

Where,

e = super-elevation in meter/ meter

V = speed in Km/hr.

R = Radius in meters

The IRC: 73-2018 design standards propose a maximum super-elevation rate of 5% for plain and rolling terrains, and 7% to 10% for the mountainous terrain.

However, it has been experienced that high super-elevation causes the reduction in sight distance especially at junctions and in hill sections. Also, as mixed traffic is expected and high value of super elevation tends to generate high speeds, there are more chances of accident at curves. To enhance the safety aspects, the Consultant's propose 5.0% maximum super-elevation rate for the project road.

The radii of curves which do not require super-elevation are as under:

- (a) For design speed of 100 Km/h: 2000 m
- (b) For design speed of 80 Km/h: 1400 m

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

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5.3.4 Pavement Camber or Cross Fall

According to IRC SP 73-2018, the cross fall on straight sections of road carriageway, paved shoulders and paved portion of median shall be 2.5% for bituminous surface and 2.0% for cement concrete surface.

Cross fall for granular shoulders on straight portions shall be at least 0.5% steeper than the slope of the pavement and paved shoulder subject to a minimum of 3 percent.

On divided roads, i.e. dual carriageways having a median, the cross fall would be unidirectional for either side carriageway sloping towards the shoulder in straight reaches and towards the lower edge on horizontal curves. The camber on existing road would be modified to unidirectional cross fall.

On super elevated sections, the paved shoulders will have the same cross fall as the pavement. And the earthen portion of the shoulder on the outer side of the curve would be provided with reverse cross fall of 0.5% so that the earth does not drain on the carriageway and the storm water drains out with minimum travel path.

5.3.5 Sight Distances

Sight distance, in the context of road design, is how far a road user (usually a vehicle driver) can see before the line of sight is blocked by a hill crest, or an obstacle on the inside of a horizontal curve or intersection. Insufficient sight distance can have implications for the safety or operations of a roadway or intersection. The ability to see ahead is of critical importance in the safe and efficient operation of a vehicle.

Sight distances are a direct function of the design speed, perception-reaction time, driver eye height, object height and the coefficient of pavement friction.

Desirable sight distances as per IRC SP 73-2018 design standards are 360 m, 260 m for design speeds of 100 Km/h, 80 Km/h respectively.

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5.4. Vertical Alignment

5.4.1 Gradient

The vertical alignment should provide for a smooth longitudinal profile. Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile. Guidelines given in IRC SP 73-2018 shall be followed.

5.4.2 Maximum Grade

The IRC: SP: 84-2014 geometric design standards propose ruling vertical grades of 3.3% and limiting gradient to 5.0% for plain and rolling terrains.

The consultants propose a maximum 3.3% vertical grade for plain and rolling terrains.

5.4.3 Minimum Grade

To ensure adequate drainage, roadways typically have a minimum longitudinal grade of 0.5% to 0.6%, depending on the terrain. A minimum longitudinal gradient of 0.3% is considered adequate in most conditions to secure satisfactory drainage as per IRC: SP: 42. Hence the consultants propose a minimum 0.3% vertical grade. The minimum longitudinal grades as per IRC: SP: 73-1980 design standards are 0.5% for lined side ditches, and 1.0% for unlined side ditches.

5.4.4 Vertical Curves

Vertical Curves are the second of the two important transition elements in geometric design for highways, the first being Horizontal Curves. A vertical curve provides a transition between two sloped roadways, allowing a vehicle to negotiate the elevation rate change at a gradual rate rather than a sharp cut. The design of the curve is dependent on the intended design speed for the roadway, as well as other factors including drainage, slope, acceptable rate of change, and friction. These curves are parabolic and are assigned stationing based on a horizontal axis. Vertical curves should be provided at all grade changes exceeding 0.5%.

Vertical curves will be designed to provide for visibility at least corresponding to the safe stopping sight distance. More liberal values will be adopted wherever this is

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economically feasible. As per IRC: SP: 73-2018 design standards, the minimum lengths of vertical curves are 60m and 50m for design speeds of 100 Km/h and 80 Km/h respectively.

5.4.5 Summit or Crest Curves

Summit or Crest Curves are designed for Intermediate sight distance. The Consultants propose minimum summit curve K values of 135 and 60 for design speeds of 100 Km/h and 80 Km/h respectively in case of four-lane section as mentioned in IRC: SP 23-1983.

5.4.6 Valley or Sag Curves

Valley or Sag Curves are designed for headlight sight distance. The Consultant propose minimum K values for valley or sag curves recommended by IRC: SP 23-1983 as 41.5 and 25.3 for design speeds of 100 Km/h and 80 Km/h respectively.

For a good vertical design generally:

- At locations of grade break of 0.5%, vertical curves will be provided.
- The length of vertical curve will be not less than $0.6V$ (Kmph).
- At locations of sight deficiency, at least Stopping Sight Distance (SSD) will be provided

6. TRAFFIC SURVEYS & ANALYSIS

6.1. Introduction

This chapter presents traffic studies and analyses carried out for addressing various objectives and issues about the widening of the project road in the state of Telangana. The results of analysis have formed inputs for designing the pavement, developing capacity augmentation proposals, carrying out economic and financial analysis, wayside amenities along the design of intersections on the widened project road.

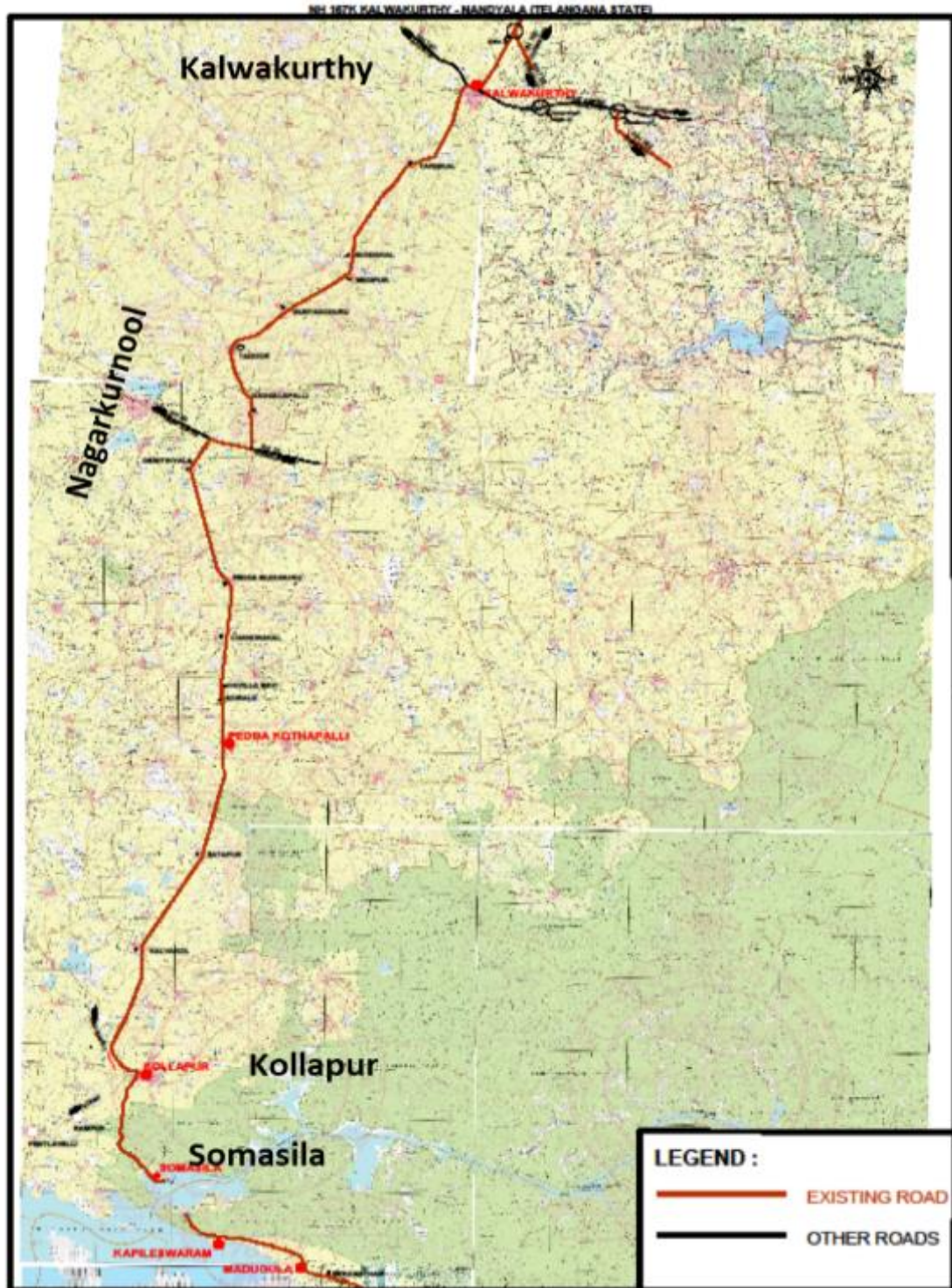
The traffic study aims at estimating the base year daily traffic and travel characteristics on the project corridor and forecasting the Average Annual Daily Traffic for project horizon year considering various constituent streams namely normal, induced, and divertible traffic on the project road considering the immediate influence area and surrounding road network of the project road. These sections proposed to be developed on a crucial aspect of the traffic study. Various aspects of traffic study are presented in the subsequence sections of this chapter.

Figure No.6.1 depicts the Project Road in Telangana and Krishna River Bridge

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Figure No 6-1: The Project Road In Telangana

6.2. Surveys and Investigations

6.2.1. Primary Surveys -Schedule

To capture traffic flow characteristics, travel pattern, speed characteristics, users preference regarding the traffic passing through the project road and other characteristics related to miscellaneous requirements on the Project Road, the following primary traffic surveys were conducted

- Classified Traffic Volume Count (TVC)
- Turning Movement Survey
- Origin-Destination Survey (OD)
- Axle Load Survey
- Speed and Delay Survey
- Pedestrian crossing survey
- Willingness to pay survey

Traffic survey Locations for carrying out TVC and OD surveys were selected after a site reconnaissance and discussed with the client officials considering the following parameters:

The survey locations are shown in **Table 6.1** for Kalwakurthy to Kollapur section.

Table: 6.1 Schedule of Traffic Surveys - Telangana

S. No.	Type of Survey	Section Name	Location & Chinage	Survey Date	
				From	To
1	Classified Traffic Volume Count Survey	Kalwakurthy to Nagarkurnool Road	Kalwakurthy (km 6.80)	25.08.2021	31.08.2021
		Nagarkurnool to Kollapur Road	Peddakothapalli (km 17.8)	23.08.2021	29.08.2021
		Kollapur to Pebbair Road	Ramapuram (km 1.60)	29.08.2021	04.09.2021
		Hyderabad to Kurnool Road	Addakal Toll Plaza	26.08.2021	01.09.2021

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S. No.	Type of Survey	Section Name	Location & Chinage	Survey Date	
				From	To
2	Origin-Destination Survey & Willingness to Pay Survey	Kalwakurthy to Jadcherla Road	Kalwakurthy	07.09.2021	08.09.2021
		Devarkonda to Boothpur Road	Vnkatapuram	01.09.2021	02.09.2021
		Hyderabad to Kurnool Road	Addakal Toll Plaza	02.09.2021	03.09.2021
3	Axle Load Survey	Kalwakurthy to Nagarkurnool Road	Kalwakurthy (km 6.80)	31.08.2021	01.09.2021
		Nagarkurnool to Kollapur Road	Peddakothapalli (km 17.8)	27.08.2021	28.08.2021
4	Turning Movement Count Survey	NH 167K & NH 167	Kalwakurthy	02.09.2021	03.09.2021
		NH 167K & SH-20	Nagarkurnool	02.09.2021	03.09.2021
		NH 167K & Wanaparthy Road	Kollapur	04.09.2021	05.09.2021
5	Speed & Delay Survey	Along the Project Road		08.09.2021	09.09.2021

Banners indicating “Traffic Volume Counting progress” with the name of Consultants is displayed near the survey stations (written in blue on white cloth) so that this is visible at least 200 m a head on both sides. Since round the clock surveys were carried out, arrangements for lighting and temporary shelters were made to conduct surveys during the night.

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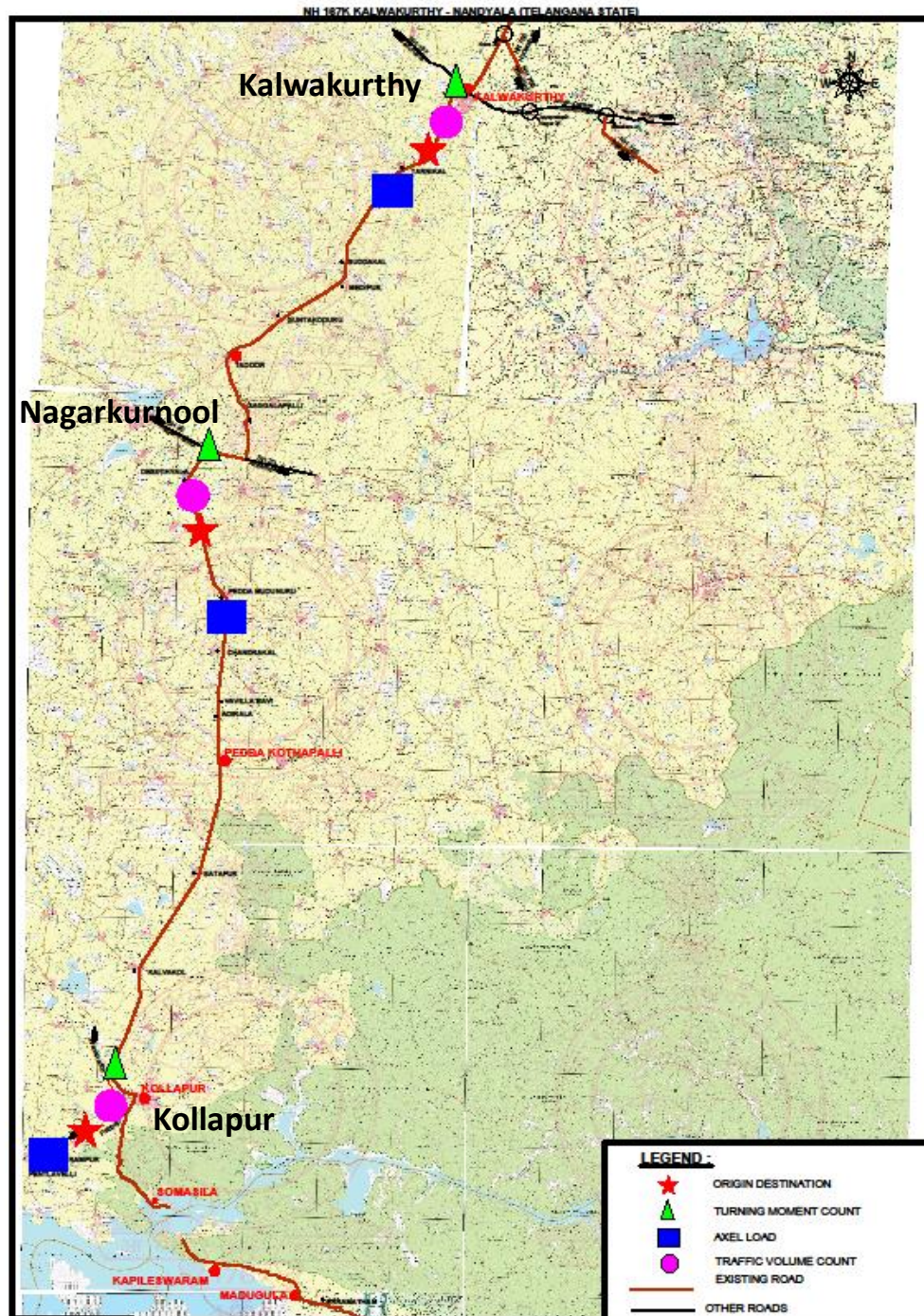


Figure No.2.1: Plan showing the Traffic Survey Locations- Telangana

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6.2.2. Classified Traffic Volume Counts

The traffic counts have been undertaken for seven (7) consecutive days for 24 hours each day. All results have been presented in tabular and graphical form. The survey data was analysed to bring out the hourly and daily variations. The traffic volume count per day has been averaged to show a weekly Average Daily Traffic (ADT) by vehicle type. The Annual Average Daily Traffic (AADT) has been worked out by applying seasonal factors.

Classified traffic volume surveys have been conducted by Automatic Traffic Counting and Classifier (ATCC). There is several methods are available for ATCC, in this study video-based traffic counts and classifier used for traffic volume count. Videography was conducted to capture traffic in each direction separately for seven continuous days. The cameras used for videography has infrared night vision, where the night video is as clear as day video even without any light.

The video camera was mounted on an object at least 12 feet high so that there is no occlusion in captured videos. The video streams were stored continuously in a DVR, and for safety, every hour video was saved in an external hard disk/pen drive. Care was taken to ensure that no vehicles are stopped in front of the camera and no obstructions interrupt video streams. Care was be taken (i) to ensure that there is a continuous power supply to cameras and DVRs, (ii) sufficient shade is provided to protect cameras from adverse climate, etc. Extra cameras, DVRs, etc., will be maintained at the site so that the video capture is continuous and uninterrupted.

The video captured was processed at the laboratory for classifying the vehicles (through an image processing software) based on the pre-decided vehicle categories in intervals of one hour. The software used for classifying vehicles will store images of detected and classified vehicles in different categories. Each image has a time of the day, date, and vehicle type in its file name.

The following photographs depict the site arrangement made for the traffic counts.

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Validation of Traffic Count and Classification

The count and classification from the above three methods were correlated to get an accurate and reliable traffic count and classification in all conditions.

The processed video was annotated through software. The annotated video contains category types of vehicles superimposed on the video (for example, when a 2-axle Truck passes through the vision of the camera, the annotated video displays the text of "2-axle Truck"). This enables review of vehicle count as well as classification later without counting the vehicles again.

6.2.3. Origin-Destination(O-D) Survey

The objective of the O-D survey is to obtain information regarding the travel pattern of passenger & goods vehicles from outside the study area.

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Consultants have conducted roadside interviews on a random sample basis covering all vehicle types and purposes, at appropriate locations. The survey has been conducted on a normal working day for twenty-four hours. The details regarding the origin, destination, the purpose of the trip and frequency of usage of road under consideration, shall be the major questions that asked the passengers. For the goods vehicles, apart from the above, the type of goods carried, and its approximate weight asked. The enumerators have been trained to ask questions and record the information carefully. The survey data was recorded on the format modified of proforma 2(a) and 2(b) on pages 13 and 14 of IRC: SP: 19-2001.

This survey has been conducted with the assistance of the local police and R&B Engineers, with regards to the stoppage of vehicle movement for the surveys.

The output from O-D surveys will be used for assessing the necessity of Bypass and desire pattern of vehicles.



O-D Survey – Kalwakurthy

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O-D Survey - Kalwakurthy during night time



O-D Survey - Nagarkurnool



O-D Survey - Nagarkurnool during nighttime

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O-D Survey at Addakal Toll Plaza(NH-44)



O-D Survey at Addakal Toll Plaza (NH-44) during Night time

The surveys locations have been shown in **Figure no.2.1**.

6.2.4. Turning Movement Count Survey

The objective is to determine a relationship between traffic volumes (by approach leg and in total) entering an intersection and the resulting average delays (seconds per vehicle).

Consultants have conducted turning movement counts on major intersections of the Project Road. The survey was carried out for 16 hours covering morning and evening peak periods at these intersection/ junctions.

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The classified Traffic volume counts of the vehicles turning from each arm of the intersection to all directions were independently noted, at intervals of 15 minutes using the standard survey forms. This data is useful to provide help in proper designing the intersection and to check whether a grade separator is warranted. The locations will however be finalised in consultation with the client before the conduct of the surveys.

The the survey locations have been shown in **Figure No.2.1**.

6.2.5. Speed and Delay Survey

The objective of the study is to obtain a basis for relating road network speeds, travel times and delays to the physical dimensions and design characteristics of the existing roads (including impacts of intersections).

Speed & delay survey, along with the road network, has been conducted by using the moving car method. Information regarding the number of vehicles overtaking the test car, overtaken by test car, number of vehicles in the opposite direction when the test car is moving in the opposite direction, the location, cause, and quantum of delay etc. has been noted. The speed will be calculated and represented by a link or by a corridor comprising several links.

The total project road has been divided into the following 3 sections and the Speed and Delay survey was conducted accordingly (section-wise).

- Kalwakurthy to Nagarkurnool
- Nagarkurnool to Kollapur
- Kollapur to Pentlavalli

The speed data is important for identifying traffic engineering improvements and management measures.

6.2.6. Axle load Surveys

The intensity of traffic loading and the corresponding damaging factor of different categories of vehicles is an important parameter for the design of pavements. The main objective of the axle load survey is to determine a Vehicle Damaging Factor (VDF) of

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each commercial vehicle and their axle load spectrum or axle load distribution and expected damage on pavement and extent of overloading.

The survey has been carried out on the trucks / LCVs and trailers alone, for 24 hours on a normal day (24 hours) at the selected location along with a classified traffic volume count survey. Apart from these vehicles, consultants have collected few samples of buses for the assessment of their weights. The survey covered traffic in both the directions and the sample selected on a random basis, which includes both loaded and empty vehicles. While selecting the location(s) of axle load survey station(s), the locations of existing bridges with load restrictions, if any, considered and such sites have been avoided.

The axle load data collected axle configuration-wise. The number of equivalent standard axles per truck was collected based on the results obtained. The results of the survey bring out the Vehicle Damage Factor (VDF).

The data from axle load surveys have been analysed to bring out the Gross Vehicle Weight (GVW) and Single Axle Load (SAL) distribution by truck type (axle configuration).



Kalwakurthy Nagarkurnool Road

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Kalwakurthy Nagarkurnool Road during Night time



Nagarkurnool Kollapur Road



Nagarkurnool Kollapur Road during nighttime

The surveys locations have been shown in **Figure No.2.1**.

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6.3. Data Analysis - Telangana

6.3.1 Analysis of Traffic Volume Count

The 7-day (24 hours, both directions) classified traffic volume count survey was carried out at Kalwakurthy, Nagarkurnool and Kollapur on the project corridor. Also conducted one day(24 hours) Classified Traffic Volume count survey at Addakal Tollplaza on NH-44 along with Origin Destination survey for estimating the intensity of traffic diverting to the project road. The traffic count locations and survey schedule are presented in **Table 6.1**.

Table 6.1 Classified Traffic Volume Count Survey Locations

S. No.	Location	Date
TVC 1	At Km 06.800 Kalwakurthy Nagarkurnool Road	25.08.2021 to 31.08.2021
TVC 2	At Km 17.900 Nagarkurnool Kollapur Road	23.08.2021 to 29.08.2021
TVC 3	At km 7.000 Kollapur Pebbair Road	29.08.2021 to 04.09.2021
TVC4	On NH-444 at Addakal Tollplaza	01.09.2021

Classified traffic volume surveys have been conducted by Automatic Traffic Counting and Classifier (ATCC). Videography was conducted to capture traffic in each direction separately for seven continuous days. The cameras used for videography has infrared night vision, where the night video is as clear as day video even without any light.

The traffic volume count data was processed using the commonly used spread sheet package. The processed hourly traffic volume data has been compiled direction-wise. Data collected from the site were analyzed to study daily variation and hourly variation of traffic, peak hour share, traffic composition and ADT at all the survey locations.

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Seasonality factors were applied for obtaining the AADT. The data on toll exempted vehicles are used while estimating the toll able traffic.

6.3.2. Passenger Car Units

The various vehicle types having different sizes and characteristics were converted into equivalent passenger car units. The Passenger Car Unit (PCU) factors recommended by the Indian Roads Congress in *Guidelines for Capacity of Roads in Rural Areas* (IRC: 64-1990). The same are presented in **Table No.6.2**.

TABLE 6.2: PCU FACTORS

Motorized Traffic		Non-Motorized Traffic	
Vehicle Group	PCU Factor	Vehicle Group	PCU Factor
Car, Jeep, Van, Taxi and Utility Vehicles	1.0	Bicycle	0.5
Auto Rickshaw / Tempo / 3-Wheeler	1.0	Cycle Rickshaw	2.0
2 Wheelers	0.5	Animal Drawn	6.0
Minibus	1.5	Hand Drawn	3.0
Standard Bus	3.0	Other Slow-Moving Vehicles	4.0
Light Commercial Vehicle (LCV)	1.5		
2 - Axle Truck	3.0		
3 - Axle Truck	3.0		
Multi Axle Truck (Semi Articulated & Articulated)/HCM/EME	4.5		
Agriculture Tractor	1.5		
Agriculture Tractor with Trailer	4.5		
Exempted Vehicles	1.0		

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

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6.3.3. Average Daily Traffic

Daily traffic volume by vehicle type and direction is added separately and averaged to determine the Average Daily Traffic (ADT). The traffic given below includes non-tollable traffic as well. ADT, observed at three survey locations, in vehicles and PCUs, are presented in **Table 3.3** and shown in **Figure 6.3**.

Table 6.3: Average Daily Traffic (ADT) on the Project Corridor

Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
Car/ Jeep/Van	1446	1176	560
Two-wheeler	2798	3036	2066
Auto Rikshaw	165	248	208
Minibus	3	5	2
School Bus	1	3	0
Bus (Govt)	108	165	87
Bus (Pvt)	5	2	2
LCV (4 Tyre)	200	210	98
LCV (6 Tyre)	67	47	20
2-Axle	22	29	8
3-Axle	33	23	10
4-Axle and 6 Axle	48	51	11
7 Axle Above	0	0	10
Tractor	15	13	14
Tractor with Trailer	16	31	19
Cycle	17	1	6
Cycle Rickshaw	0	0	1

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Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
Animal cart	1	0	0
Others	20	10	1
Total in Numbers	4963	5049	3121
Total In PCUS	4202	4312	2457

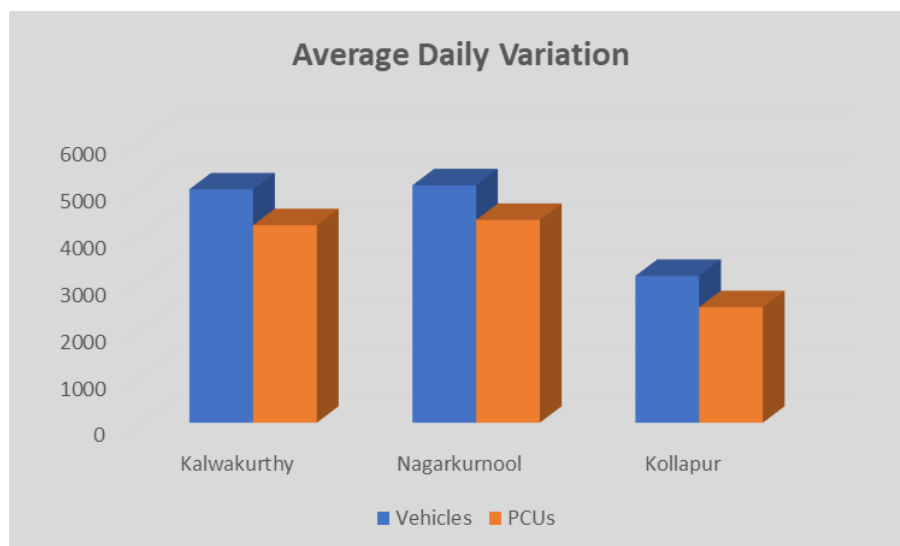


Figure 3.1: Average Daily Traffic

6.3.4. Daily Variation of Traffic

Daily traffic variation in terms of vehicles as well as in PCUs at each of the survey locations is presented in **Table 6.4 to 6.6** and graphically shown in **Figures 3.2 to and 3.4.**

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Table 6.4: Daily Variation of Traffic at Kalwakurthy

Date	Day	Kalwakurthy	
		Total Veh.	Total PCUs
25-08-2021	Wednesday	5398	4651
26-08-2021	Thursday	5646	4677
27-08-2021	Friday	5345	4570
28-08-2021	Saturday	4386	3803
29-08-2021	Sunday	4720	3929
30-08-2021	Monday	4738	3967
31-08-2021	Tuesday	4511	3817
Average Daily Traffic		4963	4202

Table 6.5: Daily Variation of Traffic at Nagarkurnool

Date	Day	Total Veh.	Total PCUs
23.08.2021	Monday	5124	4101
24.08.2021	Tuesday	5405	4442
25-08-2021	Wednesday	5425	4480
26-08-2021	Thursday	4974	4255
27-08-2021	Friday	4357	3930
28-08-2021	Saturday	5672	5100
29-08-2021	Sunday	4387	3875
Average Daily Traffic		5049	4312

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Table 6.6: Daily Variation of Traffic at Kollapur

Date	Day	Total Veh.	Total PCUs
29-08-2021	Sunday	2856	2191
30-08-2021	Monday	2945	2271
31-08-2021	Tuesday	3421	2768
01.09.2021	Wednesday	4055	3190
02.09.2021	Thursday	2984	2377
03.09.2021	Friday	2822	2235
04.09.2021	Saturday	2764	2172
Average Daily Traffic		3121	2457

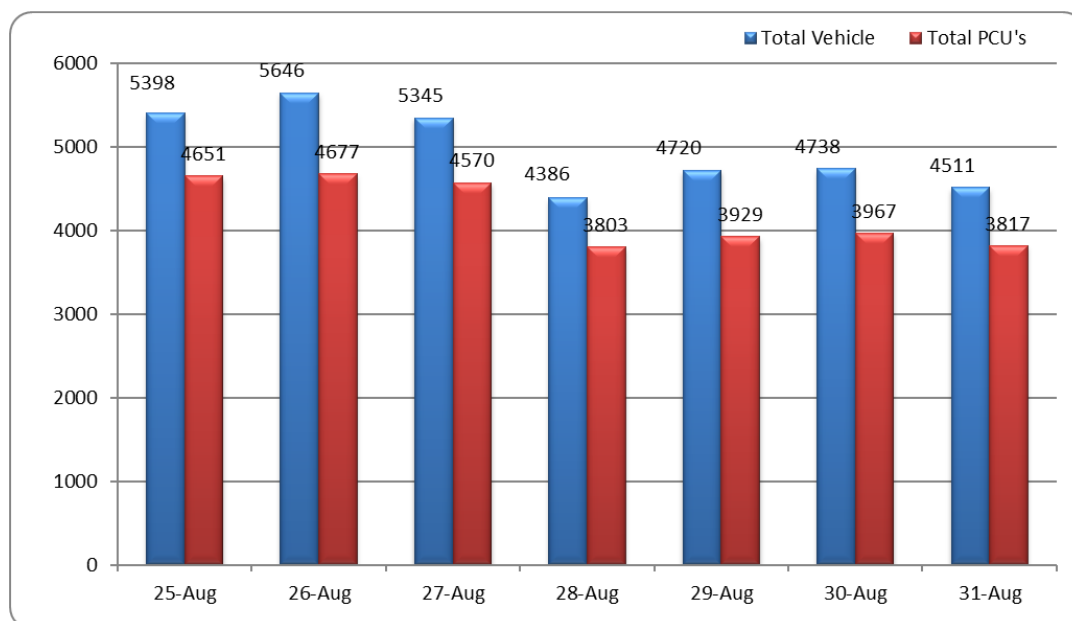


Figure 3.2 Daily Variation of near Kalwakurthy- Km 6.800

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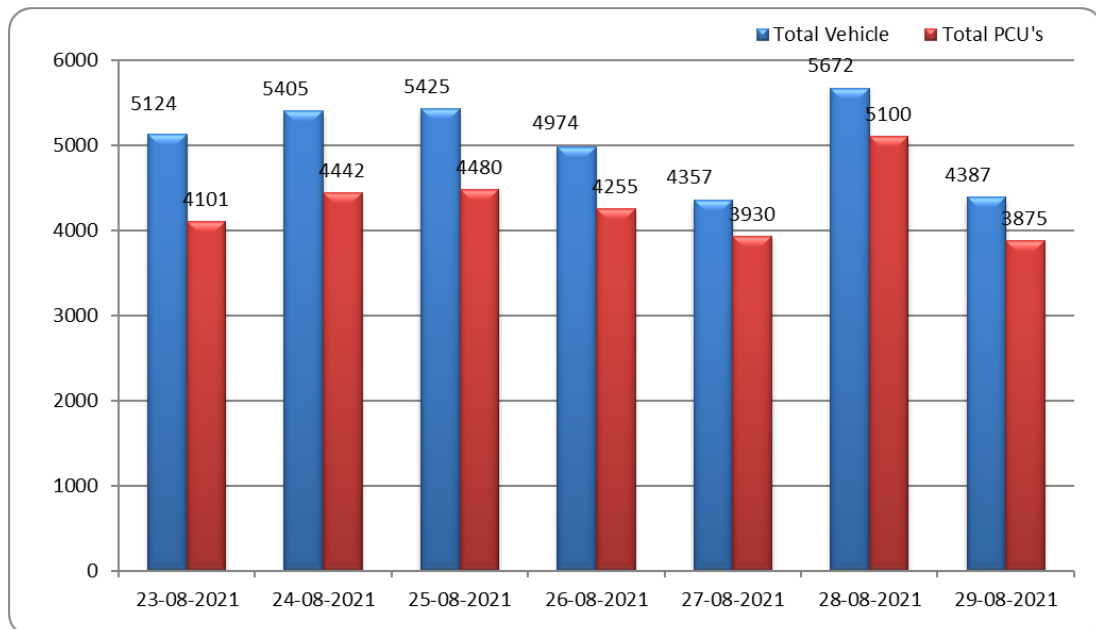


Figure 3.3 Daily Variation of Traffic near Nagarkurnool - Km 17.80

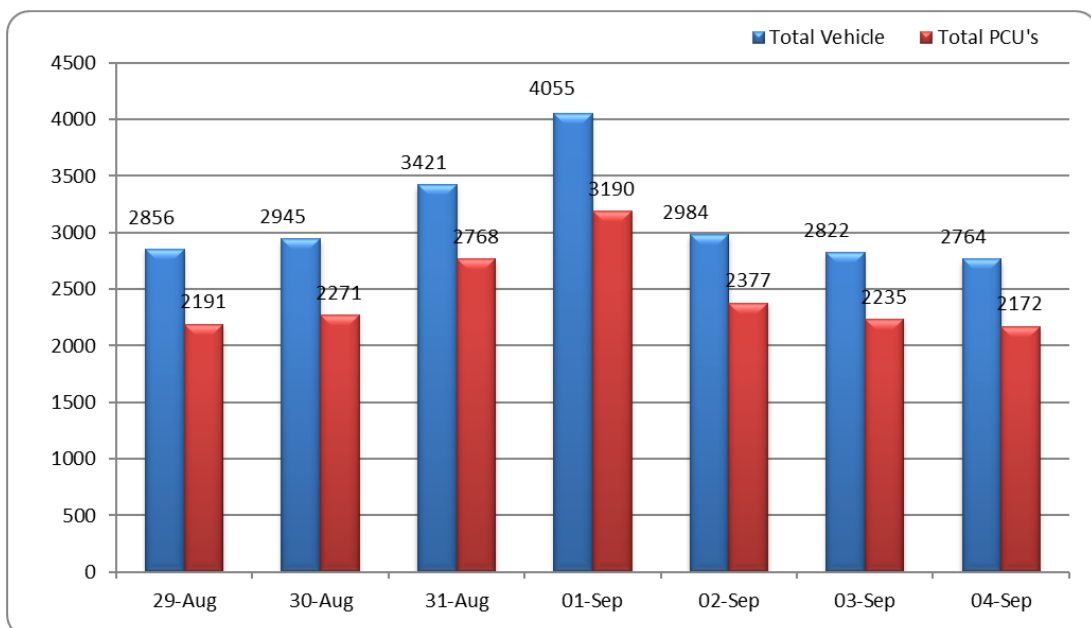


Figure 3.4 Daily Variation of Traffic near Kollapur - Km 1.600

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The mode-wise traffic breakup for the 7 days of traffic count survey and the ADT at the three survey locations is presented in **Table 3.7 to 3.9;**

The salient observations at each survey location are as follows:

- ❖ *At KM 6.800 on Kalwakurthy Nagarkurnool Road* near Kalwakurthy has registered maximum vehicles on Thursday with 5,646 vehicles, which is also the highest in terms of PCUs (4,677 PCUs).
- ❖ *KM 17.800 on Nagarkurnool Kollapur Road* near Peddakothapalli has registered maximum vehicles on Sunday with 5,672 vehicles, which is also highest in terms of PCUs (5,100 PCUs).
- ❖ *KM 1.60 on Kollapur Pebbair Road* near Kollapur has registered maximum vehicles on Wednesday with 4,055 vehicles, which is also highest in terms of PCUs (3190 PCUs).

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Table 6.7: Mode-wise Traffic - Kalwakurthy(Km 6.800)

Type of Vehicles	25-08-2021	26-08-2021	27-08-2021	28-08-2021	29-08-2021	30-08-2021	31-08-2021	ADT
	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	
Car/ Jeep/Van	1644	1660	1586	1364	1449	1284	1135	1446
Two wheeler	2970	3261	3016	2351	2615	2730	2641	2798
3wh	171	154	132	161	177	199	158	165
Minibus	5	0	3	0	5	5	3	3
School Bus	0	0	0	1	0	0	3	1
Bus (Govt)	120	107	100	101	115	104	107	108
Bus (Pvt)	4	9	10	7	0	1	5	5
LCV (4 Tyre)	229	195	194	186	163	199	236	200
LCV (6 Tyre)	55	70	92	59	85	53	52	67
2-Axle	22	21	22	25	20	24	18	22

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Type of Vehicles	25-08-2021	26-08-2021	27-08-2021	28-08-2021	29-08-2021	30-08-2021	31-08-2021	ADT
	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	
3-Axle	60	31	37	23	23	38	19	33
4-Axle and 6 Axle	48	41	62	56	31	45	52	48
7 Axle Above	0	0	3	0	0	0	0	0
Tractor	12	22	15	13	11	14	19	15
Tractor with Trailer	14	24	14	15	11	20	15	16
Cycle	6	20	22	21	11	19	20	17
Cycle Rickshaw	0	0	0	0	0	0	3	0
Animal cart	0	0	0	0	0	0	4	1
Others	38	31	37	3	4	3	21	20

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Type of Vehicles	25-08-2021	26-08-2021	27-08-2021	28-08-2021	29-08-2021	30-08-2021	31-08-2021	ADT
	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	
Total	5398	5646	5345	4386	4720	4738	4511	4963

Table 6.8: Mode-wise Traffic – Nagarkurnool (Km 17.800)

Type of Vehicles	23-08-2021	24-08-2021	25-08-2021	26-08-2021	27-08-2021	28-08-2021	29-08-2021	ADT
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
Car/ Jeep/Van	1132	1179	1197	1049	1152	1322	1203	1176
Two wheeler	3289	3365	3428	3092	2450	3179	2446	3036
3wh	217	262	215	194	172	459	214	248
Minibus	6	5	7	3	6	7	4	5

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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Type of Vehicles	23-08-2021	24-08-2021	25-08-2021	26-08-2021	27-08-2021	28-08-2021	29-08-2021	ADT
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
School Bus	0	8	0	4	0	7	0	3
Bus (Govt)	158	158	162	159	153	199	168	165
Bus (Pvt)	0	6	0	0	3	5	0	2
LCV (4 Tyre)	187	246	182	236	194	253	169	210
LCV (6 Tyre)	33	25	71	64	48	39	47	47
2-Axle	13	49	33	14	39	29	23	29
3-Axle	6	29	29	31	26	16	23	23
4-Axle and 6 Axle	43	23	42	79	72	68	30	51
7 Axle Above	0	0	0	0	0	0	0	0
Tractor	12	6	13	12	21	12	15	13

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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Type of Vehicles	23-08-2021	24-08-2021	25-08-2021	26-08-2021	27-08-2021	28-08-2021	29-08-2021	ADT
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
Tractor with Trailer	24	30	31	18	16	63	38	31
Cycle	0	0	4	0	0	0	1	1
Cycle Rickshaw	1	0	0	0	0	0	0	0
Animal cart	0	0	0	0	0	0	0	0
Others	3	14	11	19	5	14	6	10
3 wheel Goods	38	25	50	59	38	0	30	34
Total	5162	5430	5475	5033	4395	5672	4417	5083

Table 6.9: Mode-wise Traffic - Kollapur (Km 1.600)

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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Type of Vehicles	29-08-2021	30-08-2021	31-08-2021	01.09.2021	02.09.2021	03.09.2021	04.09.2021	ADT
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
Car/ Jeep/Van	499	497	667	922	498	407	429	560
Two wheeler	1876	1967	2239	2557	2004	1957	1860	2066
3wh	232	204	217	238	186	186	192	208
Minibus	2	4	2	0	3	3	1	2
School Bus	0	0	0	0	0	0	0	0
Bus (Govt)	80	85	90	98	78	81	94	87
Bus (Pvt)	1	0	4	3	0	2	1	2
LCV (4 Tyre)	86	83	98	130	112	80	98	98
LCV (6 Tyre)	13	18	17	24	16	25	25	20
2-Axle	5	6	11	5	7	9	12	8
3-Axle	6	9	9	9	20	10	9	10

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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Type of Vehicles	29-08-2021	30-08-2021	31-08-2021	01.09.2021	02.09.2021	03.09.2021	04.09.2021	ADT
	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	
4-Axle and 6 Axle	9	6	6	16	7	18	13	11
7 Axle Above	15	11	42	0	0	0	5	10
Tractor	9	31	2	22	10	7	14	14
Tractor with Trailer	0	8	17	30	38	30	7	19
Cycle	19	14	0	1	0	5	4	6
Cycle Rickshaw	2	2	0	0	0	0	0	1
Animal cart	0	0	0	0	1	0	0	0
Others	0	0	0	0	4	2	0	1
Total								

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6.3.5. Maximum, Minimum and Average ADT

Location-wise variation of traffic i.e. Maximum and Minimum traffic concerning average daily traffic in terms of vehicles and PCUs observed at all the survey locations is presented in **Table 6.10**.

Table 6.10: Minimum, Maximum and Average Daily Traffic

Location	Kalwakurthy		Nagarkurnool		Kollapur	
	Total Veh.	Total PCUs	Total Veh.	Total PCUs	Total Veh.	Total PCUs
Average Daily Traffic	4963	4202	5049	4312	3121	2457
Maximum Traffic	5646	4677	5672	5100	4055	3190
Minimum Traffic	4386	3803	4387	3905	2764	2172
% Variation of Max. Traffic w.r.to ADT	13.76%	11.31%	12.34%	18.27%	29.93	29.81
% Variation of Min. Traffic w.r.to ADT	11.63%	9.50%	13.11%	9.44%	11.44	11.63

The salient observations are as follows:

- ❖ At km 17.800 on Nagarkurnool Kollapur Road has less variation in terms of Vehicles (12.34% concerning maximum traffic and 13.11% concerning minimum traffic) and at km 1.600 on Kollapur Pebbair Road has more variation in terms of Vehicles (29.93 % concerning maximum traffic and 11.44% concerning minimum traffic).
- ❖ The variation in PCUs w.r.t. maximum and minimum traffic is high at km 1.600 on Kollapur Pebbair Road with 29.81% and 11.63% respectively.
- ❖ The difference in variation between the maximum and minimum traffic concerning the ADT is more at Km 1.600 on Kollapur Pebbair Road.

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6.3.6. Hourly Variation of Traffic

The average hourly variation of traffic observed at all the six survey locations is presented in **Figure 3.5 to 3.7**. Important inferences drawn from the analysis are presented below:

- At km 6.800 on Kalwakurthy Nagarkurnool Road, it is observed that maximum peak hour traffic of 336 PCUs/hr, which is about 8.41% of the total PCUs. The peak hour traffic is observed between 10:00 hours and 11:00 hours.
- At km 17.800 on Nagarkurnool Kollapur Road, it is observed that maximum peak hour traffic of 360 PCUs/hr, which is about 8.9% of the total PCUs. The peak hour traffic is observed between 10:00 and 11:00 hours.
- At km 1.600 on Kollapur Pebbair Road, it is observed that the maximum peak hour traffic of 201 PCUs/hr, which is about 8.34% of the total PCUs. The peak hour traffic is observed between 12:00 and 13:00 hours

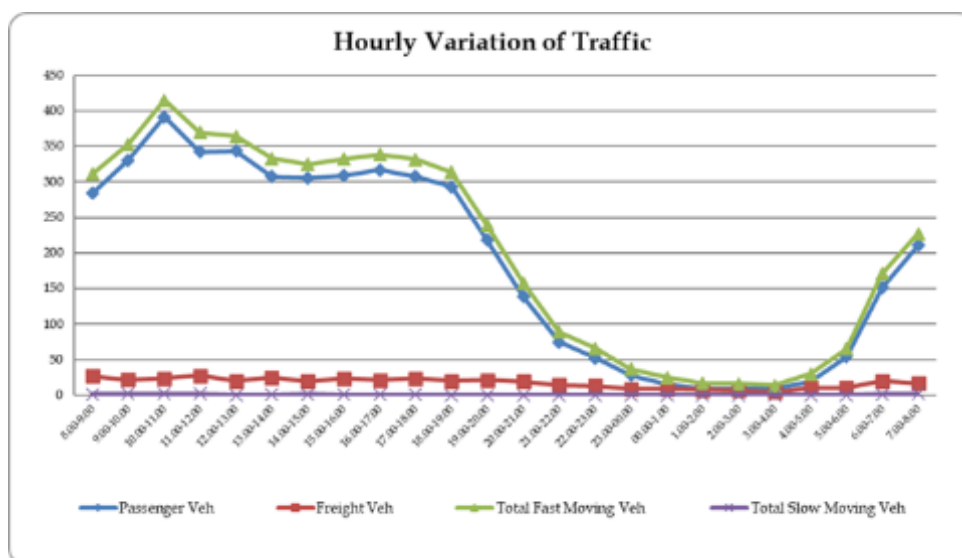


Figure 3.5 Hourly Variation of Traffic at Kalwakurthy - 6.800 km

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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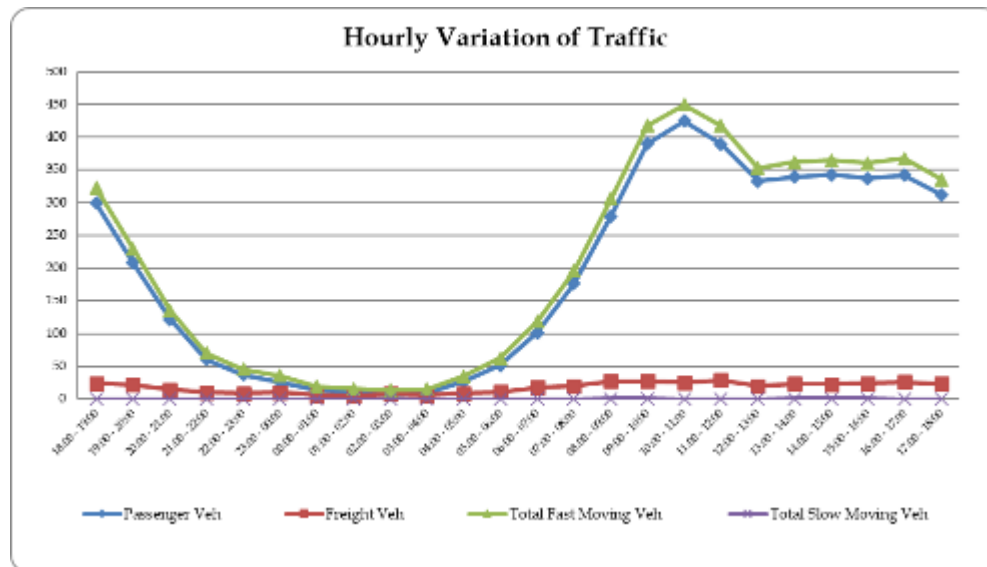


Figure 3.6 Hourly Variation of Traffic at Nagarkurnool - 17.800 km

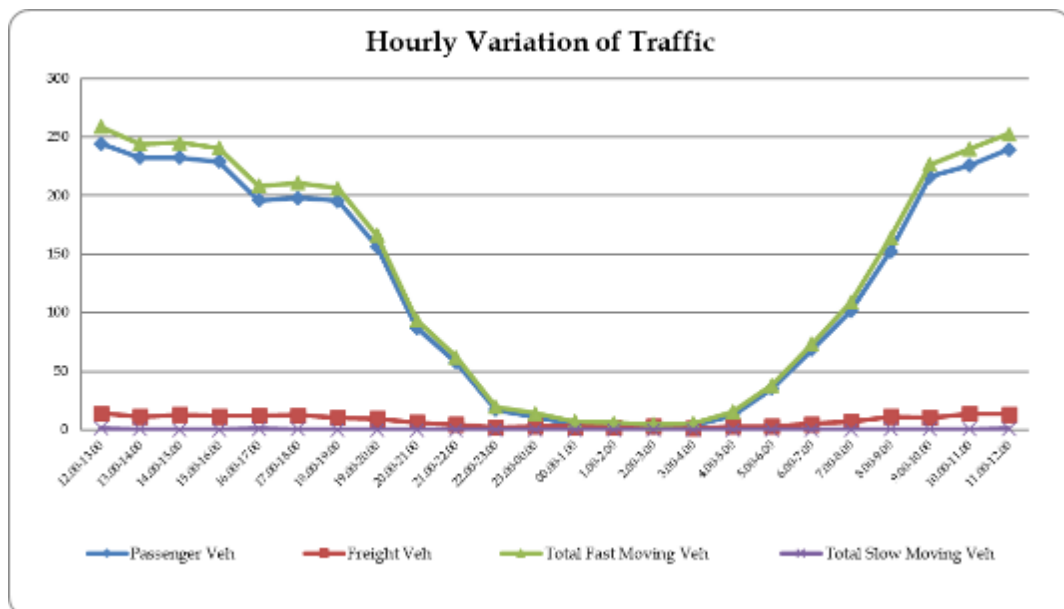


Figure 3.7 Hourly Variation of Traffic at Kollapur- 1.600 km

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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6.3.7. Directional Distribution

Directional distribution of traffic forms an important input for capacity analysis. The average directional split observed at all the locations is approximately 50:50 per cent; the directional distribution on the entire project corridor is uniform as shown in **Table 6.11 to 6.13**.

Table 6.11 Directional Split of Traffic at Kalwakurthy

Location	Vehicle Split (%)
Kalwakurthy to Nagarkurnool	49
Nagarkurnool to Kalwakurthy	51

Table 6.12 Directional Split of Traffic at Nagarkurnool

Location	Vehicle Split (%)
Kollapur to Pebbair	51
Pebbair to Kollapur	49

Table 6.13 Directional Split of Traffic at Kollapur

Location	Vehicle Split (%)
Kollapur to Pebbair	50
Pebbair to Kollapur	50

6.3.8. Traffic Composition

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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The average composition of traffic observed at the volume count survey locations is presented in **Table 6.14** and graphically shown in **Figure 3.8 to 3.10**.

Table 6.14 Average Traffic Composition at Survey Locations

Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
Cars	29.13%	23.30%	17.94%
Buses	2.35%	3.47%	2.89%
Two wheelers	56.37%	60.12%	66.19%
Three Wheelers	3.32%	4.90%	6.66%
LCV	5.38%	5.08%	3.78%
Trucks	2.08%	2.03%	1.26%
Tractors	0.63%	0.88%	1.03%
Total vehicles	100.00%	100.00%	100.00%

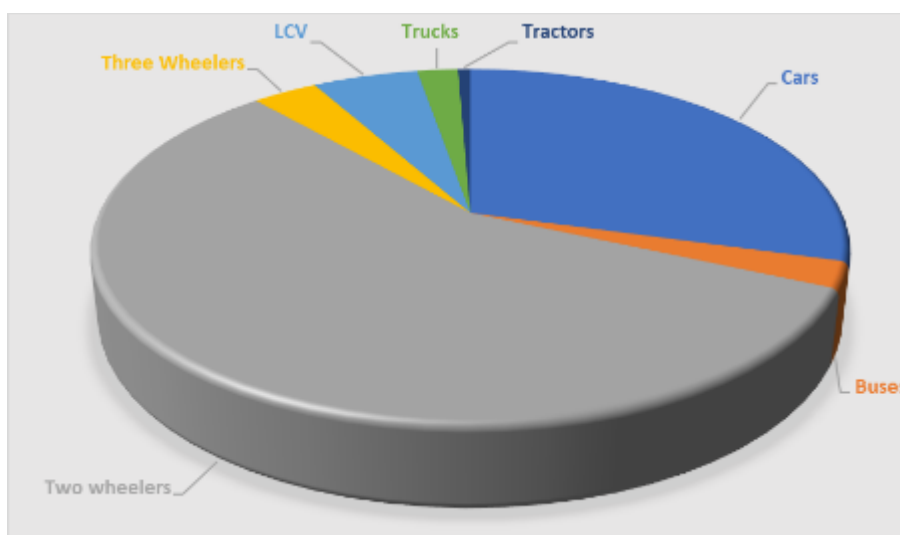


Figure 3.8 Traffic Composition at Kalwakurthy-6.800 km

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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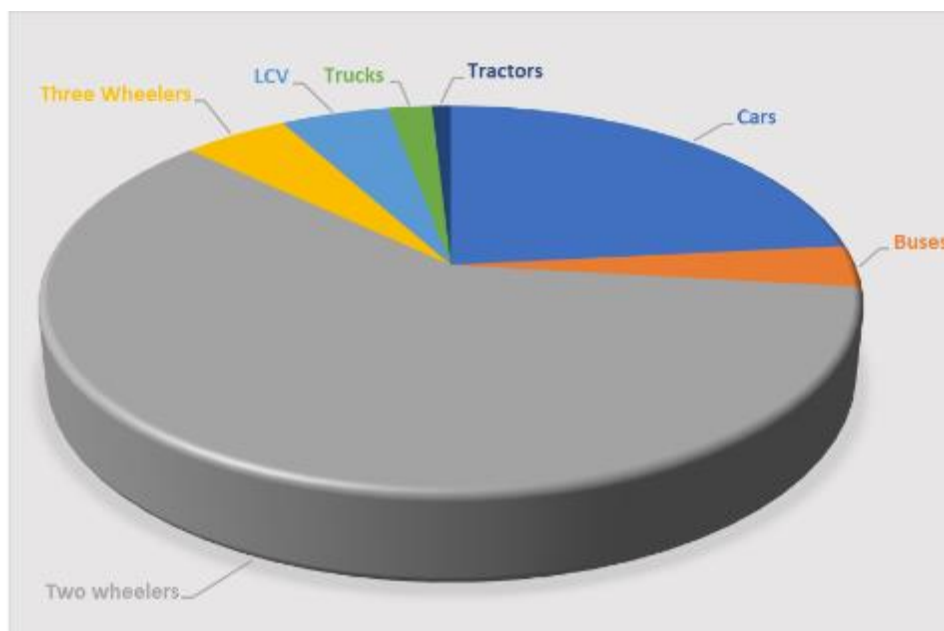


Figure 3.9 Traffic Composition at Nagarkurnool-Km 17.800

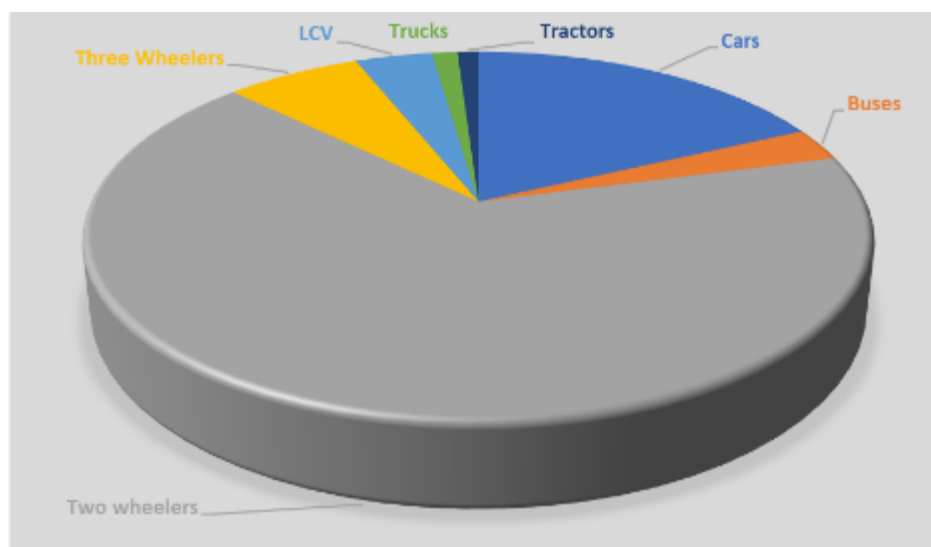


Figure 3.10 Traffic Composition at Kollapur-Km 1.600

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The major inferences drawn are:

- The share of Two-wheelers is more than half of the total traffic at all surveyed locations. The share of two-wheelers at km 6.800, km 17.800 and Km 1.600 is about 56.37%, 60.12% and 66.19%.
- Share of Car/Jeep/Van at km 6.800, km 17.800 and Km 1.600 is 29.13%, 23.03% and 17.94%.
- Share of freight vehicles at km 6.800, km 17.800 and Km 1.600 is about 7.46%, 7.11% and 5.04%.

6.3.9. Estimation of Seasonal Variation Factors

To account for the seasonal variation in the traffic, seasonal variation factors have been worked out using data (number of vehicles & revenue) collected from the fuel sales data. Due to inadequate data/ inconsistency in the collected Petrol / Diesel data, we have used the Seasonality factors. Seasonal variation factors derived from this data are used for the estimation of Annual Average Daily Traffic (AADT). These factors are presented in **Table 6.15**.

Table 6.15: Seasonal Variation Factors

Vehicles	Seasonality Factors
Passenger Vehicles	0.97
Commercial Vehicles	1.11

6.3.10. Annual Average Daily Traffic (AADT)

Considering the above seasonality factors, the Annual Average Daily Traffic at the three survey locations on the project corridor is estimated. The mode wise Annual Average Daily Traffic (AADT) and Tollable traffic at the count survey locations is presented in **Table 6.16 and 6.17** and is represented graphically in **Figure 3.11**.

Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

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Table 6.16: Annual Average Daily Traffic (AADT)

Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
Car/ Jeep/Van	1403	1141	543
Two wheeler	2714	2945	2004
3wh	160	240	202
Minibus	3	5	2
School Bus	1	3	0
Bus (Govt)	104	160	84
Bus (Pvt)	5	2	2
LCV (4 Tyre)	222	233	109
LCV (6 Tyre)	74	52	22
2-Axle	24	32	9
3-Axle	37	25	11
4-Axle and 6 Axle	53	57	12
7 Axle Above	0	0	12
Tractor	17	14	15
Tractor with Trailer	18	35	21
Cycle	17	1	6
Cycle Rickshaw	0	0	1
Animal cart	1	0	0
Others	20	10	1
Non Toll	0	0	0
Total in Numbers	4872	4954	3054
Total in PCUs	4299	4418	2492

Table 6.17: Annual Average Daily Traffic (Tollable)

Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
Car/ Jeep/Van	1403	1141	543
Minibus	3	5	2
School Bus	1	3	0
Bus (Govt)	104	160	84
Bus (Pvt)	5	2	2
LCV (4 Tyre)	222	233	109
LCV (6 Tyre)	74	52	22

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Type of Vehicle	Kalwakurthy	Nagarkurnool	Kollapur
2-Axle	24	32	9
3-Axle	37	25	11
4-Axle and 6 Axle	53	57	12
7 Axle Above	0	0	12
Total in Numbers	1926	1709	805
Total in PCUs	1895	2496	1165

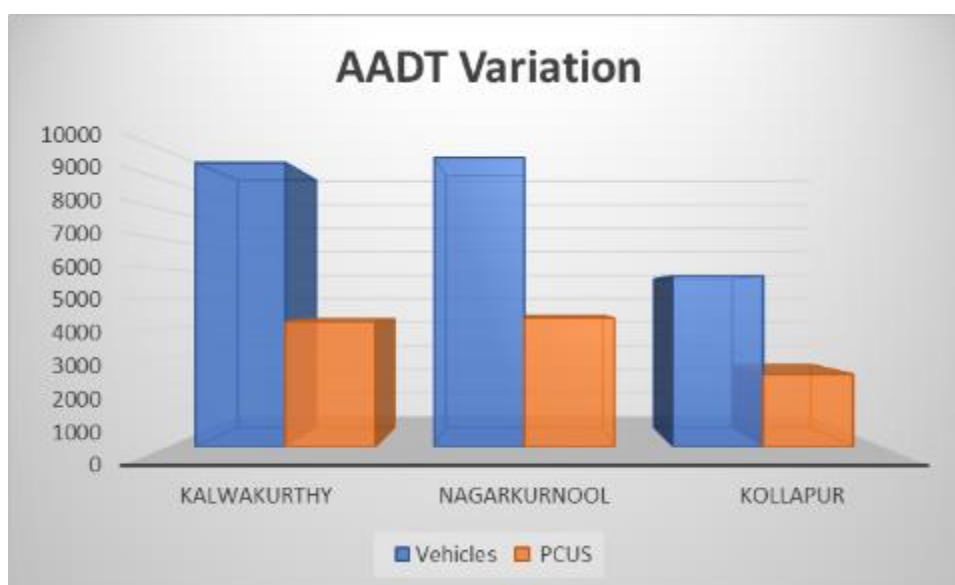


Figure 3.11: AADT Variation

6.4. Turning Movement Survey

The Turning Movement Survey was carried out at the junction of NH-167 and NH-167K in Kalwakurthy, NH-167K and Srisailam Road near Nagarkurnool and NH-167K and Wanaparthy Road near Kollapur.

As mentioned in the above section the traffic surveys at intersections have been conducted for one day (24 hours) at the above-mentioned intersections. The total traffic intensity in several vehicles and PCUs at all three intersections are presented in Table NO.3.1. The data analysis of turning movements reveals that the Minimum

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traffic flow observed at Kalwakurthy (218167 PCUs) and minimum at Kollapur (4750 PCUs).

Recommendations for grade separations at junctions are made based on projected traffic on the minor roads, as per IRC: 62 - 1976, 'Guidelines for control of access on highways. IRC: 62 - 1976 warrants grade separation if ADT projected for the next five years on a minor road is exceeding 5000 PCUs. **Table 6.18** shows the present traffic for the project junctions along with recommendations.

Table No.6.18: Total Daily Traffic at junctions

Sl.No	Junction Location	Type of Junction	Total Traffic	
			Vehicles	PCUs
1	Kalwakurthy	3 Arm	23346	18167
2	Nagarkurnool	3 Arm	13655	11416
3	Kollapur (wanaparty Jn.)	3 Arm	5156	4750

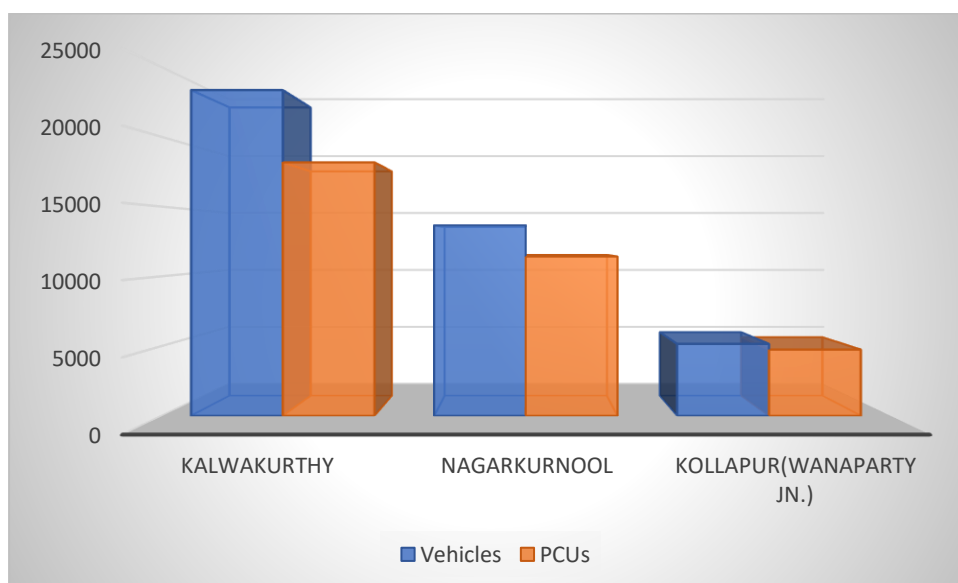


Figure No.3.12: Junction Traffic

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The peak hour traffic in **vehicles and PCUs** at **Kalwakurthy, Nagarkurnool and Kollapur** are presented in the following **Table No.3.19**. The peak hour traffic flow diagrams for the intersection in number of vehicles and PCUs is shown in **Figure 3.13 to Figure 6.18**.

Table No.6.19: Peak Hour Traffic at junctions

Sl.No	Junction Location	Peak Hour	Peak Hour Traffic	
			Vehicles	PCUs
1	Kalwakurthy	13.00-14.00	1902	1393
2	Nagarkurnool	11.00-12.00	1137	964
3	Kollapur (Wanaparty Jn.)	12.00-13.00	422	350

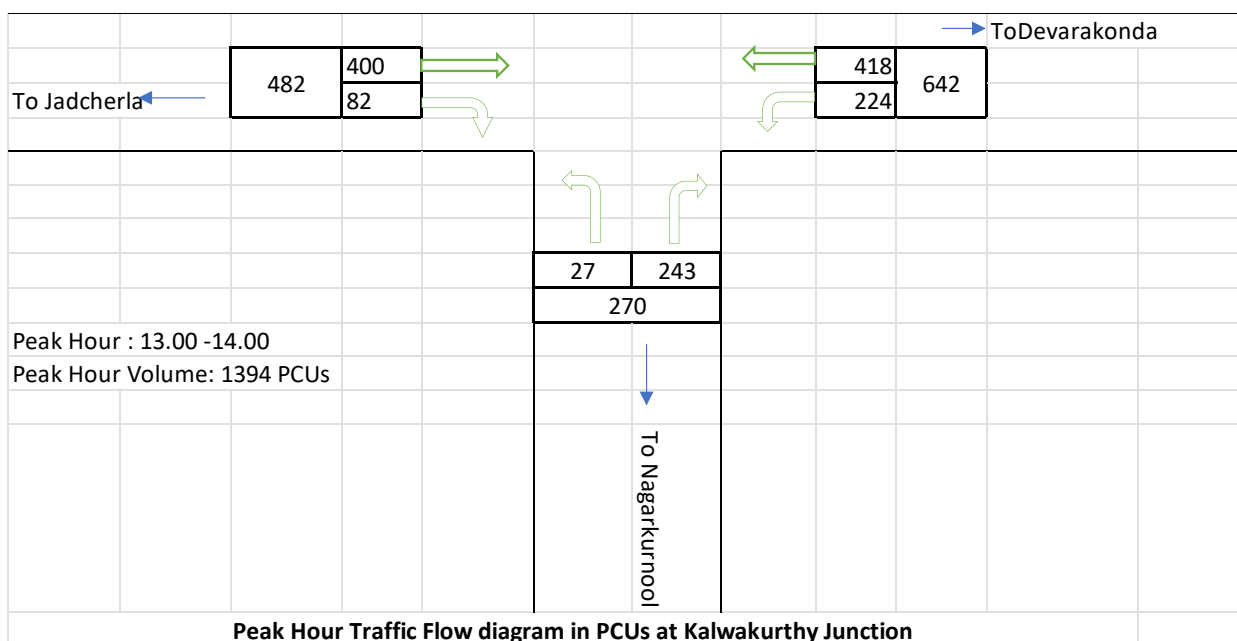


Figure No.3.14: Peak Hour Traffic Flow Diagram in number of PCUs at Kalwakurthy Junction

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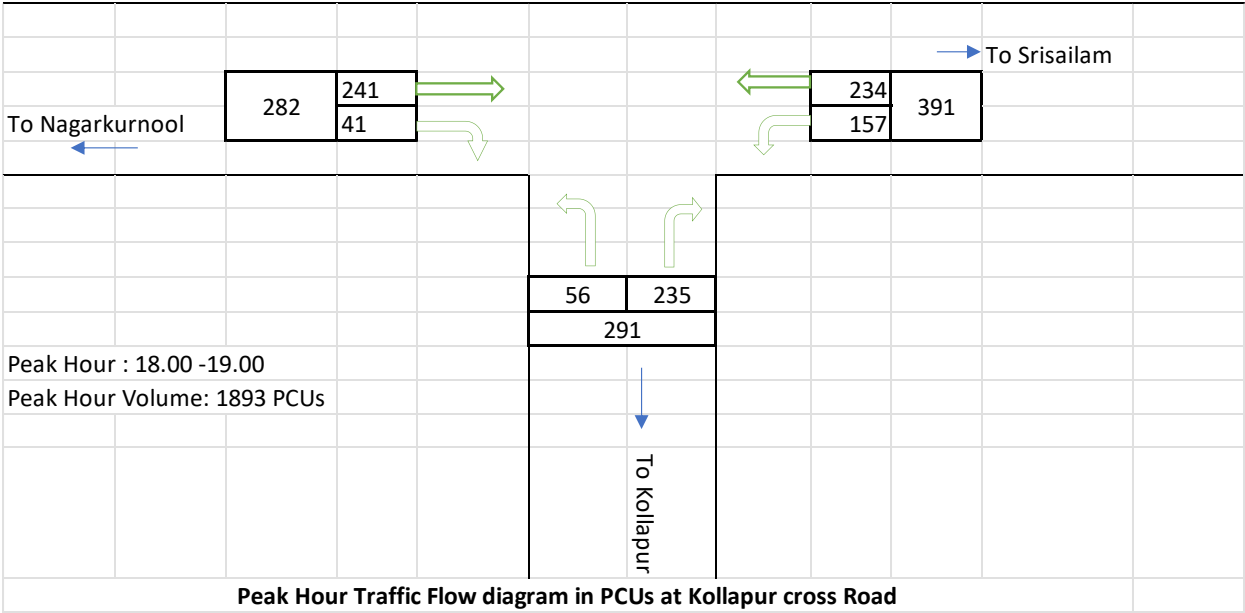


Figure No.3.16: Peak Hour Traffic Flow Diagram in number of PCUs at Nagarkurnool Junction

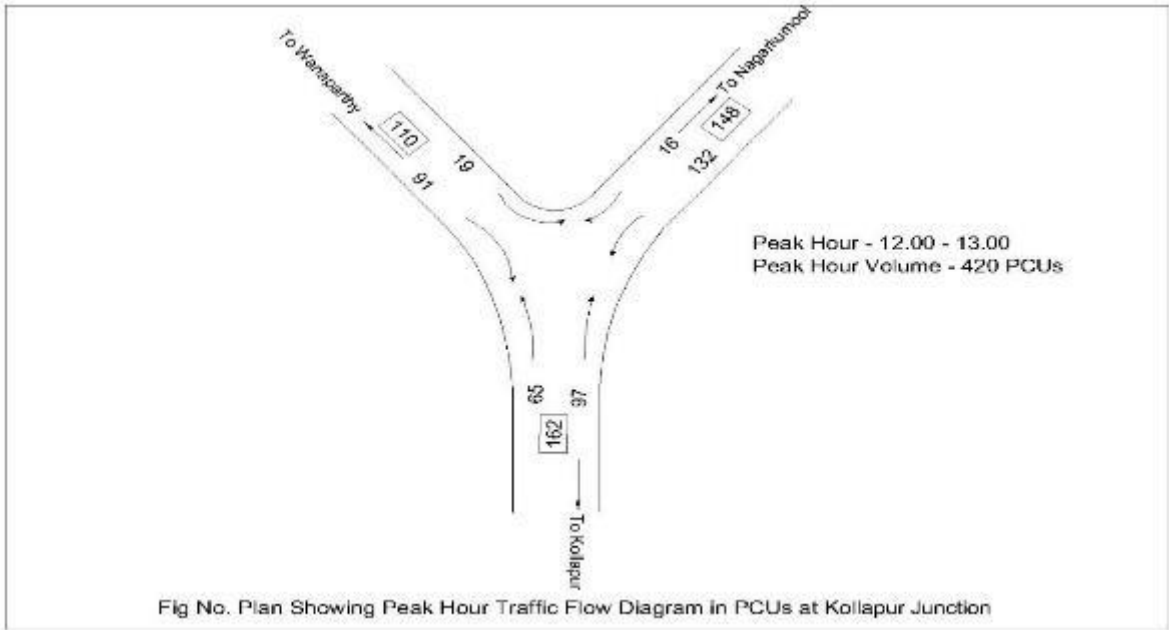


Figure No.3.18: Peak Hour Traffic Flow Diagram in number of PCUs at Kollapur Junction

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The Turning movement diagrams and data of these junctions would also be used for Identifying major movement streams and predominant modes at the junctions for geometric designs and preparation of junction improvement plans.

The junctions are analyzed on the following criteria:

- No signalized intersection will be provided on NH even if the junction warrants signalization as per IRC: 93-1985.
- A grade-separated intersection, besides other warrants, is justified when the total traffic of all the arms of the intersection is more than 10,000 PCU's per hour as per IRC SP: 73-2018 Manual of Specifications and Standards for two laning of highways with paved shoulders.
- The peak hour volume of all intersections is below the traffic that is warranting grade separation as mentioned above. So the junctions will be designed at grade

6.5. [Origin Destination data analysis](#)

Origin Destination (O-D) surveys were conducted to elicit information related to the base year travel characteristics of goods and passenger trips for the proposed project road. The travel characteristics obtained by the O-D survey would facilitate the identification of through traffic diverted to the proposed project road

The survey was carried out for both passenger and goods vehicles for 24 hours (in both directions). For this purpose, cars and buses were considered passenger vehicles. Similarly, LCVs, 2-Axle Trucks, 3-Axle Trucks and Multi-Axle Trucks were considered as goods vehicles. Trained enumerators under the supervision of the Traffic Engineer collected the travel information.

The information collected contained trip origin and trip destination. In addition, commodity type for goods vehicles and purpose and occupancy for passenger vehicles were also collected. Further, trip length, travel time during O-D surveys.

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The information collected during roadside interviews was analyzed to obtain the trip distribution based on a zoning system suitably designed in the study to conduct diversion analysis.

The O-D survey stations are as follows

Table: 6.20 Sample Size: Origin and Destination - Passenger's survey

OD - Passengers Survey				
Sl.No	Survey Locations	Total No of Vehicles	Interviewed vehicles	Sample Taken (%)
1	Kalwakurthy	2658	873	33
2	Nagarkurnool	2265	1638	72
3	NH-44	9304	4255	46

Table: 6.21 Sample Size: Origin and Destination - Goods survey

OD - Goods Survey				
Sl.No	Survey Locations	Total No of Vehicles	Interviewed vehicles	Sample Taken (%)
1	Kalwakurthy	898	410	46
2	Nagarkurnool	414	339	82
3	NH-44	8576	4059	47

6.5.1. Adopted Zoning System

For analysis of O-D data collected from the field, it is required to code it for the origin and destination of the trip. The zoning was done at four levels. In the first level, all-important towns located along the project stretch were assigned a zoning code. Secondly, immediate influence areas of project road were considered, and nearby areas/towns were defined as zones. In the next level, all nearby districts were grouped into zones. Finally, states beyond the influence area were aggregated broadly in terms of the direction of the project road. In all, a total of 44 Traffic

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Analysis Zones (TAZ) were considered. The details of traffic zones and codes adopted for the study are presented in Table 3.12 and Figure 4.10.

Table: 6.22 Adopted Zoning System for Project Road

Zone No.	Zone Name	Location Names
1	North Telangana	Adilabad, Nizamabad, Karimnagar, Warangal
2	West Telangana	Vikarabad, Sanga Reddy
3	Ranga Reddy	Ranga Reddy, Shamshabad
4	Hyderabad	Hyderabad
6	Kalwakurthy	Kalwakurthy
7	NagarKurnool	Bejnapally, Telkapally, Gopal Pet, Peddapally, Buddaram, Wanaparthy
8	Kollapur	Kalvakol, Nervakonda, Somasila
9	Atmakur	Rallapenta, Kapileshwaram, Veligodu
10	NandiKotkur	NandiKotkur
11	Dornala	Dornala
12	Nandyala	Velgodu, Mahanandi, Panyam, Bageswaram, Auto Nagar, Venkata Puram
13	Kunrool Town	Kurnool Urban
14	Kunrool Rural	Bethamcherla, Banagana Palli, Dhone
15	Kurnool Dist	Other Part of Kurnool District like Allagadda, Chagalamarri

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Zone No.	Zone Name	Location Names
16	Mahaboob Nagar	Mahaboob Nagar, Shad Nagar, Tandur, Marikal, Gadwal, Makthal
17	Khammam	Khammam, Palvanha, Badrachalam, Kothagudem, Sathupally
18	Nalgonda	Nalgonda, Nagarjuna Sagar, Miryalaguda, Suryapeta, Narketpally, Nakirekal
19	Srisailam	Srisailam
20	Ananthapur	Gooty, Thadipatri, Ananthapur, Kadiri, Hindupur, Dharmavaram, Other place in Ananthapur
21	Kadapa	Kadapa, Mydukur, Proddutur, Rajampeta, Jammalamadugu, Pulivendula, Duvvur, Porumamilla, Badvel, Rayachoty,
22	Chittoor	Tirupathi, Madanapalli, Chittor,
23	Prakasam	Prakasam, Ongole, Addanki
24	Guntur, Krishna	Guntur, Krishna
25	Coastal Districts	Nellore
26	Andhra Districts	West Godawari, East Godawari, Vishakhapatnam, Vijayanagaram, Srikakulam
27	North Karnataka	Bellary, Bidar, Raichur, Yadgiri, Bagalkot, Dharwad, Hospeta

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Zone No.	Zone Name	Location Names
28	South Karnataka	Bengaluru, Ramanagara, Mysore, Kolar, Chikkaballapur, Tumkuru, Hassan, Mandya,
29	Rest of Karnataka	Rest of Karnataka
30	South India States	Tamilnadu , Kerala
31	Goa	Goa
32	Western India	Maharasthra, Gujarat
33	Chhattisgarh	Chhattisgarh
34	Northern East States	Odisha, West Bengal, Jharkhand, Meghalaya, Assam, Nagaland, Arunachala Pradesh
35	North States	Madhya Pradesh, Rajasthan, Delhi, Punjab, Haryana, Himachal Pradesh, J & K

6.5.2. Expansion Factors and Development of Origin-Destination Matrices

The origin-destination details were collected from the trip makers during the O-D survey on a sample basis as stopping and interviewing all the vehicles was not possible. The sample size varied for different survey locations depending upon the quantum of traffic volume moving on the road. The sampling rate varied with the changes in traffic flow during different parts of the day at the same location as well. Since the data was collected on a sample basis expansion factors are required to replicate the pattern as reflected in the sample to the total number of vehicular trips made during the day. These expansion factors are calculated separately for each class of vehicle. For Example, if “xc” is the number of cars interviewed and “Xc” is the total number of cars counted during the day, then “Xc/xc” is the expansion

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factor for Cars. The vehicle wise expansion factors are presented in the following **Table No. 6.23.**

Table No. 6.23: Expansion Factors

Type of Vehicle	Expansion Factor		
	Kalwakurthy	Nagarkurnool	NH-44
Car/Jeep/Van	3.21	1.36	2.21
Taxi (Yellow Board)	3.15	1.35	2.49
Local/Shared Vehicle	3.00	4.75	4.40
Mini Bus	3.36	2.00	1.60
School/Institution Bus	1.00	0.00	2.00
Govt Bus	1.61	1.33	2.07
Private Bus	3.50	1.57	1.20
LCV 4	1.23	1.13	4.85
LCV 6	2.24	1.13	1.13
2 AT	4.45	1.35	2.81
3 AT	4.55	1.41	1.62
MAV	2.07	1.20	1.99

OD Matrices are developed to assess the traffic movement pattern. These matrices provide the distribution of trips for each zone as various inter-zonal movements. Multiplying the sample O-D matrix obtained from the survey data with the expansion factor develops the vehicle wise O-D matrices for both the survey locations. Accordingly, matrices by various vehicle categories were developed. Based on O-D matrices, the travel pattern of the vehicles moving on the project road is discussed below.

The O-D matrix estimates describing the travel pattern of both goods and passenger vehicles observed at various O-D survey locations. The travel pattern reveals the following.

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6.5.3. Trip Length Distribution Pattern

Passenger Vehicles

From Trip length analysis it is observed that about 23% of passenger cars have a trip length between 50-100 Km at Kalwakurthy location whereas 82% of the bus have a trip length of 50-100 Km at the same location.

At Nagarkurnool location, it is observed that about 44% of passenger cars have a trip length between 20-50 Km. 40% of buses and 50% private buses have a trip length between 20-50 km.

At NH-44 location, 46% passenger cars, 52% buses and 46% private buses are having trip length between 200-500 kms.

The trip length distribution is presented in **Table 6.24** for the passenger traffic.

Table No.6.24: Trip Length Distribution - Passenger Vehicles

Trip Length (Km)	Kalwakurthy					Nagarkurnool					NH-44				
	Car/Jeep	Minibuses	Govt Bus	Pvt Bus		Car/jeep	Mini Bus	Govt Bus	Pvt Bus		Car/jeep	Mini Bus	Govt Bus	Pvt Bus	
0-20	15%	36%	1%	50%		7%	0%	0%	7%		0%	0%	0%	0%	
20-50	22%	27%	7%	0%		44%	0%	40%	50%		3%	0%	2%	0%	
50-100	23%	0%	82%	0%		15%	0%	0%	14%		7%	0%	7%	1%	
100-200	22%	18%	8%	0%		28%	0%	40%	29%		23%	0%	15%	6%	
200-500	14%	10%	2%	50%		6%	0%	20%	0%		46%	0%	52%	46%	
> 500	4%	9%	0%	0%		1%	0%	0%	0%		21%	0%	24%	47%	

Commercial Vehicles

From the distance matrix, it is observed that about 76% of Trucks and 20% of light commercial vehicles have their trips lengths between 100-200 Km at location Kalwakurthy location and location Km 288.50 about 66% of trucks and 35% of light

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commercial vehicles having trip lengths between 100-200 Km. The trip length distribution is presented in **Table 6.25** for the commercial traffic.

Table No.6.25: Trip Length Distribution - Commercial Vehicles

Trip Length (Km)	Kalwakurthy				Nagarkurnool				NH-44			
	LCV	2 Axle	3 Axle	MAV	LCV	2 Axle	3 Axle	MAV	LCV	2 Axle	3 Axle	MAV
0-20	6%	2%	3%	1%	12%	16%	3%	4%	1%	0%	0%	0%
20-50	36%	33%	19%	14%	21%	38%	19%	16%	3%	1%	0%	0%
50-100	19%	24%	19%	17%	23%	21%	19%	14%	4%	1%	1%	1%
100-200	20%	31%	23%	22%	35%	17%	24%	25%	15%	7%	5%	3%
200-500	12%	7%	23%	26%	9%	5%	23%	33%	44%	32%	29%	25%
> 500	7%	3%	13%	20%	0%	3%	12%	8%	33%	59%	65%	71%

Commodity Analysis

During the O-D surveys, information on the commodity carried out by goods vehicles was recorded along with the origin and destination details. To understand the commodity movement on the project road, the commodities are classified into 13 major categories as given in **Table 6.26**.

Table No.6.26: Commodity Codes

Code	Vehicle Type
1	Empty
2	Vegetables & Food Grains
3	Processed Food Items
4	Forest Products
5	Fuel & Oil
6	Construction Material
7	Minerals
8	Chemical & Fertilisers
9	Machinery
10	Milk, Poultry & Animals
11	Others

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12	Parcel
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The information collected was analyzed to access the kind of goods movement the project road caters to. The commodities carried by freight vehicles are analyzed and presented in **Table 6.27 to 6.29**.

Table No 6.27: Commodity Distribution- Kalwakurthy

Code	Commodity Carried by Goods Vehicles	Vehicle Classification					
		LCV 4	LCV 6	2-Axle Trucks	3-Axle Trucks	MAV	Total
1	Empty	63	29	15	9	35	151
2	Vegetables & Food Grains	10	2	9	1	10	32
3	Processed Food Items	10	2	3	2	8	25
4	Forest Products	3	1	0	3	5	12
5	Fuel & Oil	7	1	1	1	3	13
6	Construction Material	10	3	3	6	24	46
7	Minerals	1	0	2	4	7	14
8	Chemical & Fertilisers	0	0	0	0	0	0
9	Machinery	2	1	0	0	0	3
10	Milk, Poultry & Animals	32	11	4	4	9	60
11	Others	23	7	4	0	14	48
12	Parcel	3	1	1	1	0	6
Grand Total		164	58	42	31	115	410

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Table No 6.28: Commodity Distribution- Nagarkurnool

Code	Commodity Carried by Goods Vehicles	Vehicle Classification					
		LCV 4	LCV 6	2-Axle Trucks	3-Axle Trucks	MAV	Total
1	Empty	52	19	26	24	19	140
2	Vegetables & Food Grains	9	6	8	5	6	34
3	Processed Food Items	2	0	1	0	0	3
4	Forest Products	0	0	0	0	0	0
5	Fuel & Oil	9	1	4	5	1	20
6	Construction Material	3	1	3	11	22	40
7	Minerals	0	1	0	0	1	2
8	Chemical & Fertilisers	1	2	6	1	0	10
9	Machinery	3	10	2	0	1	16
10	Milk, Poultry & Animals	12	6	6	0	0	24
11	Others	35	8	6	3	1	53
12	Parcel	3	2	1	2	0	8
Grand Total		129	56	63	51	51	350

Table No 6.29: Commodity Distribution- NH-44

Code	Commodity Carried by Goods Vehicles	Vehicle Classification					
		LCV 4	LCV 6	2-Axle Trucks	3-Axle Trucks	MAV	Total
1	Empty	57	114	138	114	159	582
2	Vegetables & Food Grains	196	384	202	223	327	1332
3	Processed Food Items	4	10	7	8	6	35

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4	Forest Products	1	0	9	5	8	23
5	Fuel & Oil	5	36	26	34	46	147
6	Construction Material	7	39	57	115	214	432
7	Minerals	0	3	2	10	10	25
8	Chemical & Fertilisers	2	13	6	19	26	66
9	Machinery	8	18	53	72	133	284
10	Milk, Poultry & Animals	14	27	19	27	20	107
11	Others	17	96	71	92	120	396
12	Parcel	27	155	164	160	124	630
Grand Total		338	895	754	879	1193	4059

The information collected was analyzed to assess the kind of goods movement the project road caters to. The commodities carried by freight vehicles are analyzed and presented in **Table 6.30**.

Table No.6.30: Load Distribution - Tonnage/Liters (%)

Tonnage/Litres	Kalwakrthy		Nagarkurnool		NH-44	
	Trucks (2 Axle+3 Axle +MAV)	LCV (4 and 6 Tyre)	Trucks (2 Axle+3 Axle +MAV)	LCV (4 and 6 Tyre)	Trucks (2 Axle+3 Axle +MAV)	LCV (4 and 6 Tyre)
Empty	31	42	42	41	20	14
01-05	4	58	11	59	2	48
05-10	18	0	15	0	16	20
10-15	20	0	15	0	17	14
15-20	8	0	7	0	4	4
20-30	16	0	10	0	21	0
30-40	2	0	0	0	18	0

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40-50	0	0	0	0	2	0
>50	0	0	0	0	1	0
Total	100	100	100	100	100	100

6.5.4. Trip Purpose

The findings from the trip purpose analysis are the work trips are more than other purpose trips at all locations followed by Business trips. Due to the Corona-19 a smaller number of Tourism/Religious trips observed.

Table No. 6.31: Passenger trips (%) by Purpose wise at Kalwakurthy

Type of Vehicle	Trip Purpose (%)							
	Work	Business	Education	Shopping	Religious /Tourism	Social	Others	Total
Car/Jeep	50%	6%	3%	2%	14%	1%	24%	100%
Taxi	48%	9%	0%	0%	20%	2%	21%	100%
Local/Shared Vehicle	100%	0%	0%	0%	0%	0%	0%	100%
School Bus	33%	33%	33%	0%	0%	0%	0%	100%
Mini Bus	18%	27%	0%	0%	27%	18%	9%	100%
Govt. Bus	22%	1%	0%	0%	0%	76%	0%	100%
Private Bus	0%	0%	0%	0%	50%	0%	50%	100%

Table No. 6.32: Passenger trips (%) by Purpose wise at Nagarkurnool

Type of Vehicle	Trip Purpose (%)							
	Work	Business	Education	Shopping	Religious/ Tourism	Social	Others	Total
Car/Jeep	44%	14%	1%	5%	15%	3%	18%	100%
Taxi	41%	20%	1%	8%	27%	1%	2%	100%
Local/Shared Vehicle	67%	17%	0%	0%	8%	8%	0%	100%

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School Bus	40%	0%	0%	0%	20%	0%	40%	100%
Mini Bus	0%	0%	0%	0%	0%	0%	0%	0%
Govt.Bus	2%	0%	0%	0%	1%	96%	0%	100%
Private Bus	67%	17%	0%	15%	0%	1%	1%	100%

Table No 6.33: Passenger trips (%) by Purpose wise at Nagarkurnool

Type of Vehicle	Trip Purpose (%)							
	Work	Business	Education	Shopping	Religious/ Tourism	Social	Others	Total
Car/Jeep	49%	37%	4%	5%	4%	1%	1%	100%
Taxi	48%	40%	3%	3%	5%	0%	0%	100%
Local/Shared Vehicle	51%	36%	4%	0%	6%	2%	0%	100%
School Bus	0%	0%	100%	0%	0%	0%	0%	100%
Mini Bus	56%	20%	0%	2%	8%	14%	0%	100%
Govt Bus	33%	12%	1%	1%	2%	49%	1%	100%
Private Bus	38%	14%	1%	1%	1%	45%	0%	100%

6.5.5. Willingness to pay

The survey is carried out on a random sample basis and the sample size obtained for each class of vehicle is shown in Table. A thorough understanding of the road user characteristics becomes essential to decide on the tolling strategies and planning for toll plaza locations. This would enable higher acceptability levels and hence would ensure the success of a project. The percentage of acceptance of willingness to pay is presented in the Table No. 6.34.

Table No. 6.34: Percentage of acceptance of willingness to pay survey

Type of Vehicle	Willing to Pay (%)					
	Kalwakurthy		Nagarkurnool		NH-44	
	Yes	No	Yes	No	Yes	No
Passenger	73%	27%	79%	21%	81%	19%
Goods	81%	19%	81%	19%	83%	17%

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It is observed that from the opinion of users at all locations more than 75% of people are accepting willing to pay and remaining are not accepting.

6.6. Analysis of Axle Load Survey Data

6.6.1. General

The intensity of traffic loading and the corresponding damaging power of different categories of vehicles is an important parameter for the design of pavements. The main objective of the axle load survey is to determine a Vehicle Damaging Factor (VDF) of each commercial vehicle and their axle load spectrum/distribution and expected damage on pavement and extent of overloading.

6.6.2. Location

Axle load survey was conducted for a duration of about 24-hours in each direction along with the volume count simultaneously at three locations in Kalwakurthy and Kollapur Section to assess the axle load spectrum on the project road and in turn to determine the Vehicle Damage Factor (VDF) for commercial vehicles. The survey was done using a portable weigh pad. Axle load survey was conducted to cover both directional traffic and both for empty and loaded commercial vehicles i.e. Light Goods Vehicles, 2-axle trucks, 3-axle trucks, multi-axle trucks and buses.

6.6.3. Vehicle Damaging Factor

Vehicle Damaging factor (VDF) is an important indexing factor for characterizing the traffic loading on the road. The VDF can easily be computed from the axle load data by the following formula, provided a sufficiently large and fairly distributed sample of vehicles are included in the axle load survey. The vehicle damage factor is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as an equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, terrain, type of road and from region to region.

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Total EAL

$$\text{VDF} = \frac{\text{Number of Vehicles Weighed}}{\text{Total EAL}}$$

6.6.4. Load Equivalence Factors

For design purposes, the variation in axle loads is usually handled by reducing the actual axle load to “Equivalent Axle Load (EAL)”. An equivalency is simply a convenient means for indexing the wide spectrum of actual loads to one selected value. One of the most important and useful products of the AASHO Road Test was the development of a relationship characterizing the relative damaging effect of varying axle load on pavements in terms of equivalent 8.2 T single axle load. This relationship sometimes referred to as the “**Fourth Power**” rule, has subsequently been verified by studies reported by several agencies in different countries.

- **Single axle with single wheel on either side** = (axle load in kg / 6500) ^4
- **Single axle with a dual wheel on either side** = (axle load in kg / 8000) ^4
- **Tandem axle with dual wheel on either side** = (axle load in kg / 14800) ^4
- **Tridem axle with dual wheel on either side** = (axle load in kg / 22400) ^4

The rule states that the damaging power of an axle load increases roughly as fourth power with the weight of an axle. Any single axle load less than 8000kg is some fractional EAL; whereas any greater single load is some multiple of EAL. To convert axle loads, from axle load surveys into EAL, these are usually grouped into the intervals of 2000kg and the frequency of each vehicle interval is found out. Equivalencies factors are obtained for each category from the “**Fourth Power**” rule. Product of frequency of axle load and load equivalency factors gives the EAL for that weight class of the sample.

6.6.5. Axle Load Spectrum Analysis

Axle load spectrum analysis was done direction wise and vehicle wise. Various parameters have arrived and the same is described below:

6.6.6. Vehicle Damage Factor Values

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The vehicle damage factor values were arrived at for each vehicle type and direction wise and are presented in **Table No 6.35 and 6.36** at Kalwakurthy and Nagarkurnool locations respectively.

Table No.6.35: Vehicle Damage Factors on Kalwakurthy Nagarkurnool Road

S.No	Vehicle type	Kalwakurthy- Nagarkurnool	Nagarkurnool- Kalwakurthy
1	LCV	0.21	0.11
2	2A	3.87	1.55
3	3A	5.78	2.55
4	MAV	9.02	1.66
5	BUS	0.61	0.51

Table No. 6.36: Vehicle Damage Factors on Nagarkurnool Kollapur Road

Sr. No	Vehicle type	Nagarkurnool - Kollapur	Kollapur- Nagarkurnool
1	LCV	0.14	0.31
2	2A	2.79	3.38
3	3A	3.25	2.89
4	MAV	9.04	0.38
5	BUS	0.62	0.67

6.6.7. Analysis of Speed and Delay Survey Data

The speed and delay survey were conducted using the moving observer method. It was conducted for the stretches of NH-167K from Kalwakurthy to Nagarkurnool, Nagarkurnool to Kollapur section. The test vehicle was run at the perceptible average speed of the traffic stream along the project road so that the number of vehicles overtaken by the test vehicle equaled the number of vehicles overtaking the test vehicle. The observers inside the test vehicles recorded the travel time and stopping delay timings along with the causes of delays. The test vehicle was made to travel in both directions of travel covering different peak and off-peak traffic flow conditions on the project road. The section-wise Speed and Delay data are presented in the below **Table No. 6.38 to Table No. 6.40**.

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Table No.6.38: Speed and Delay Survey (0.000 to 32.200) (Kalwakurthy to Nagar Kurnool)								
Trip No	Direction of Trip	Distance (Km)	Journey Time (Min. Sec)	Total Stopped Delay (Min.)	Reason for Delay	No.Of Vehicles		
						Overtaking	Overtaken	In Opposite Direction
UP-1	0.000 to 32.200	32.200	30.20	0.00		20	1	172
UP-2	0.000 to 32.200	32.200	31.40	0.00		18	0	159
UP-3	0.000 to 32.200	32.200	29.15	0.00		23	1	168
		Total:	90.75	0.00		61.00	2.00	499.00
		Mean:	30.25	0.00		20.33	0.67	166.33
Speed and Delay Survey (32.200 to 0.000) (NagarKurnool to Kalwakurthy)								
Trip No	Direction Of Trip	Distance (Km)	Journey Time (Min. Sec)	Total Stopped Delay (Min.)	Reason For Delay	No. of Vehicles		
						Overtaking	Overtaken	In Opposite Direction
DN-1	32.200 to 0.000	32.200	31.15	0.00		24	2	162
DN-2	32.200 to 0.000	32.200	30.54	0.00		23	1	174
DN-3	32.200 to 0.000	32.200	30.28	0.00		21	2	168
		Total:	91.97	0.00		68	5	504

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		Mean:	30.66	0.00		22.67	1.67	168.00
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Table No.6.39: Speed And Delay Survey (32.200 to 79.400) (Nagar Kurnool to Kollapur)

Trip No	Direction Of Trip	Distance (Km)	Journey Time (Min. Sec)	Total Stopped Delay (Min. Sec)	Reason For Delay	No.of Vehicles		
						Overtaking	Overtaken	In Opposite Direction
UP-1	32.200 to 79.400	52.6	53.56	0		49	4	394
UP-2	32.200 to 79.400	52.6	51.43	0		35	1	375
UP-3	32.200 to 79.400	52.6	55.24	0		38	3	321
		Total:	160.23	0		122	8	1090
		Mean:	53.41	0		40.67	2.67	363.33

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Speed And Delay Survey (32.200 to 79.400) (Kollapur to NagarKurnool)									
Trip No	Direction Of Trip	Distance (Km)	Journey Time (Min. Sec)	Total Stopped Delay (Min. Sec)	Chainage	Reason For Delay	No.of Vehicles		
							Overtaking	Overtaken	In Opposite Direction
DN-1	79.400 to 32.200	52.6	48.02	0			63	2	328
DN-2	79.400 to 32.200	52.6	48.21	0.15	78.65	Animal	54	1	294
DN-3	79.400 to 32.200	52.6	48.16	0.1	34.4	Traffic	61	2	291
		Total:	144.39	0.25			178	5	913
		Mean:	48.13	0.08			59.33	1.67	304.33

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Table No.6.40: Speed And Delay Survey (79.400 to 86.100) (Kollapur to Pentlavelli)

Trip No	Direction Of Trip	Distance (Km)	Journey Time (Min. Sec)	Total Stopped Delay (Min. Sec)	Reason For Delay	No. of Vehicles		
						Overtaking	Overtaken	In Opposite Direction
UP-1	79.400 to 86.100	6.1	11.48	0		13	1	38
UP-2	79.400 to 86.100	6.1	12.43	0		15	0	34
UP-3	79.400 to 86.100	6.1	12.04	0		12	0	36
		Total:	35.95	0		40	1	108
		Mean:	11.98	0		13.33	0.33	36

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Speed And Delay Survey (79.400 to 86.100) (Pentlavelli to Kollapur)								
Trip No	Direction Of Trip	Distance (Km)	Journey Time (Min. Sec)	Total Stopped Delay (Min. Sec)	Reason For Delay	No.of Vehicles		
						Overtaking	Overtaken	In Opposite Direction
DN-1	86.100 to 79.400	6.1	12.01	0		15	1	29
DN-2	86.100 to 79.400	6.1	11.56	0		12	0	35
DN-3	86.100 to 79.400	6.1	12.1	0		10	0	31
		Total:	35.67	0		37	1	95
		Mean:	11.89	0		12.33	0.33	31.67

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The survey data has been analysed and section-wise Journey speed and running speed estimated. The estimated journey speed and running speed is shown in the below **Table No.6.41**

Table No. 6.41: Observed Speed along Project Road

Sl.No	Section	Distance	Time in hours		Average		Journey speed			Running Speed			Reasons for Delay
		(km)	(Hours)		Delays (Sec)		(kmph)			(kmph)			
			Up	Down	Up	Down	Up	Down	Avg	Up	Down	Avg	
1	Kalkurthy to Nagarkurnool	32.2	0.504	0.511	0	0	63.87	63.01	63.44	63.87	63.01	63.45	No delays
2	Nagarkurnool to Kollapur	52.6	0.89	0.802	15	10	59.10	65.59	62.34	66.33	65.71	66.02	Due to animal crossing
3	Kollapur to Pentlavalli	6.1	0.3	0.28	0	0	30.55	30.78	30.67	30.55	30.78	30.55	Cattle Crossing

It may be observed that the average journey speed along the project road varies between 30.0 KMPH to 65 KMPH. The delays in Project Road observed on Nagarkurnool to Kollapur section due to the crossing of animals. The difference in speeds in upward and downward movements is marginal in all the sections. The difference in running and journey speeds is very marginal.

6.7. Estimation of Diverting Traffic

6.7.1. Diversion Analysis

It is believed that most of the NH-44 traffic can be diverted from Hyderabad towards Nandyal via Kurnool to NH-167K. As a result, a simultaneous Origin and Destination survey, as well as a Traffic Volume Count survey, was undertaken for twenty-four hours at the Addakal Toll plaza on NH-44. First the origin and destination zones to and from which the traffic likely to be diverted has been identified. Then found the number of vehicles originating and destined from these identified potential zones. Then these number vehicles has been converted into percentage comparing with the number of vehicles interviewed at the time O D survey. The same percentage has applied to the actual traffic as per the one day Traffic Volume Count survey to find the potential divertible traffic. Finally 60% of these potential divertible traffic has been considered as divertible traffic to NH-

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167K. The summery of one day Traffic Volume count survey is given below **Table No.3.42**. The estimated divertible traffic is presented in **Table 6.43**.

Table No.6.42: Daily Traffic volume on NH-44

Type of Vehicle	NH-44	
	Vehicles	PCUs
Car/ Jeep/ Van	8309	8309
Two wheeler	4976	2488
3wh	401	401
Minibus	40	60
School Bus	0	0
Bus (Govt)	704	2112
Bus (Pvt)	139	417
LCV (4 Tyre)	1639	1639
LCV (6 Tyre)	1011	1517
2-Axle	2118	6354
3-Axle	1428	4284
4-Axle and 6 Axle	2332	10494
7 Axle Above	48	216
Tractor	30	45
Tractor with Trailer	42	189
Cycle	3	2
Cycle Rickshaw	0	0
Animal cart	2	0
Others	2	0
Non Toll	67	79
Total	23291	38606

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Table No 6.43: Divertible Traffic volume estimated

S.No	Type of Vehicle	No of vehicles interviewed	Divertible traffic as per OD survey		Actual Traffic per day as per TVC survey	Petential divertible Traffic	Divertible Traffic to be considered (60%)
			No of vehicles	in %			
1	Cars	3326	1202	36.14	8309	3003	1802
2	Govt.Bus	321	150	46.73	704	329	197
3	Pvt.Bus	208	88	42.31	139	59	35
4	LCV (6 tyres)	895	272	30.39	1011	307	184
5	Two axle trucks	754	343	45.49	2118	963	578
6	Three axle trucks	879	442	50.28	1428	718	431
7	4 & 6 axle trucks	1193	425	35.62	2332	831	498
	Total	7576	2922	287	16041	6210	3726

6.7.2. Total Traffic on the Project Road

The total traffic including observed traffic and divertible traffic is presented in the following **Table 6.44 and 6.45**.

Table No.6.44: Total traffic Volume on Kalwakurthy Nagarkurnool section

Type of Vehicle	Observed		Diverted Traffic		Total Traffic	
	Vehicles	PCUs	Vehicles	PCUs	Vehicles	PCUs
Car/ Jeep/Van	1374	1374	1802	1802	3176	3176
Two-wheeler	2658	1329	0	0	2658	1329
3wh	156	156	0	0	156	156
Minibus	3	5	0	0	3	5
School Bus	1	3	0	0	1	3
Bus (Govt)	102	306	197	591	299	897
Bus (Pvt)	5	15	35	105	40	120
LCV (4 Tyre)	222	333	0	0	222	333
LCV (6 Tyre)	74	111	184	276	258	387
2-Axle	24	72	578	1734	602	1806
3-Axle	37	111	431	1293	468	1404

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4-Axle and 6 Axle	53	239	498	2241	551	2480
7 Axle Above	0	0	0	0	0	0
Tractor	17	26	0	0	17	26
Tractor with Trailer	18	81	0	0	18	81
Cycle	16	8	0	0	16	8
Cycle Rickshaw	0	0	0	0	0	0
Animal cart	1	6	0	0	1	6
Others	19	46	0	0	19	46
Total	4780	4220	3725	8042	8505	12262

Table No.6.45: Total traffic volume on Nagarkurnool Kollapur section

Type of Vehicle	Observed		Diverted Traffic		Total Traffic	
	Vehicles	PCUs	Vehicles	PCUs	Vehicles	PCUs
Car/ Jeep/Van	1117	1117	1802	1802	2919	2919
Two-wheeler	2884	1442	0	0	2884	1442
3wh	235	235	0	0	235	235
Minibus	5	8	0	0	5	8
School Bus	3	9	0	0	3	9
Bus (Govt)	157	471	197	591	354	1062
Bus (Pvt)	2	6	35	105	37	111
LCV (4 Tyre)	233	350	0	0	233	350
LCV (6 Tyre)	52	78	184	276	236	354
2-Axle	32	96	578	1734	610	1830
3-Axle	25	75	431	1293	456	1368
4-Axle and 6 Axle	57	257	498	2241	555	2498
7 Axle Above	0	0	0	0	0	0
Tractor	14	21	0	0	14	21
Tractor with Trailer	35	158	0	0	35	158
Cycle	1	1	0	0	1	1
Cycle Rickshaw	0	0	0	0	0	0
Animal cart	0	0	0	0	0	0
Others	10	46	0	0	10	46
Total	4862	4368	3725	8042	8587	12410

6.8. Secondary Data

6.8.1. General

NH 167k is a major National Highway that runs through the state of Telangana and Andhra Pradesh. The project corridor connects Nagarkurnool district in Telangana and Kurnool district in Andhra Pradesh. The traffic intensity on any highway is a function of population, Net State Domestic Product (NSDP) / Net District Domestic Product (NDDP) and several registered motor vehicles in the influencing area. The growth in each parameter will have a significant impact on the traffic intensity on the project corridor. For the estimation of future traffic on the corridor Consultants have collected secondary information/ data including the following:

- ❖ The population of Telangana State and influencing State Andhra Pradesh and other influencing districts.
- ❖ Net State Domestic Product (NSDP) of Telangana and Andhra Pradesh.
- ❖ Net District Domestic Product (NDDP) and Per Capita Income of Nagarkurnool and Kurnool.
- ❖ Registered Motor Vehicles in the state of Telangana and Andhra Pradesh
- ❖ Fuel sales data along the project corridor

6.8.2. Socio-Economic Indicators - Influencing States

In estimating travel demand elasticity, it is logical to relate growth in passenger and freight traffic with NSDP, NDDP, Per Capita Income and population. The compiled data of NSDP, Population and Per Capita Income for Telangana and NH-167 corridor influencing states (Telangana and Andhra Pradesh) are presented in **Table 6.46** and **Table 6.47**.

Table 6.46: Net State Domestic Product (NSDP) and Per Capita Income of Telangana State

Year	NSDP at Constant (2011-12) Prices (Rs. Crore)	Per Capita Income at Constant (2011-12) Prices (Rs.)
2011-12	3,25,139	91,121
2012-13	3,34,205	92,732

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Year	NSDP at Constant (2011-12) Prices (Rs. Crore)	Per Capita Income at Constant (2011-12) Prices (Rs.)
2013-14	3,49,593	96,039
2014-15	3,72,897	1,01,424
2015-16	4,16,892	1,12,512
2016-17	4,55,731	1,21,512
2017-18	5,01,140	1,32,293
2018-19	5,49,481	1,43,618
2019-20	5,94,806	1,53,927

Source: Socio-Economic Outlook of Telangana-2021

**Table 6.47: Net State Domestic Product (NSDP), and Per Capita Income of
Andhra Pradesh**

Year	NSDP at Constant (2011-12) Prices (Rs. Crore)	Per Capita Income at Constant (2011-12) Prices (Rs.)
2011-12	3,39,338	69000
2012-13	3,40,666	74687
2013-14	3,69,253	82870
2014-15	3,98,407	93903
2015-16	4,41,337	108002
2016-17	4,84,930	120676
2017-18	5,43,818	139680
2018-19	6,05,561	151173
2019-20	6,72,018	169519

Source: Statistical Abstract Andhra Pradesh, 2019

- The Estimated Net State Domestic Product of Telangana state during the year 2018-19(FRE) is 5,49,481 crores against 5,01,140 crores during the year 2017-18 (SRE) and the Per Capita Income (PCI) raises to 1,43,618 during the year 2018-19 1,32,293 during the year 2017-18.
- The average annual growth in NSDP and Per Capita Income of Telangana state during 2011-12 to 2019-20 at a constant price (2011-12) is about 6.87% and 5.94% per annum respectively.

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- The Estimated Net State Domestic Product of Andhra Pradesh state during the year 2018-19(A.E) is 6,05,561 crores against 5, 45,445 crores during the year 2017-18 (FRE) and the Per Capita Income (PCI) raises to 1,51,173 during the year 2018-19 1,39,680 during the year 2017-18.
- The average annual growth in NSDP and Per Capita Income of Andhra Pradesh State during 2011-12 to 2019-20 at a constant price (2011-12) is about 7.81 % and 10.39 % per annum respectively.

6.8.3. Socio-Economic Indicators - Influencing Districts

The main influencing districts of the project corridor are Nagarkurnool and Hyderabad in Telangana state, Kurnool, Kadapa and Prakasham districts in Andhra Pradesh. The Gross District Domestic Product (GDDP) at constant prices (2011-2012) of these districts is presented in **Table 4.3**. The major inferences from these indicators are as follows.

- Earlier Nagarkurnool district was part of Mahaboobnagar district. So, the Gross District Domestic Product of Nagarkurool district is available from 2014-2015. The average annual growth in GDDP of Nagarkurnool District during 2014-15 to 2018-19 is worked out as 4.39% per annum.
- The average annual growth in GDDP of Hyderabad District during 2011-12 to 2018-19 is about 4.25% per annum.
- The average annual growth in GDDP of Kurnool District during 2013-14 to 2018-19 is about 9.16% per annum.
- The average annual growth in GDDP of Kadapa District during 2013-14 to 2018-19 is about 10.72% per annum.
- The average annual growth in GDDP of Prakasham District during 2013-14 to 2018-19 is about 8.17% per annum.

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Table 6.48: Influencing Districts Economic Indicators - GDDP Constant Prices (2011-12)

Year	GDDP at Constant (2011-12) Prices (Rs crores)				
	Nagarkurnool	Hyderabad	Kurnool	Kadapa	Prakasham
2011-12		86081	22917	18529	24842
2012-13		89442			
2013-14		94888	25338	18568	25081
2014-15	5967	91961	29913	21776	29133
2015-16	6256	10134	32227	24210	32166
2016-17	6672	111259	35748	25900	32886
2017-18	7378	106947	38920	29669	35631
2018-19	7395	118534	42439	33808	39809

Source: Socio Economic Outlook of Telangana-2015,2016,2017,2018&2019
Socio Economic Survey of AP, 2014-15,2015-17,2016-17,2017-18 & 2018-19

6.8.4. Registered Motor Vehicles - Influencing States

Consultants also collected registered motor vehicles data from the Socio-economic Survey and Statistical Handbook of Telangana and Andhra Pradesh and the same are presented in **Table 4.4 &4.5**.

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Table 6.49: Registered Motor Vehicles - Telangana

No.	Class of Vehicle	2016	2017	2018	2019
1	Auto Rickshaws	38346	31307	33449	40428
2	Contract Carriage Vehicles	7285	2970	2893	2457
3	School Bus	1426	1426	1746	2174
4	Goods Carriage	34967	55874	65548	98170
5	Maxi Cabs	16547	4884	13669	5262
6	Motorcycles	628290	766587	837197	918950
7	Motor Cars	88470	118110	124858	134476
11	Tractor	11589	18795	23144	22042

**Source: Statistical Handbook of Telangana (2017 - 2020)*

Table 6.50: Registered Motor Vehicles - Andhra Pradesh

No.	Class of Vehicle	2015	2016	2017	2018	2019
1	Auto Rickshaws	397126	444295	490242	534713	567990
2	Contract Carriage Vehicles	3022	3357	3667	4574	5514
3	School Bus	20471	21761	23633	26747	27387
4	Goods Carriage	313078	342028	374746	422954	474406
5	Maxi Cabs	73324	77538	82422	90132	95231
6	Motorcycles	6147523	6824016	7671213	8378772	9326888
7	Motor Cars	486307	533542	599988	691025	770488
9	Private Vehicles	1735	1824	1979	2229	2258
10	Stage Carriage Vehicles	13041	14245	15923	18239	19239
11	Tractor And Trailers	186330	203651	227099	271232	307365

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**Source: Statistical Handbook of Andhra Pradesh (2015 - 2020)*

6.8.5. Fuel Sales Data

The fuel sales data is collected from the pumps located along the project corridor. The month-wise fuel sales data is used in assessing the seasonality factors. The summary of the month-wise fuel sales data of Petrol and Diesel at different locations of Project Road is presented in **Table 6.51 to 6.52**.

Table 6.51: Fuel Sales Data

GPS Coordinates: 16.6712179, 78.4905208(near Kalwakurthy)								
Month	2018		2019		2020		2021	
	Diesel(l)	Petrol(l)	Diesel(l)	Petrol(l)	Diesel(l)	Petrol(l)	Diesel(l)	Petrol(l)
Apr	62,453	1,40,777	63,390	1,42,889	68,145	1,53,606	65,888	1,48,520
May	69,473	1,56,639	70,516	1,58,989	75,810	1,70,913	73,295	1,65,255
Jun	57,255	1,58,332	58,114	1,60,707	62,473	1,72,761	53,415	1,47,711
July	42,978	1,58,332	43,623	1,60,707	46,994	1,72,761	40,180	1,47,711
Aug	44,958	1,23,227	45,633	1,25,076	49,155	1,34,457		
Sep	44,855	1,01,968	45,528	1,03,498	48,943	1,11,260		
Oct	48,846	99,684	49,579	1,01,180	53,298	1,08,768		
Nov	54,649	93,825	55,469	95,233	59,629	1,02,375		
Dec	46,749	67,585	47,451	68,599	51,010	73,744		
Jan	42,762	85,041	43,404	86,317	46,659	92,791		
Feb	41,995	72,248	42,625	73,332	45,822	78,832		
Mar	43,642	62,854	44,297	63,797	47,619	68,582		

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Table 6.52: Fuel Sales Data

GPS Coordinates: 16.680942, 78.4803307(near Kalwakurthy)				
Month	2020		2021	
	Diesel(l)	Petrol(l)	Diesel(l)	Petrol(l)
Apr	59,049	34,054	88,632	56,682
May	78,708	55,525	1,17,561	57,858
Jun	1,07,028	57,329	1,21,852	60,948
July	88,597	60,692	1,07,252	58,032
Aug	83,684	58,637	99,352	61,359
Sep	79,601	60,650		
Oct	78,047	63,655		
Nov	98,541	67,238		
Dec	1,21,004	71,443		
Jan	1,17,765	71,186		
Feb	92,951	58,820		
Mar	87,273	60,627		

Table 6.53: Fuel Sales Data

GPS Coordinates: 16.463662, 78.345885(near Kollapur)				
Month	2020		2021	
	Diesel(l)	Petrol(l)	Diesel(l)	Petrol(l)
Apr			62309	21216
May			112186	23669
Jun			122844	22959
July			82435	23450
Aug	67514	23805	81950	23290

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Sep	53772	22433		
Oct	69373	25646		
Nov	96799	28058		
Dec	104460	28747		
Jan	104152	27407		
Feb	60828	20724		
Mar	49317	21479		

Table 6.54: Fuel Sales Data

GPS Coordinates: 16.1100207, 78.3096326(near Kollapur)				
Month	2020		2021	
	Diesel(l)	Petrol(l)	Diesel(l)	Petrol(l)
Apr			76,422	21,023
May			89,788	21,989
Jun	52,422	21,652	92,844	20,689
July	68,425	20,145	72,438	20,869
Aug	68,256	22,999	64,859	23,396
Sep	70,251	23,069		
Oct	71,256	23,857		
Nov	72,544	24,363		
Dec	73,444	23,557		
Jan	76,899	24,056		
Feb	68,942	21,369		
Mar	70,981	21,478		

6.9. Traffic forecast

6.9.1. General

The investment priorities are governed by the traffic demand, assessed benefits, and cost of the project. Demand plays an important role, which governs the type of facility/infrastructure to be created. This in turn determines likely benefits and costs to develop the same. A highway project of this nature calls for significant investment. Prediction of traffic demand becomes an important task and must be carried out near accurately. The accurate estimation of traffic has a direct bearing

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on the design of the facility and the viability of a project. Recognizing this, efforts are made to carefully assess all the parameters that help in predicting the traffic demand in future.

For the design of pavement and to plan maintenance programme and economic evaluation, it is necessary to have a realistic estimate of the size of traffic in the design period of 30 years from the year 2021 to the year 2041. Traffic forecasting is made by determining the past trend of traffic flow along the corridor and by use of economic models developed to co-relate past vehicle registration data and economic indicators such as per capita income (PCI), gross state domestic product (GSDP) and gross domestic product (GDP). By using the elasticity values obtained from the economic models and the likely rate of growth of indicators, the mode wise growth rates are obtained. Applying these growth rates, future traffic volume is estimated.

6.9.2. Past registration of vehicles

The past vehicle registration data of Telangana and Andhra Pradesh for past years are presented in **Table 6.55** and **Table No.6.56**.

Table No.6.55: Past vehicle registration of Telangana

Year	2 Wheelers	Cars/Jeeps	Buses	Goods Vehicles
2015-16	628290	88470	3033	34967
2016-17	766587	118110	4396	55874
2017-18	837197	124858	4639	65548
2018-19	918950	134476	4631	68170

Source: Statistical Handbook of Telangana-(2017-2020)

Table No. 6.56: Past vehicle registration of Andhra Pradesh

Year	2 Wheelers	Cars	Buses	Goods
2015	6147523	486307	23493	313078
2016	6824016	533542	25118	342028
2017	7671213	599988	27300	374746

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2018	8378772	691025	31321	422954
2019	9326888	770488	32901	474406

Source: Statistical Handbook of Andhra Pradesh-(2015-2020)

6.9.3. Economic growth of states

Net state domestic product (NSDP) and per capita income of the states are direct indices of the economic performances of a state. **Table 6.57** and **Table 5.4** gives the indices with growth rates for Telangana and Andhra Pradesh State.

Table No. 6.57: Net State Domestic Product (NSDP) and Per-capita NSDP at factor cost -Telangana

Year	At current prices				At constant prices (2011-12)			
	NSDP	%	Per capita NSDP	%	NSDP	%	Per capita NSDP	%
	(Rest Crores)		(in Rs)		(Rs Crores)		(in Rs)	
Telangana								
2011-12	325139		91121		325139		91121	
2012-13	364030	11.9613	101007	10.8493	334205	2.78835	92732	1.7679788
2013-14	408282	12.1561	121162	19.9541	349593	4.60436	96039	3.5661907
2014-15	456280	11.7561	124104	2.42815	372897	6.66604	101424	5.6070971
2015-16	522994	14.6213	140840	13.4855	416892	11.7982	112267	10.690764
2016-17	598519	14.4409	159584	13.3087	455940	9.36645	121568	8.2847141
2017-18	684500	14.3656	180697	13.23	501467	9.98531	132380	8.8937878
2018-19	786991	14.9731	205696	13.8348	555084	10.692	145082	9.595105

Source: Socio-Economic Out Look-2019, Govt of Telangana

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**Table No.6.58: Net State Domestic Product (NSDP) and Per-capita
NSDP at factor cost -Andhra Pradesh**

Year	At current prices				At constant prices (2011-12)			
	NSDP (Rest Crores)	% Growth	Per capita NSDP (in Rs)	% Growth	NSDP (Rs Crores)	% Growth	Per capita NSDP (in Rs)	% Growth
Andhra Pradesh								
2011-12	339996		69000		339996		69000	
2012-13	370196	8.88246	74688	8.24348	341335	0.39383	68865	- 0.195652
2013-14	413164	11.6068	82870	10.9549	360239	5.53825	72255	4.922674 8
2014-15	470934	13.9823	93903	13.3136	397064	10.2224	79174	9.575807 9
2015-16	544827	15.6907	108002	15.0144	446997	12.5756	88609	11.91679 1
2016-17	631249	15.8623	124401	15.184	492644	10.2119	97086	9.566748 3
2017-18	734659	16.3818	143935	15.7024	545445	10.7179	106864	10.07148 3
2018-19	847056	15.2992	164025	13.9577	605561	11.0215	117261	9.729188 5

Source: Statistical Abstract of Andhra Pradesh (2015-2019)

6.9.4. Forecasting of socio-economic parameters

Net state domestic product projection

The NSDP of both states at constant prices (2011-12) has shown a significant increase in past years. Close examination of past traffic data and economic indices has been done. The O - D data analysis shows that the traffic on the road is generated in Telangana and Andhra Pradesh equally. Considering these factors,

it is decided to apply growth in economic parameters of both the states for the entire stretch. In this case, it is logical to apply regional growth rates, i.e., NSDP of Telangana and Andhra Pradesh rather than national parameter (GDP).

For the future years NSDP has been worked out in the following manner:

1. NSDP figures at constant prices (2011-12) have been made available for Telangana and Andhra Pradesh for the past 10 years from different volumes of Economic Review.
2. These NSDP figures have been plotted against respective GDP figures. From the Ninth Five Year Plan, growth rates of GDP projected for the future have been obtained.
3. The co-relation (based on best-fit) between GDP and NSDP has been developed. From the equation of this trend line, the future values of NSDP have been obtained and the five-yearly growth rates have been worked out.

Past NSDP values for other states have been obtained from different volumes of the Indian Economy Survey. They have been proportionately grown undergrowth in GDP.

6.9.5. Economic perspective

The economy of India has grown up gradually and average annual growth in terms of Gross Domestic Product at constant prices (2011-12) is shown below.

Year	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
GDP (%)	5.24	5.5	6.4	7.4	8.0	8.3	6.8	6.5	4.0	-7.96

Source: Ministry of Statistics and Program Implementation

The economy of India has achieved an average annual growth of approximately 8.0% in terms of Gross Domestic Product (GDP) from 2.11-12 onwards. The growth rate has reduced to 4.04 % in 2.09-20 due to total lockdown because of Covid-19 decrease further decline to -7.25% in 2020-21. From the above tables, the actual reduction in GDP from 2017-18 to 2020-21 is given below

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- India GDP growth rate for 2020 was **-7.96%**, a **12.01% decline** from 2019.
- India GDP growth rate for 2019 was **4.04%**, a **2.49% decline** from 2018.
- India GDP growth rate for 2018 was **6.53%**, a **0.26% decline** from 2017.
- India GDP growth rate for 2017 was **6.80%**, a **1.46% decline** from 2016.

Similarly, the Telangana and Andhra Pradesh state economy has achieved a growth of 14.245 % and 15.10% (in terms of NSDP) respectively, which is quite remarkable. In 2020-21 it has reduced to 2.42% and 1.58%. The average growth of PCI in Telangana and Andhra Pradesh is 5.94% and 10.39% respectively.

GDP Annual Growth Rate in India is expected to be 12.00 per cent by the end of this quarter, according to Trading Economics global macro models and analysts expectations. In the long-term, the India GDP Annual Growth Rate is projected to trend around 7.00 per cent in 2022 and 6.50 per cent in 2023. It is assumed that there would be a likely fall in GDP growth and elasticity values will tend to decrease with economic development in future years.

Given the above discussion, it is felt that the economy should neither be under nor over targeted. The complexities involved and sensitive dimensions of the economy are many, larger issues of this must be addressed by constructing different scenarios. Thus, an effort has been made to develop three different scenarios of varying growth rates of economic indicators as under:

- Optimistic Scenario
- Most Likely Scenario
- Pessimistic Scenario

6.9.6. Transport Demand Elasticity

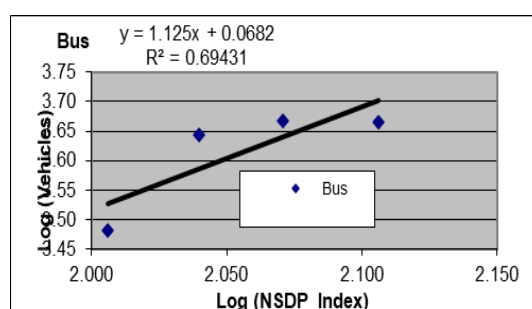
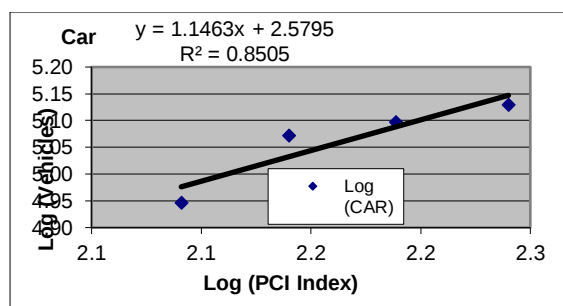
The elasticity approach has been used for determining the growth rates of future traffic. This involved establishing a quantitative relationship between traffic growth as the dependent variable and growth in NSDP or sectoral income as the independent variable. The methodology involved fitting log-log regression equations to the time series data.

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The traffic flow on the project road is mostly originating from/destined to various parts of Telangana and Andhra Pradesh state. As the time series traffic data on project road is not available, elasticity values are established by using registered vehicles as a dependent variable and the state income of Telangana and Andhra Pradesh has been used as an independent variable. In the case of freight vehicles, regression has been done using two sets of independent variables, namely, NSDP and combined income from agriculture and manufacturing. The transport demand elasticity by vehicle type is presented in Table 6.59 and Table 6.60 for Telangana and Andhra Pradesh respectively.

**Table No.6.59: Transport Demand Elasticity using Vehicle Registration Data-
Telangana**

Vehicle Type	Independent Variable	R ² Value	Elasticity Value
Car/Jeep/Taxi	NSDP	0.85	1.1463
Buses/Light pass vehicle	NSDP	0.7	1.12
Trucks / MAV	NSDP	0.83	1.2162
Tractors	NSDP	0.76	1.775



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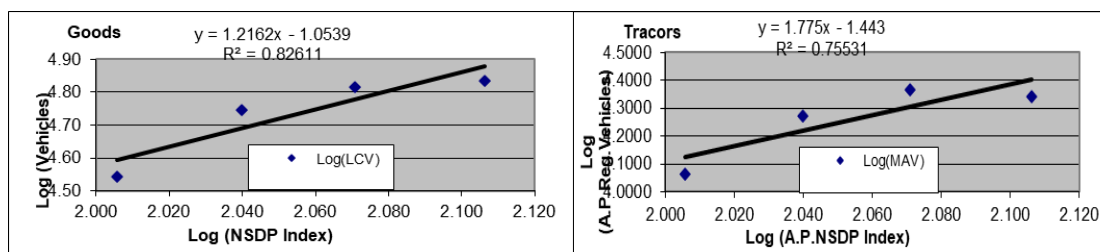
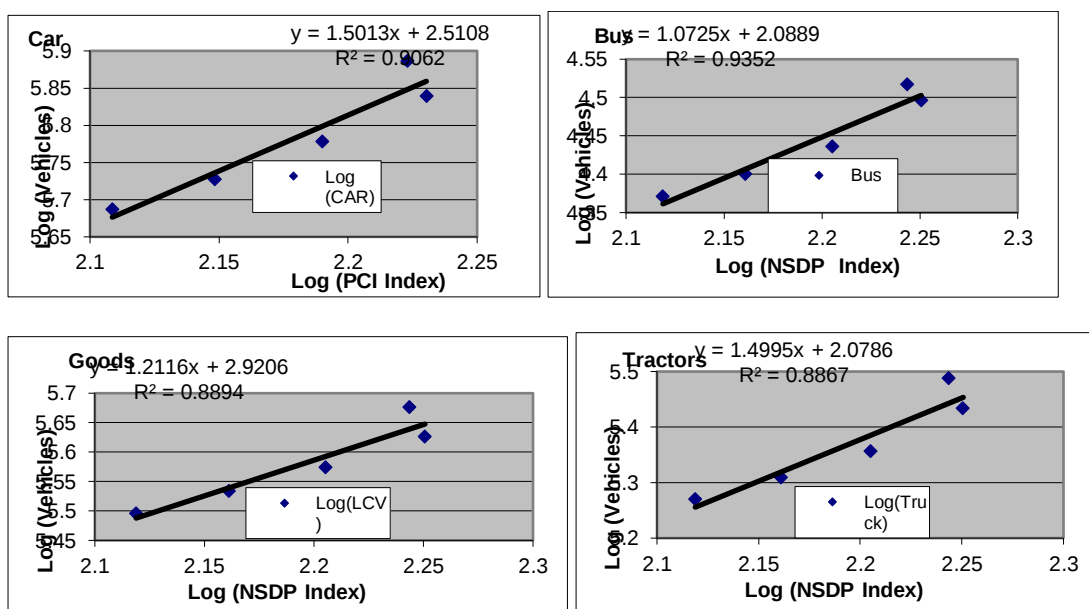


Table No.6.60: Transport Demand Elasticity using Vehicle Registration Data- Andhra Pradesh

Vehicle Type	Independent Variable	R ² Value	Elasticity Value
Car/Jeep/Taxi	NSDP	0.90	1.5013
Buses/Light pass vehicle	NSDP	0.94	1.0725
Trucks / MAV	NSDP	0.89	1.2116
Tractors	NSDP	0.89	1.4995



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In the case of freight vehicles, the result based on NSDP shows a better fit as compared to the results based on weighted income from agriculture and manufacturing. Because of the multiplier effect of developments in the services sector, growth rates for freight vehicles have been estimated using state income and not weighted income from agriculture and manufacturing.

In India, the ownership of personalized modes is usually concentrated in urban areas. Also, these vehicles are used for travel in urban and sub-urban areas, mainly on short hauls. The growth of these vehicles on inter-city roads is below the growth in vehicle ownership. Hence, the elasticity values obtained by using registered vehicles are an overestimate for the traffic moving on inter-city routes. Considering this, elasticity values for personalized vehicles obtained by using registration data must be moderated. For cars, a value of 1.15 for Telangana 1.5 for Andhra Pradesh has been adopted for the initial period for the Kalwakurthy-Nagarkurnool-Kollapur section.

The projected elasticity values adopted in the study for 5 yearly intervals are presented in **Table 6.61 for Telangana** and **Table 6.62 for Andhra Pradesh**. Elasticity values in the initial period are related to either actual or moderated (as described above) past elasticity values. Thereafter, the values are based on the premise that transport demand Elasticities for both freight and passenger traffic tend to decline over time, despite growth in per capita income. As the economy and its various sectors grow, every region tends to become self-sufficient

Table No.6.61: Projected Transport Demand Elasticities- Telangana

Year period	Vehicle Type			
	Car	Bus	Goods	Tractors
2021	1.15	1.10	1.20	1.8
2022-2025	1.15	1.10	1.20	1.8
2026-2030	1.04	0.99	1.08	1.6
2021-2025	0.94	0.90	0.98	1.5
2026-2030	0.85	0.81	0.89	1.33
2031-2035	0.77	0.73	0.80	1.20

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Table No.6.62: Projected Transport Demand Elasticities-Andhra Pradesh

Year period	Vehicle Type			
	Car	Bus	Trucks	Tractors
2021	1.50	1.07	1.21	1.5
2022-2025	1.50	1.07	1.21	1.5
2026-2030	1.36	0.97	1.10	1.4
2031-2035	1.23	0.88	0.99	1.2
2036-2040	1.11	0.79	0.89	1.1

6.9.7. Projected Traffic Growth Rates

The analysis of O-D survey data along the project road section indicates that the majority of the traffic is destined to/originating from within the states of Telangana and Andhra Pradesh. For Kalwakurthy-Nagarkurnool-Kollapur section, PIA districts of Hyderabad, Rangareddy, Nagarkurnool, Kurnool, Ananthapur, Kadapa and Chittoor are the major contributors to total traffic.

The traffic growth rates for the three scenarios, by vehicle type, over the time horizon of the study are given in **Table 5.9** for Kalwakurthy -Nagarkurnool-Kollapur Section. These growth rates are based on transport demand Elasticities and weighted economic perspectives for different districts.

Table No. 6.63: Projected Traffic Growth Rates by Vehicle type - Kalwakurthy-Nagarkurnool-Kollapur Section
(Figures in percentage)

Period	Type of Vehicle			
	Cars	Bus	Trucks	Tractors
'Most Likely' Scenario				
2021	9.00	7.00	6.50	9.00
2022-2025	9.00	7.00	6.50	9.00
2026-2030	8.50	7.00	6.00	8.50

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2031-2035	8.00	6.50	6.00	8.00
2036-2040	7.00	6.00	5.50	7.00
2041-2045	7.00	6.00	5.50	7.00
'Optimistic' Scenario				
2021	10.00	8.00	7.50	10.00
2022-2025	10.00	8.00	7.50	10.00
2026-2030	9.50	8.00	7.00	9.50
2031-2035	9.00	7.50	7.00	9.00
2036-2040	8.00	7.00	6.50	8.00
2041-2045	8.00	7.00	6.50	8.00
'Pessimistic' Scenario				
2021	8.00	6.00	5.50	8.00
2022-2025	8.00	6.00	5.50	8.00
2026-2030	7.50	6.00	5.00	7.50
2031-2035	7.00	5.50	5.00	7.00
2036-2040	6.00	5.00	4.50	6.00
2041-2045	6.00	5.00	4.50	6.00

6.9.8. Growth Rates for Slow Moving Traffic

The slow-moving vehicles essentially cater to short-haul traffic, meeting localized demand for transportation of passengers and goods from rural areas in the up country to the nearest market towns and urban centers. Motorized vehicles are gradually replacing these. The slow-moving traffic is not expected to have high growth rates on NH's. As such, slow-moving traffic of animal-drawn vehicles, cycle and cycle rickshaws are likely to be phased out from the project road by a negative growth rate of 1 per cent per annum.

6.9.9. Traffic projections

The base year estimated traffic intensity including both observed and diverting for the Kalwakurthy – Kollapur section and Atmakuru – Nandyala sections are presented in the following Table No.6.64 and 6.65.

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Table No.6.64: Total traffic on the Project Road – Kalwakurthy-Nagarkurnool section

Type of Vehicle	Observed		Diverted Traffic		Total Traffic	
	Vehicles	PCUs	Vehicles	PCUs	Vehicles	PCUs
Car/ Jeep/Van	1403	1403	796	796	2199	2199
Two-wheeler	2714	1357	0	0	2714	1357
3wh	160	160	0	0	160	160
Minibus	3	4	0	0	3	4
School Bus	1	2	0	0	1	2
Bus (Govt)	104	313	45	135	149	448
Bus (Pvt)	5	15	62	187	67	202
LCV (4 Tyre)	222	333	263	395	485	728
LCV (6 Tyre)	74	111	222	333	296	444
2-Axle	24	72	317	952	341	1024
3-Axle	37	110	121	363	158	473
4-Axle and 6 Axle	53	239	416	1873	469	2112
7 Axle Above	0	2	19	85	19	87
Tractor	17	25	0	0	17	25
Tractor with Trailer	18	81	0	0	18	81
Cycle	17	9	0	0	17	9
Cycle Rickshaw	0	1	0	0	0	1
Animal cart	1	3	0	0	1	3
Others	20	59	0	0	20	59
Total	4872	4299	2262	5119	7133	9418

Table No.6.65: Total traffic on the Project Road – Kalwakurthy-Nagarkurnool section

Type of Vehicle	Observed		Diverted Traffic		Total Traffic	
	Vehicles	PCUs	Vehicles	PCUs	Vehicles	PCUs
Car/ Jeep/Van	1141	1141	796	796	1937	1937
Two-wheeler	2945	1472	0	0	2945	1472

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3wh	240	240	0	0	240	240
Minibus	5	8	0	0	5	8
School Bus	3	8	0	0	3	8
Bus (Govt)	160	481	45	135	205	616
Bus (Pvt)	2	6	62	187	64	193
LCV (4 Tyre)	233	349	263	395	496	744
LCV (6 Tyre)	52	78	222	333	274	411
2-Axle	32	95	317	952	349	1047
3-Axle	25	76	121	363	146	439
4-Axle and 6 Axle	57	255	416	1873	473	2128
7 Axle Above	0	0	19	85	19	85
Tractor	14	22	0	0	14	22
Tractor with Trailer	35	157	0	0	35	157
Cycle	1	1	0	0	1	1
Cycle Rickshaw	0	0	0	0	0	0
Animal cart	0	0	0	0	0	0
Others	10	30	0	0	10	30
Total	4954	4418	2262	5119	7215	9537

The traffic projections for the horizon year 2045 on Kalwakurthy – Nagarkurnool, Nagarkurnool-Kollapur Section in Telangana state has been done by using the estimated traffic growth rates mentioned in the above section. The projected traffic is presented in **Table 6.66** and **Table 6.67**.

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Table 6.66: Projected Sectional Traffic in PCUs- Kalwakurthy- Nagarkurnool section

Year	Cars	Two wheel	Three Wheel ers	Minib us	Schoo l Bus	Bus (Govt)	Bus (Pvt)	LCV (4)	LCV (6)	2-Axle	3-Axle	4-Axle and 6	7 Axle Above	Tracto r	Tracto r with	Total PCU
2021	3176	1329	156	5	3	897	120	333	387	1806	1404	2480	0	26	81	12202
2022	3462	1449	170	5	3	982	131	370	430	2005	1558	2752	0	28	90	13436
2023	3773	1579	185	5	4	1076	144	410	477	2225	1730	3055	0	32	101	14796
2024	4113	1721	202	6	4	1178	158	455	529	2470	1920	3391	0	35	112	16295
2025	4483	1876	220	6	4	1290	173	506	587	2742	2131	3764	0	39	125	17947
2026	4887	2035	239	7	5	1406	188	559	649	3030	2355	4159	0	44	139	19701
2027	5326	2208	259	8	5	1532	205	617	717	3348	2602	4596	0	49	154	21628
2028	5806	2396	281	8	6	1670	223	682	793	3699	2876	5079	0	54	171	23744
2029	6328	2600	305	9	6	1820	244	754	876	4088	3178	5612	0	60	190	26069
2030	6898	2821	331	10	7	1984	265	833	968	4517	3511	6201	0	66	211	28623
2031	7519	3047	358	11	7	2153	288	916	1065	4968	3862	6821	0	73	233	31321
2032	8195	3290	386	12	8	2336	312	1008	1171	5465	4249	7503	0	81	258	34274
2033	8933	3553	417	13	8	2534	339	1108	1288	6012	4674	8254	0	90	285	37508
2034	9737	3838	450	14	9	2750	368	1219	1417	6613	5141	9079	0	99	315	41049
2035	10613	4145	487	15	10	2984	399	1341	1559	7274	5655	9987	0	109	348	44925
2036	11569	4435	521	16	11	3207	429	1462	1699	7929	6164	10886	0	120	381	48827
2037	12610	4745	557	17	12	3448	461	1594	1852	8642	6719	11865	0	131	417	53070

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2038	13745	5077	596	19	12	3706	496	1737	2019	9420	7323	12933	0	144	456	57684
2039	14982	5433	638	20	13	3984	533	1893	2200	10268	7983	14097	0	157	500	62701
2040	16330	5813	682	21	14	4283	573	2064	2398	11192	8701	15366	0	172	547	68158
2041	17800	6220	730	23	15	4604	616	2249	2614	12200	9484	16749	0	189	599	74093
2042	19402	6656	781	25	17	4950	662	2452	2849	13297	10338	18256	0	207	656	80547
2043	21148	7121	836	27	18	5321	712	2673	3106	14494	11268	19900	0	226	718	87567
2044	23051	7620	894	29	19	5720	765	2913	3385	15799	12282	21690	0	248	787	95203
2045	25126	8153	957	31	21	6149	823	3175	3690	17221	13387	23643	0	271	861	103508

Table 6.67: Projected Sectional Traffic in PCUs- Nagarkurnool – Kollapur section

Year	Cars	Two wheelers	Three Wheelers	Minibuses	School Bus	Bus (Govt)	Bus (Pvt)	LCV (4 Tyre)	LCV (6 Tyre)	2-Axle	3-Axle	4-Axle and 6	7 Axle Above	Tractor	Tractor with Trailer	Total PCU
2021	2919	1442	235	8	9	1062	111	350	354	1830	1368	2498	0	21	158	12363
2022	3153	1557	254	8	10	1152	120	384	389	2013	1505	2747	0	23	174	13490
2023	3405	1682	274	9	11	1250	131	423	428	2214	1655	3022	0	26	192	14722
2024	3677	1817	296	10	11	1356	142	465	471	2436	1821	3324	0	28	213	16067
2025	3971	1962	320	10	12	1472	154	512	518	2679	2003	3657	0	31	235	17536
2026	4289	2119	345	11	14	1597	167	563	570	2947	2203	4022	0	35	259	19141
2027	4632	2288	373	12	15	1733	181	619	627	3242	2423	4424	0	38	287	20895
2028	5003	2471	403	13	16	1880	196	681	690	3566	2666	4867	0	42	317	22811

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Year	Cars	Two wheelers	Three Wheelers	Minibuses	School Bus	Bus (Govt)	Bus (Pvt)	LCV (4 Tyre)	LCV (6 Tyre)	2-Axle	3-Axle	4-Axle and 6	7 Axle Above	Tractor	Tractor with Trailer	Total PCU
2029	5403	2669	435	14	17	2040	213	749	759	3923	2932	5354	0	47	350	24905
2030	5835	2883	470	16	19	2213	231	824	835	4315	3226	5889	0	52	387	27193
2031	6302	3113	507	17	20	2401	251	907	918	4747	3548	6478	0	57	427	29694
2032	6806	3362	548	18	22	2605	272	997	1010	5221	3903	7126	0	63	472	32427
2033	7351	3631	592	20	24	2827	295	1097	1111	5743	4293	7838	0	70	522	35414
2034	7939	3922	639	22	26	3067	321	1207	1222	6318	4723	8622	0	77	577	38679
2035	8574	4235	690	24	28	3328	348	1327	1344	6949	5195	9484	0	85	637	42249
2036	9260	4574	745	25	31	3611	377	1460	1479	7644	5714	10433	0	94	704	46152
2037	10000	4940	805	28	33	3917	409	1606	1627	8409	6286	11476	0	104	778	50419
2038	10800	5335	870	30	36	4250	444	1767	1789	9250	6915	12624	0	115	860	55084
2039	11664	5762	939	33	39	4612	482	1943	1968	10175	7606	13886	0	127	950	60186
2040	12598	6223	1014	35	42	5004	523	2138	2165	11192	8367	15274	0	140	1050	65765
2041	13605	6721	1095	38	46	5429	567	2351	2382	12311	9203	16802	0	155	1160	71867
2042	14694	7259	1183	42	50	5890	616	2586	2620	13542	10124	18482	0	171	1282	78540
2043	15869	7839	1278	45	54	6391	668	2845	2882	14897	11136	20330	0	189	1417	85840
2044	17139	8467	1380	49	59	6934	725	3130	3170	16386	12249	22363	0	209	1565	93825
2045	18510	9144	1490	53	64	7524	786	3442	3487	18025	13474	24600	0	231	1730	102560

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6.10. Capacity Analysis

Capacity analysis for project road has been carried out to define the Level of Service offered by road sections under the prevailing roadway and traffic conditions.

6.10.1.Capacity and Level of Service Guidelines

Capacity and design service volumes for various lane configurations specified by IRC -64-1990 "Capacity of Roads in Rural Areas" (Table 3-25) has been used as these capacity figures relate to peak hour traffic in the range of 8-10% and LOS B. The design service volumes are presented in **Table 6.68 and 6.69**

Table No.6.68: Capacity and Design Service Volume as per IRC 64: 1990

Lane Configuration	Capacity (PCUs/day)	Design Service Volume (PCUs/day)
2 Lane		
With earthen shoulder	30000	15000
With Paved shoulder	34500	17250
4 Lane		
With earthen shoulder	70000	35000
With Paved shoulder	80000	40000

Table No. 6.69: Design Service Volumes at Different Levels of Services

Level of Service	2 Lane	4 Lane with Paved Shoulder	6 Lane with Paved Shoulder
A	10350	24000	36000
B	17250	40000	60000
C	24150	56000	84000
D	29325	68000	102000

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Level of Service	2 Lane	4 Lane with Paved Shoulder	6 Lane with Paved Shoulder
E	34500	80000	120000

6.10.2. Capacity Augmentation Proposals

Projected sectional Average Annual Daily Traffic was compared with the adopted Design Service Volume. The Design Service Volume for project road is considered at the end of LOS-B and capacity augmentation is suggested for road sections, which carry traffic volume more than design service volume. **Table 6.70** presents the level of service offered by project road sections.

Table 6.70: Level of Service (LoS) offered by The project road

Year	Kalwakurthy-Nangarkurnool section			
	AADT (PCU s)	LOS		
		2L	4L+PS	6L+PS
2021	12202	B	A	A
2022	13436	B	A	A
2023	14796	B	A	A
2024	16295	B	A	A
2025	17947	B	A	A
2026	19701	C	A	A
2027	21628	C	A	A
2028	23744	C	A	A
2029	26069	D	B	A
2030	28623	D	B	A
2031	31321	E	B	A

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2032	34274	E	B	A
2033	37508	E	B	B
2034	41049	E	B	B
2035	44925	E	C	B
2036	48827	E	C	B
2037	53070	E	C	B
2038	57684	E	C	B
2039	62701	E	D	C
2040	68158	E	D	C
2041	74093	E	E	C
2042	80547	E	E	C
2043	87567	E	E	D
2044	95203	E	E	D
2045	103508	E	E	D

Year	Nagarkurnool Kollapur section			
	AADT (PCU s)	LOS		
		2L	4L+PS	6L+PS
2021	12363	B	A	A
2022	13490	B	A	A
2023	14722	B	A	A
2024	16067	B	A	A
2025	17536	B	A	A

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2026	19141	C	A	A
2027	20895	C	A	A
2028	22811	C	A	A
2029	24905	C	A	A
2030	27193	D	B	A
2031	29694	D	B	A
2032	32427	E	B	A
2033	35414	E	B	A
2034	38679	E	B	B
2035	42249	E	B	B
2036	46152	E	C	B
2037	50419	E	C	B
2038	55084	E	C	B
2039	60186	E	D	B
2040	65765	E	D	C
2041	71867	E	E	C
2042	78540	E	E	C
2043	85840	E	E	C
2044	93825	E	E	D
2045	102560	E	E	D

It has been observed from the traffic projections and capacity analysis presented above the Level of Service will be B once the project road is ready for traffic movement upto the year 2025 in both the Kalwakurthy Nagarkurnool and Nagarkurnool Kollapur sections of NH-167K. The level of Service B will be continued upto 2025. From 2026 onwards Kalwakurthy to Kollapur section of NH-167K need up-gradation to 4 lanes.

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7. IMPROVEMENT PROPOSALS

7.1 General

Design Standards proposed for the various project components are presented in this report. This chapter describes the details of Krishana River Bridge.

Krishna River Bridge, passes over the River Krishna, and connects two states, namely Telangana and Andhra Pradesh. This highway also passes by touching the Two famous and Significant Pilgrimage centres, namely Somasila (Sri Lalitha Someswara Swamy Temple) on Telangana side and Sangameswara temple on Andhra Pradesh side.

This proposed Bridge, would now not only connect two states, but will also connect both these pilgrim centres by road and would allow the Pilgrims and the tourist to commute easily between both these Place. During Pushkara Snanam, this bridge could be used by Lakhs of pedestrians.

This bridge now gains importance due to following reasons.

1. It becomes a Gateway for both the States.
2. It connects 2 pilgrim centres across the River Krishna.
3. It is located in Scenic environment, also used to promote Eco- tourism.

The bridge has to reflect the sensitivity of the Place and at the same time address the advancement of technology. It is hence proposed to be designed as an Iconic Bridge. In order to make this Bridge an Iconic structure, a strong Architectural Concept and Sensitivity to Details is proposed. The propose bridge will have two levels of serviceability for users. At first i.e. top deck four lane vehicular traffic with median and maintenance walkway are proposed. For second level 12.9m walkway consisting of 6m glass walkway at centre and 3.45m side walkway on either side are proposed.

Due to the scenic and eco-sensitive environment, the bridge needed to have minimum intervention with nature, especially with the river. A large span bridge would be an ideal solution to address this type of concerns. We generally have two types of large span bridge, viz, a Suspension Bridge and a Cable stay bridge. Various geometry for this type of bridge were explored. When seen from Somasila side, the bride sits, between two hill tops. The bridge geometry selected is a hybrid of Suspension Bridge and a Cable stay bridge, so as to reduce the height of the Pylon and such that the silhouette of the bridge is continuous to the Hill geometry on both sides. The Proposed bridge would now

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be a cable stay bridge, with the middle section as suspension bridge. This arrangement also makes this bridge unique. Unlike most pure Suspension and Pure Cable stay bridges.

7.2 Salient Features of the Bridge:

The Salient Features of proposed bridge is indicated as below;

Span arrangement for hybrid-cable stayed : 192m+480m+192m= 864m
No. of Traffic Lanes : 4 Lanes

Bridge Superstructure

Clear Carriageway Width : 9.0 m each (LHS & RHS).
Width of Walkway : 12.9m (6m glass sheets and 6m & 6.9 concrete deck slab)
Overall Deck Width of Bridge : 25 m
Tie beams : 4 tie beams with RCC hollow sections are proposed at different elevation level

Bridge Substructure

Lower Pylon : 2 no. s of RCC hollow rectangular section with 12m x 5m
Upper Pylon : 2 no. s of RCC hollow rectangular section with 8m x 4m
Stay Arrangement : Semi-fan type and suspension system
Abutment : RCC Solid Rectangular Shape

Bearings

Spherical bearings are proposed to be provided for Cable Stayed Portion The design of such bearings shall conform to IRC: 83 (Part III & IV).

Wearing Coat

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75mm thick wearing coat comprising of 75mm thick wearing coat comprising of bituminous concrete 50mm thick overlaid with 25mm thick mastic asphalt.

Bridge Design Criteria

The bridge shall be designed mainly as per provisions of IRC Codes and Standards and sound engineering practice. All calculations and drawings shall be made in SI (Metric) Units.

Other Design Standards:

Following IRC Standards for Design of Roads shall be followed.

Design Speed	:	100 kmph
Cross-slope on bridge deck:		2.5%
Longitudinal Gradient	:	5.0% (max)

Foundation:

Foundation shall be designed as per IRC 78 2020.

Pylon Design:

The bridge now would have 2 Pylons, one standing on each state. This allows each pylon to be the Gateway to the respective States. This bridge being located in the Temple town of both states, the Pylon now could reflect the local character. South Indian temples have a distinct element called as the GOPURAMS, or the Entrance Gates. Pylons are Trapezoidal in shape when seen in Elevation. For Cable stay Bridges, 'H'- shaped Pylon is the closest geometry that resembles that of the Gopurams. This shape when modified and articulated can signify the Entrance Gate for each state. Hence a H-shape Pylon is been selected for this bridge.

The Bridge Pylon is conceptually designed on the geometry of Traditional Gopurams. It has distinct 3 sections.

The Lower section is broader and wider and becomes the base for the Bridge deck.

The Middle Section is made to look of stories of reducing portions.

The Upper section is made like a Barrel with series of Finials, similar to the temple finials of Somasila and Someshwara temples. A Welcome Note shall also be displayed on these Pylon.

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Care has been taken to abstract the geometry, such that it does not directly create an impression of a Temple Gopuram, but does it symbolically. Also, the shapes derived are easy to construct in RCC. No Deity images or religious figures are used on this structure, as done in Gopurams, so that it is secular and maintains the sanctity of it not being a Temple structure. The Pylon now gives you a sense of Place, and still gives it a Unique Signature, which has not been used anywhere else in the world.

The Bridge Deck:

The Bridge deck is proposed to be made as Prefabricated Steel Box Sections, with RCC Deck slabs on the Top Flange, that shall be used for the Vehicular Traffic. Typically, the underbelly of such bridge is left empty. But as we have a huge Pedestrian crowd that could use the Road portion to traverse across both sides, especially during Auspicious days and Festive seasons, this would create traffic on the highway, and also be a potential danger for accidents. And it would be a tedious task for Authorities to control such huge crowd on the highway.

To solve the above issue, it is now proposed to make a Pedestrian Bridge (Footbridge) as a part of this bridge. The Bottom flange of the bridge is now being designed to accommodate the Pedestrian Bridge (Footbridge). The Cross Section of the Belly is made into a series of Archway, instead of a typical uninteresting N- Trusses, which makes the space welcoming. And the Box Section is made Trapezoidal, to add some dynamism to the Volume.

The Pedestrian Pathway shall ensure One Way Movement towards each direction. This shall help to manage crowd and avoid conflict. Each Side of the Pathway has Built in Seats throughout the length of the Bridge, to allow for Pedestrians to rest, as we expect lots of Old aged pilgrims traversing this bridge. These seats have full height MS Rails on the edge, designed such that One cannot climb the same and try jumping into the river. The space between the 2 pathways has been proposed as a Glass Bridge. This shall be the Longest Glass bridge over river in the World. This Glass bridge shall have the View of the Krishna River below. This Glass Bridge is separated by 1.05m (3.5 feet) high Glass partition so that people do not misuse this Glass Bridge. These Glass bridge shall have concrete Cross overs after every 60.0m length. They can also be closed during heavy pedestrian movement to ensure supervision and safety.

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This Glass Bridge will attract tourist from all over the places as it is going to be an experience of its kind in the World.

The Entrance and Exit Point of this Pedestrian bridge is also being designed as a Gateway. The walls here would have a large Art wall that can showcase the Story of the Place. These Bridges are then connected to the main road by Ramps, shaded by PTFE Tensile Fabric. The Entire Pedestrian bridge is Physically challenged friendly, allowing Wheel chair, Electric-cart movement between two ends. Electric charging points shall be proposed for such vehicles at both ends. The Portals of the Tensile fabric is also designed to depict a Gopuram like Entrance Gate, similar to the geometry of the Pylon.

The Pylon Portion of the bridge also accommodates Emergency staircase that connects the Road to the Pedestrian Bridge. This portion is also aesthetically designed as a part of the Gopuram.

Anti-glare on median:

The Antiglare on the median is being designed to look like the Finial, used on the top of the Pylon. These shall attribute to the sense of Place while driving.

Lighting:

The Whole bridge is being illuminated with special façade lighting, to give it a character at Night.

Security:

The complete bridge is equipped with CCTV cameras to ensure complete surveillance of the Traffic, at both Vehicular and Pedestrian level. This bridge shall be supersized from Security Office, provided at the Way Side Infrastructure, which includes place for Parking and Way side Amenities like Toilets, convenient shopping, food court etc.

Signages:

Necessary signages as per IRC has been proposed wherever necessary. Special Signage for Pedestrian also has been proposed.

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7.3 Specification of material:

The specification of material used for bridge construction as below;

a. Concrete

All concrete shall be according to "Section 1700 STRUCTURAL CONCRETE" of MoRTH Specifications for Road and Bridge Works.

b. Structural Steel

All structural steel shall be according to "Section 1900 STRUCTURAL STEEL" of MoRTH Specifications for Road and Bridge Works.

c. Reinforcing Steel

All reinforcing steel shall be according to "Section 1600 STEEL REINFORCEMENT" of MoRTH Specifications for Road and Bridge Works.

d. Cable stays and Suspension cable

For Cable, Testing and Installation, 6th edition, 2012 of Post Tensioning Institute or Guidelines of SETRA Stay Cable Recommendations for French Inter-ministerial Commission on Prestressing, June 2002 or EN 10264-1 for Cable stays and EN 10264-2 for Suspension cable shall be used.

e. Spherical bearings

Spherical bearings shall be according to "Section 2004 STRUCTURAL CONCRETE" of MoRTH Specifications for Road and Bridge Works.

f. Modular expansion joint

Modular expansion joint shall be according to "Section 2600 STRUCTURAL CONCRETE" of MoRTH Specifications for Road and Bridge Works.

7.4 Bridge Health Monitoring:

i. Introduction

Transportation places a major role in today's life. In that bridge is one of the important transportation infrastructures for social and economic activities of

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country. Keeping in view to improve the connectivity between the state of Telangana and Andhra Pradesh a new Four lane cable-stayed bridge is currently under proposal for construction across the River Krishna at Somsila.

The bridge will have a total length of 864 m. The proposed main span is of 480 m with two back spans of 192m on either end. The super structure is of steel-concrete composite deck, with a total width of 25 m which will carry two lanes of traffic in each direction. The twin pylon with a height of 100 meters, with hybrid cable stay design, will make it a particularly attractive and imposing addition to the Krishna River from Somsila to Sangmeshwaram.

ii. Proposal for instrumentation and digital twin

The iconic bridge on completion will be required to be continuous monitored for the parameters considered during the design stage and during operations/service. As the bridge is in the remote location the monitoring of the bridge will be difficult. The present system of monitoring of the bridge periodically over the specified period will not meet the requirement to get status of the bridge and will lead to accumulation of defects and failure of the structure.

Therefore, there is requirement of preparation of the digital twin of the cable stay bridge which is subjected to instrumentation for continuous monitoring of the design and in-service parameters. The digital twin will be based on the reduced based finite element modelling for faster and accurate data analysis. One of the major benefits of dynamic monitoring is the possibility to exploit the recorded data for the application of vibration-based damage identification techniques which are extremely helpful for early-stage damage identification.

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The instrumentation with digital twin provides a versatile platform for remote monitoring of structures on a wide range of structural quantities; examples include but not limited to; strain (stress), vibration, tilt, inclination, temperature, humidity etc.

iii. Data to be Recorded

Automatic Bridge monitor system using wireless sensors network is proposed. The system collects the data from sensors and status is collected by the controller and transferred to wireless node. This data at transmitter node is sent to the receiver node and is analysed by the system analyse data is sent to the management centre for integration with the digital twin.

The following data will be recorded by the system.

a. Environmental Factors

Environmental conditions at the top of the pylon will be recorded by a weather station which will measure ambient temperature, relative humidity, precipitation levels, barometric pressure, as well as wind speed and direction. Wind speed and direction will also be measured at deck level, by an ultrasonic sensor.

Factors affecting specific structural members will also be assessed. Relative humidity and temperature inside the hollow sections of the deck structure will be measured by four hygrometers, and the level of corrosion in the pylon base structure will be monitored by means of embedded chloride ion and corrosion sensors.

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In addition seismic events, which could have a serious impact on the entire structure, will be measured at the pylon base using 3D high-definition accelerometers in each leg plinth.

b. Load Factors

Natural vibrations will be measured by eight 3D-accelerometers, which will be capable of relocation along the length of the structure to provide total coverage on a cyclical basis.

Traffic data will be recorded by laser analysers, enabling lane usage, average lane speed and vehicle classification are to be determined.

Traffic congestion, accidents and other anomalies will be captured by a video surveillance unit featuring colour cameras, capable of recording 30 frames per second and night-time usage.

c. Bridge Structural Response

Strain in the pylon, compensated for temperature, will be measured by welded strain gauges, while strain in the deck girders, also temperature compensated, will be measured by bolted strain gauges.

Stay cable forces will be measured by electromagnetic sensors, weatherproof and telecommunications shielded, on the longest, shortest and medium length cables of each set of cables – two sets on the main span and one on the back span.

Cable vibrations will be recorded by 3D-accelerometers, which will be detachable to allow relocation during and after the construction phase to assist in calculation and verification of damping, as well as assessment of changes in harmonics during operation.

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Tilt of the deck on each span and of the pylon (above and below the elbow) will be measured by inclinometers, and displacement of the deck by strain gauges at the expansion joints.

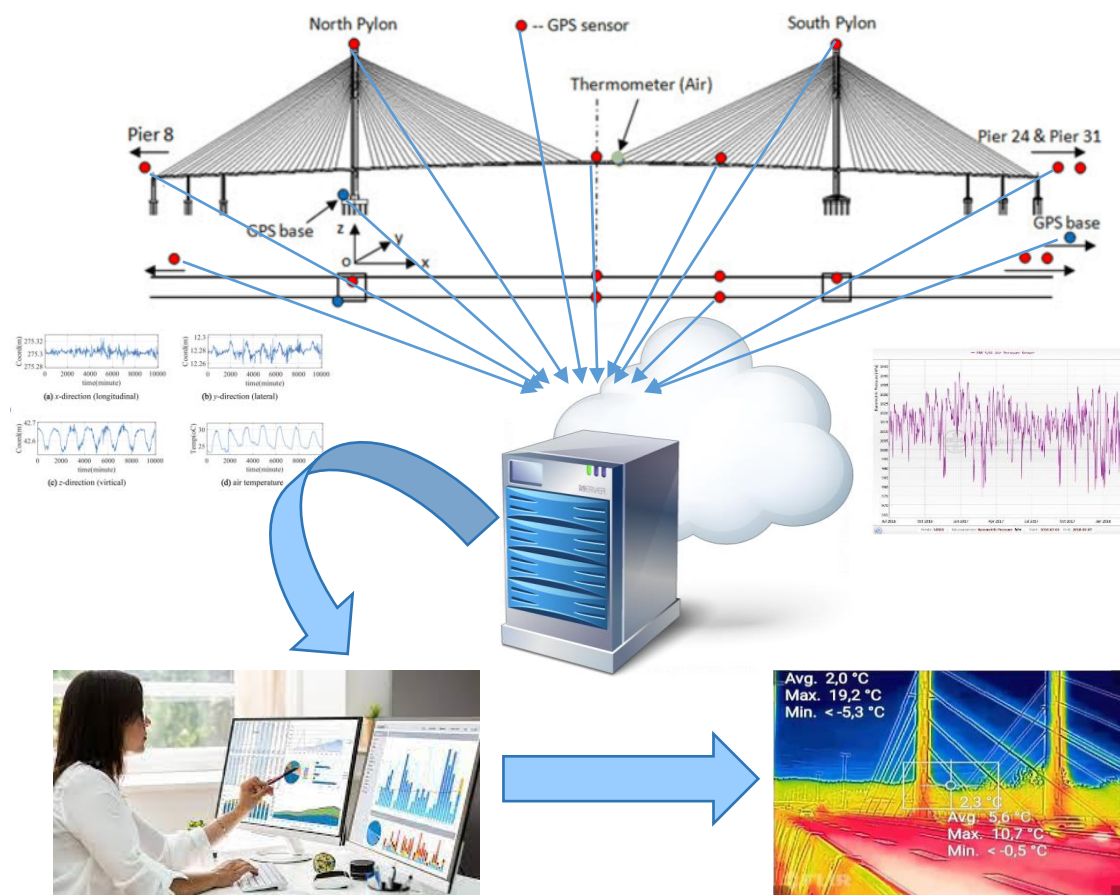
Figure 2: Sensor layout

Sr. No	Description of item	Codes	Quantity
1	Inclinometer (INC)	INC	2 Nos
2	Displacement Sensors (DIS)	DIS	6 Nos
3	2D Accelerometer (2DACC)	2DACC	176 Nos
4	3D Accelerometer (3DACC)	3DACC	8 Nos
5	OFSS/SG (Static)	STATIC	31 Nos
6	Optical Strain Sensor on Cable (OFS)	OFS	24 Nos
7	Temperature Sensor (WS)	WS	5 Nos
8	Weather Station (WS)	WS	2 Nos
9	Speed Trap Cameras (STC)	STC	2 Nos
10	Weigh In Motion Camera (WIN)	WIN	4 Nos.
11	Corrosion Sensors (CS)	CS	4 Nos
12	Data Acquisition System (DAU)	DAU	2 Nos

iv. Data transfer from the master station to the local data server

The data connection between the master station on the bridge and the bridge operator's control room is by means of a wireless LAN bridge using a private static IP. This can operate over a distance of four to five kilometres. This system enables real-time data transmission, independent of mobile telecommunication service providers.

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Data presentation is controlled by a local monitoring data server in an office of the client's choice. Since the server is connected to the internet and the data transfer from the master station on the bridge to the server is wireless, the location can be freely chosen.

All data received from the master station is stored permanently on two independent hard discs to prevent data loss in case of disc failure.

The server is also capable of processing, managing and presenting data from any other permanent monitoring system that might be connected in the future.

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v. Web User Interface

The user interface enables an authorized user to log on to the system, and view any data which may be of interest, for any period of time during which measurements were made (Figures 5 to 7). It also enables the user to input condition and event values and, if necessary, instructions for personnel.

Information is presented in a user-friendly and simply understandable format. High frequency data is displayed in clear graphics (e.g. mimic panel format).

The user can also instruct the system to provide an alarm if predefined threshold values of any variable are exceeded. Such alarms can take the form of a visual notification on a monitor, or an email or SMS to a selected person. This user interface is accessible at any time, from anywhere in the world with an internet connection.

vi. Report Generation

A data file with summarized results is automatically generated and stored on the hard disc at the end of each month. This report file summarizes the month's data on environmental conditions, bridge behaviour and bridge performance. If desired, the reporting period can be adjusted to cover shorter or longer intervals.

The generated reports are presented in PDF format, and are password protected for security. For each report, two emails are sent to a previously defined list of recipients - one with the report and the other with the corresponding password.

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vii. Delivery of the monitoring system

Smooth delivery, installation and operation of the system are ensured by several measures. First, the system will be pre-assembled in the factory to enable a test of every component and of the whole system to be carried out. This also includes the initial calibration of the sensors, the creation of quality control documentation and final updates of pre-installed PC and server operating systems.

Following installation of the system (taking approximately 16 weeks), final calibration of all sensors and a function test of the complete system are carried out. This includes, for example, checking of the horizontal fixation of tilt sensors, subtraction of static offset values of accelerometers and similar tasks. It also includes the initial operation of the operator's workstations.

Operation and maintenance training is then carried out, in relation to the monitoring system on the bridge, the web interface and the user interface in the monitoring office. Maintenance tasks performed by the bridge owner's personnel include, for example, software updates, replacement of batteries and general visual inspection of components. The operation and maintenance manual defines the relevant tasks.

Finally, a comprehensive maintenance package is included, for a period of five years from completion of installation.

viii. Digital Twin

The digital twin will be prepared using reduced based finite element analysis for real time monitoring of the forces structural members being subjected to. The data from the calibrated instrumentation will be integrated with the digital twin to record and compare the response of the structural members thereby bridge in particular.

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7.5 Typical Cross Sections

Typical Cross Sections generally comply by the stipulations in IRC: SP: 73-2018 “Manual for Standards and Specifications for Four Laning of National Highways”.

7.6 Geotechnical & Geophysical Investigations:

Detailed Geotechnical investigations was carried on the structure location, in the form of bore logs taken on site and further testing of materials obtained. It was inferred that on Telangana side weathered rock is encountered at approx. 20 – 25 m. However, on AP side, hard rock is encountered at approx. 15-20 m. Considering suitable socketing as per standards, the founding depth for pile foundation was decided.

However, due to high cutting section of about 60-80 m in the approved alignment, the alignment was shifted slightly to LHS and RHS, depending upon the cutting and filling sections to achieve techno-feasible & economical solutions.

Hence, this alignment was adjusted to achieve max. cutting of about 25 m. Now, the locations of abutments and pylons have been shifted on this alignment and there aroused a need for geotechnical investigations on these new locations. Due to time restrictions, it was jointly inferred by the consultant and client that geophysical investigations may be carried out. Accordingly, the geophysical investigations were carried out and as per its results the foundation details for the iconic Krishna River bridge, were freezed. The detailed geotechnical and geophysical reports are attached in the Annexures which includes methodology of testing, analysis of data collected from site and detailed recommendations / conclusions.

There are relations established between the geotechnical and geophysical investigations, which helped us derive appropriate solutions.

7.7 Forest and Environmental Clearances:

In package 2, we encounter forest area, which is to be acquired, as provisions are made considering future 4 lane expansion of the highway. Our forest expert has superimposed the alignment on village maps and verified the forest stretches. Accordingly, we have approached the forest dept. for the forest clearance proposal, which is, presently, under process. Furthermore, along with forest, environmental clearance also needs to be taken. The same is under process.

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7.8 Right of Way:

As the terrain is rolling, it involves cutting – filling up to a max. ht. of approx. 25.00 m. This attracts requirement of additional land to achieve the desired slope. In addition to this, there is demand for extra land due to considerations of future 4 lane expansion of the highway, have been made. Geophysical tests have been carried out to know the nature of strata available for cutting so that the slope stabilization / protection can be tackled with.

The details of proposal for side slopes, benching, drains, breast walls etc. are shown in the TCS in Annexure I.

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ANNEXURE-1: PROPOSED TCS FOR THE PROJECT



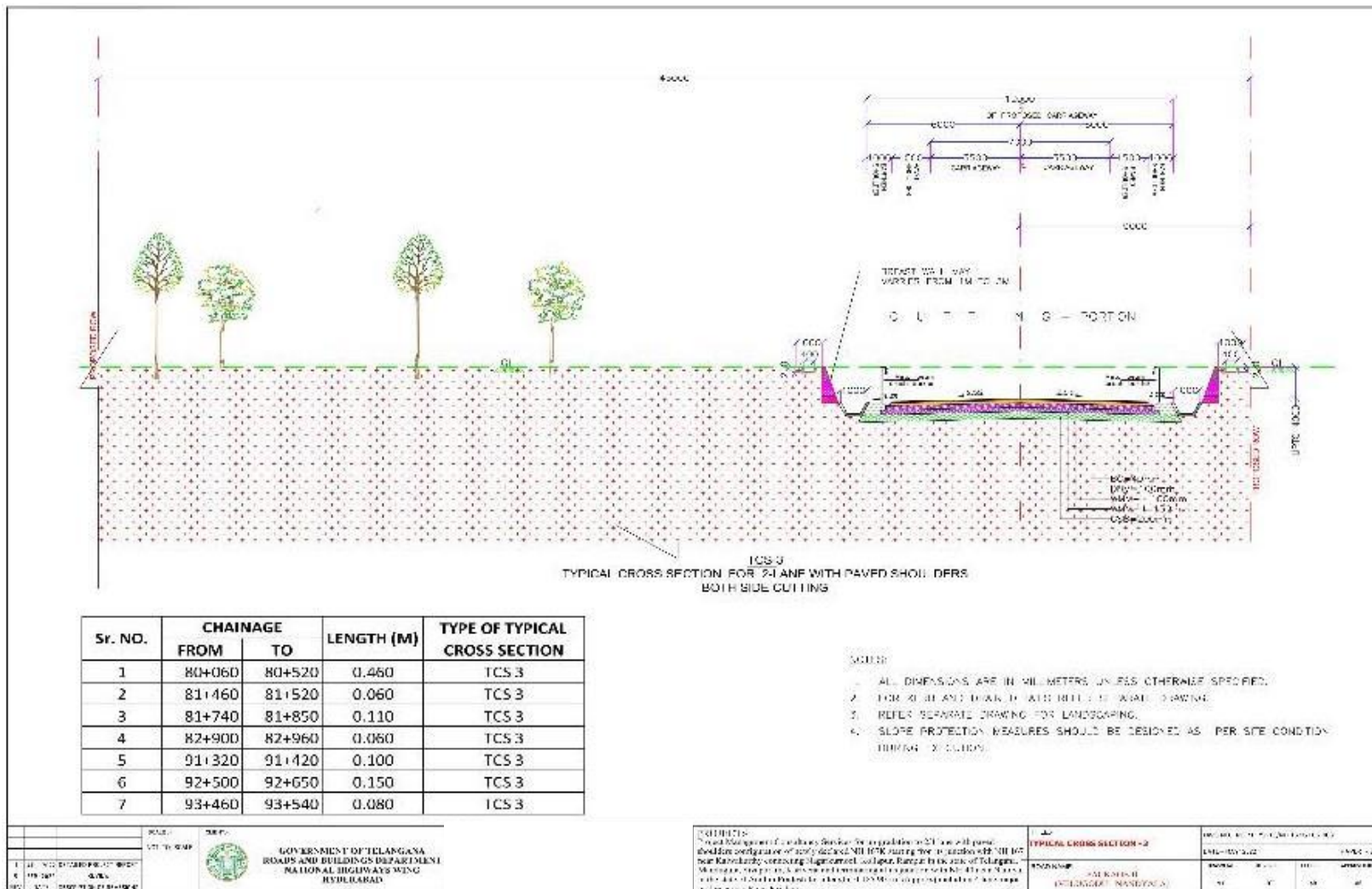
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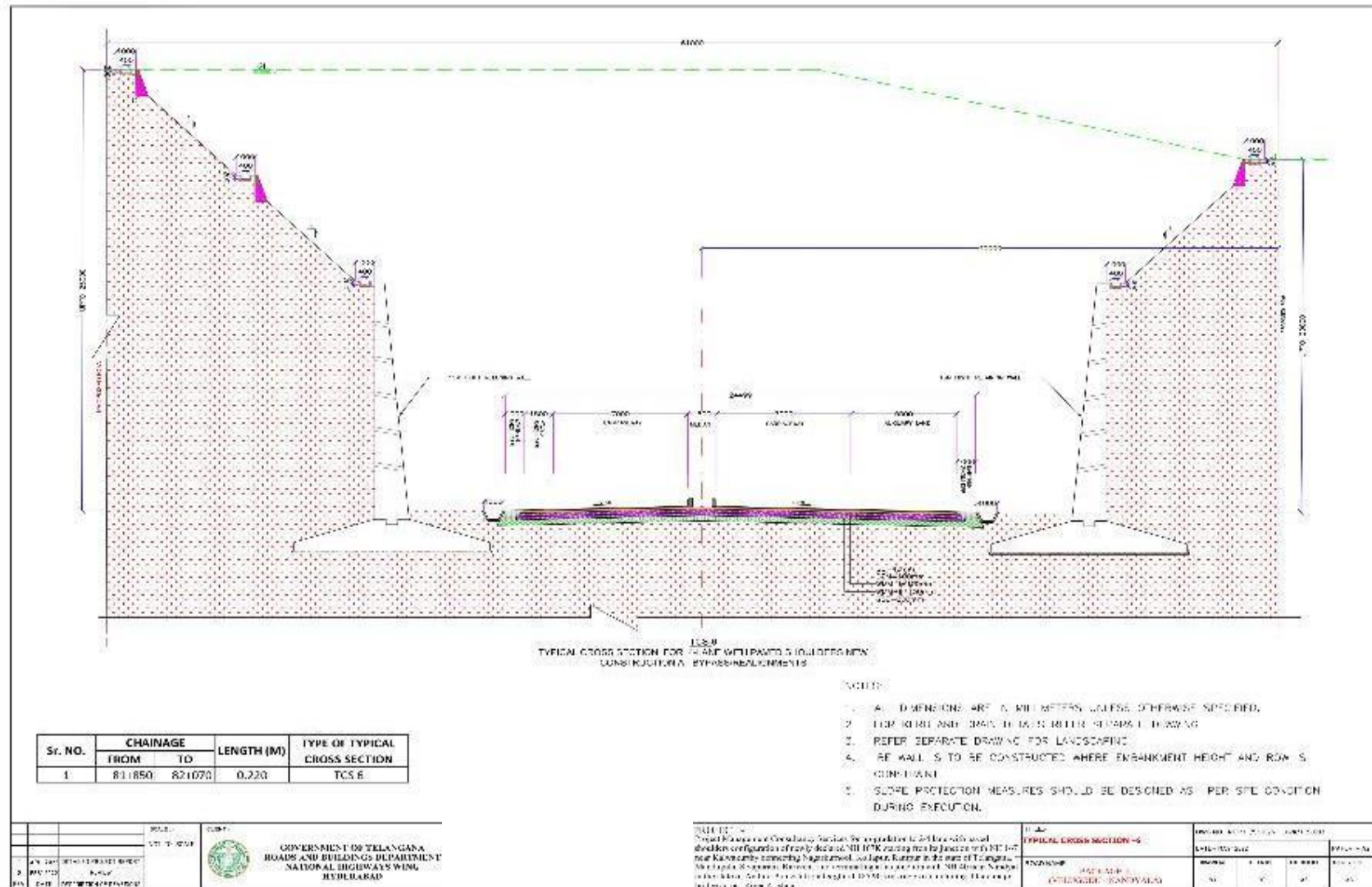
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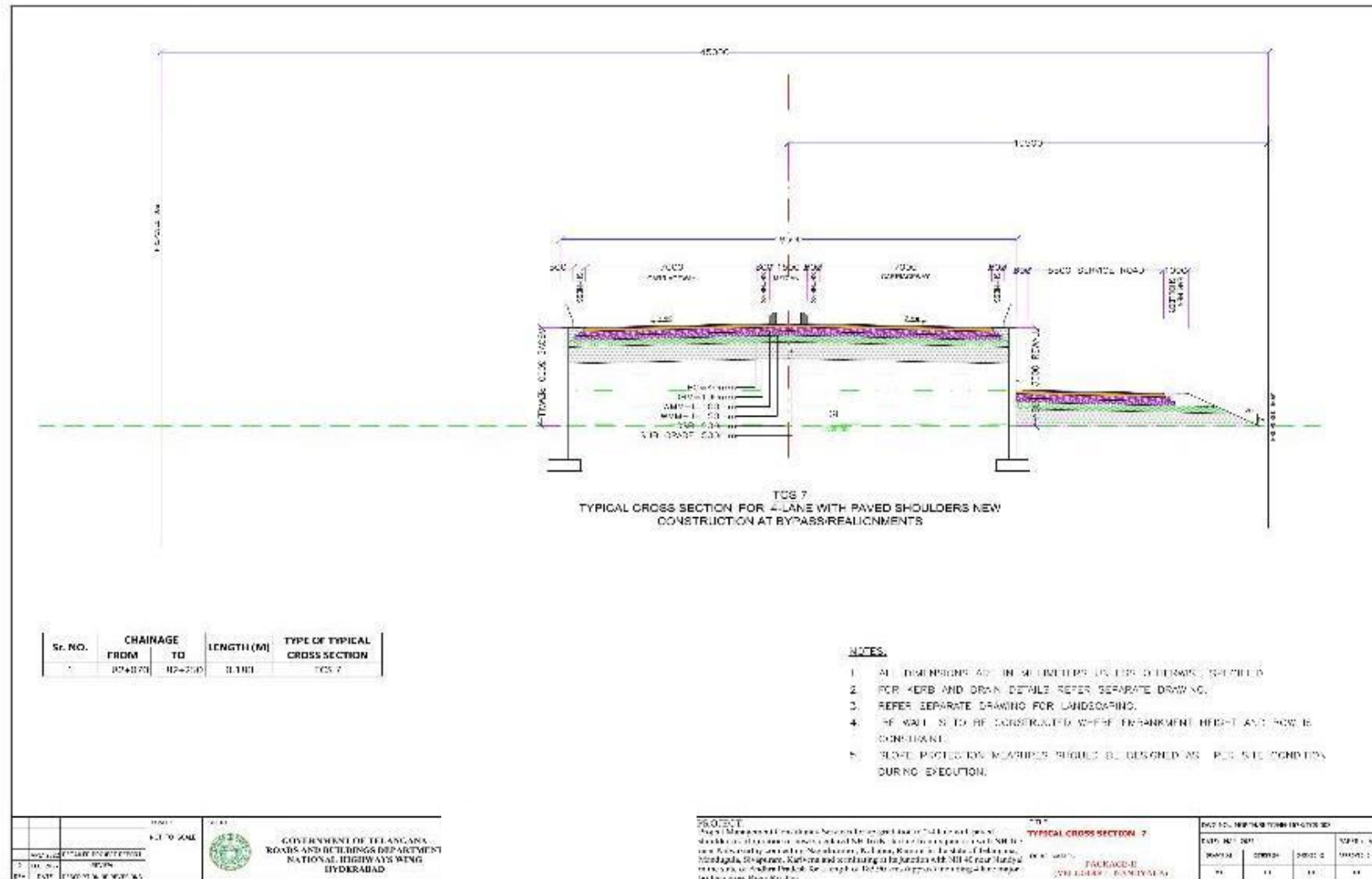
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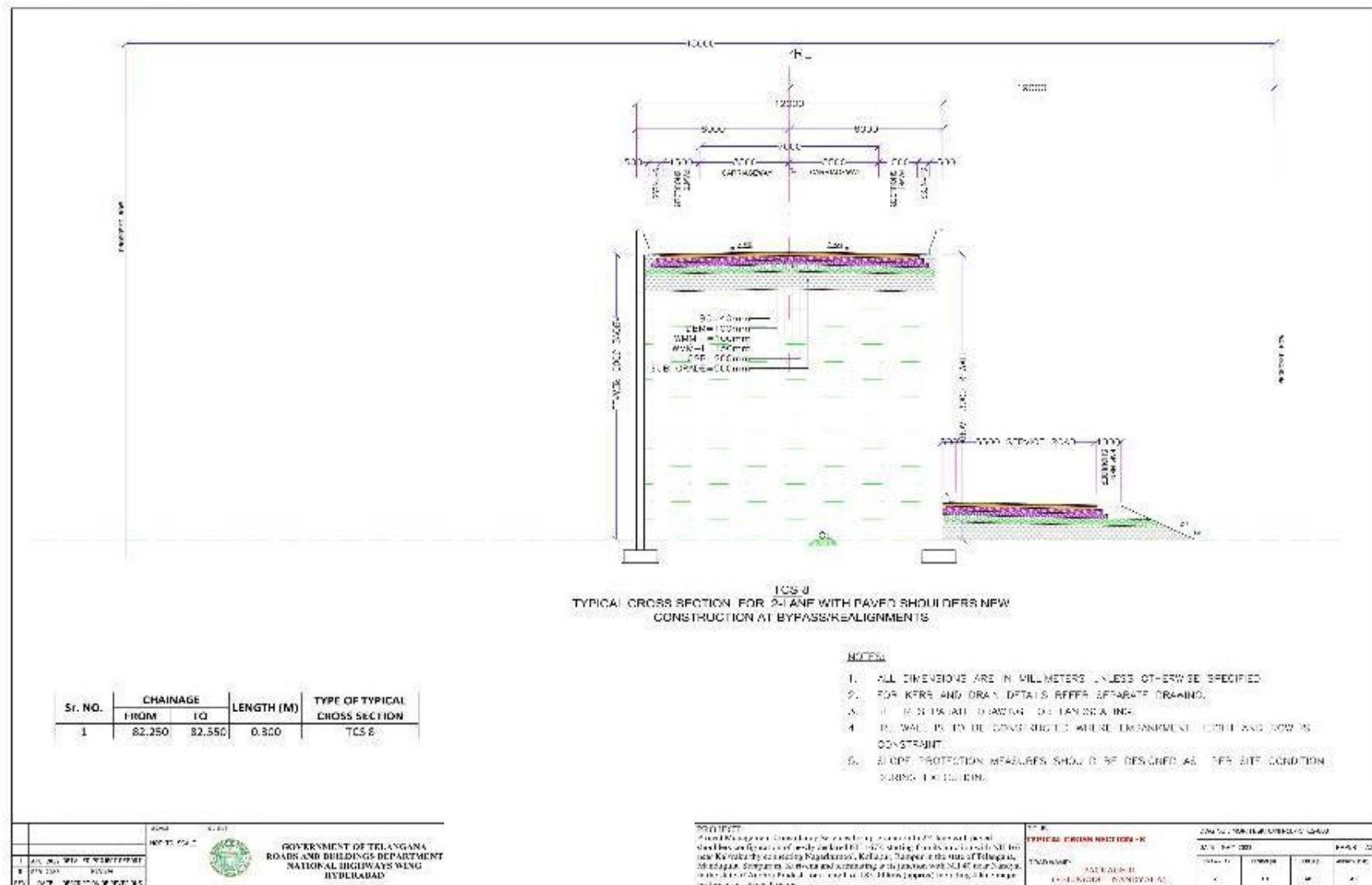
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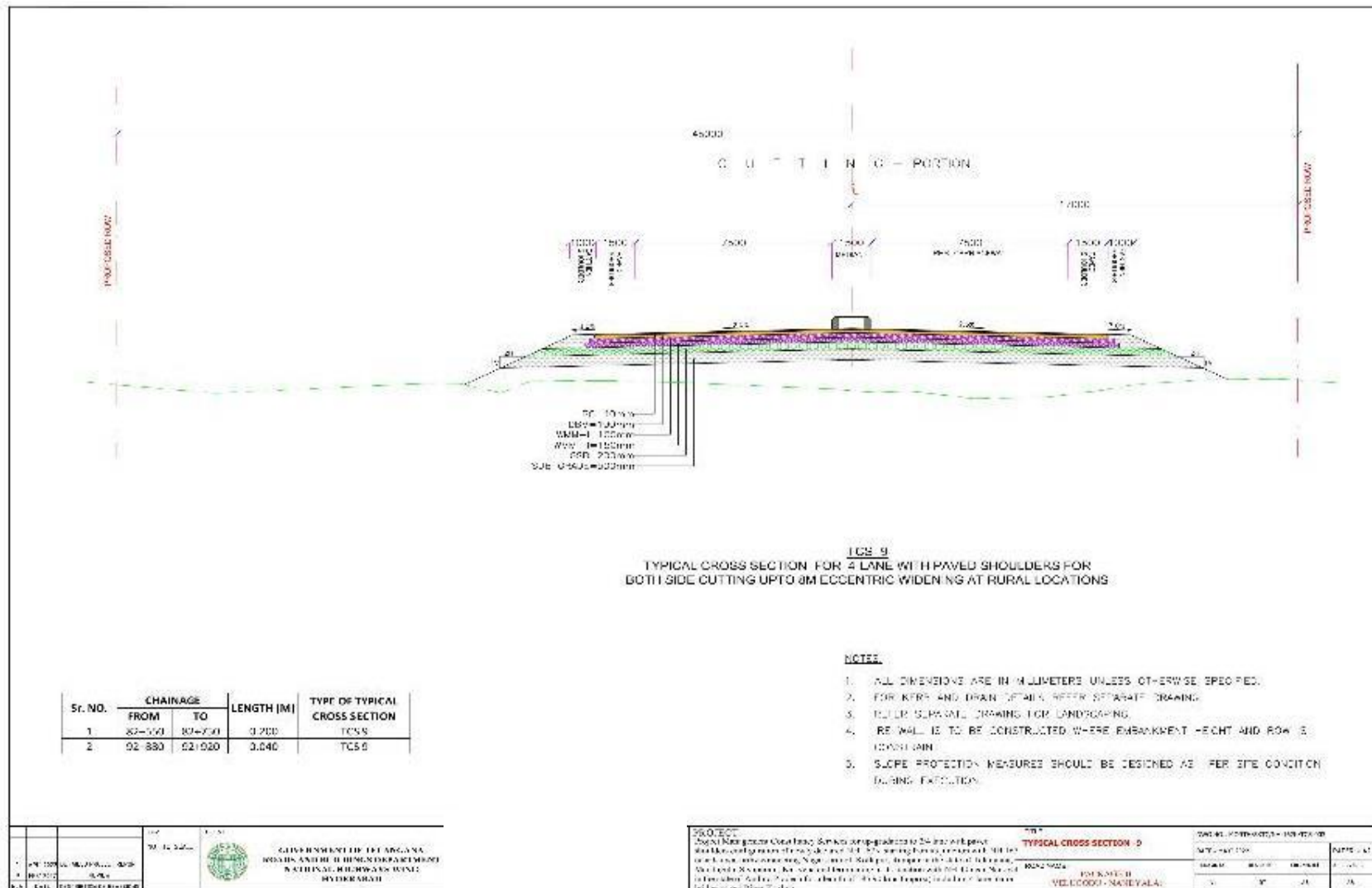
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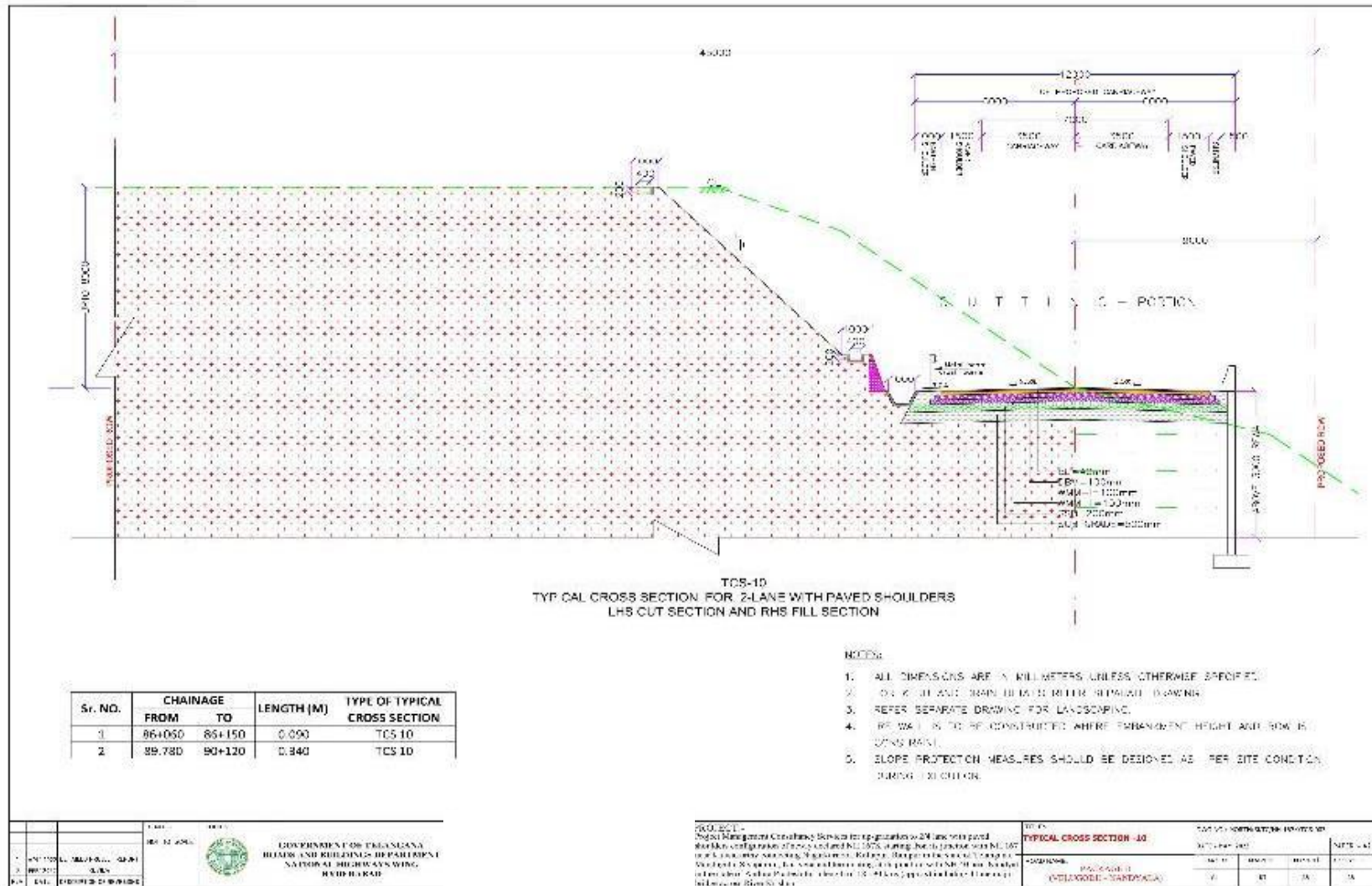
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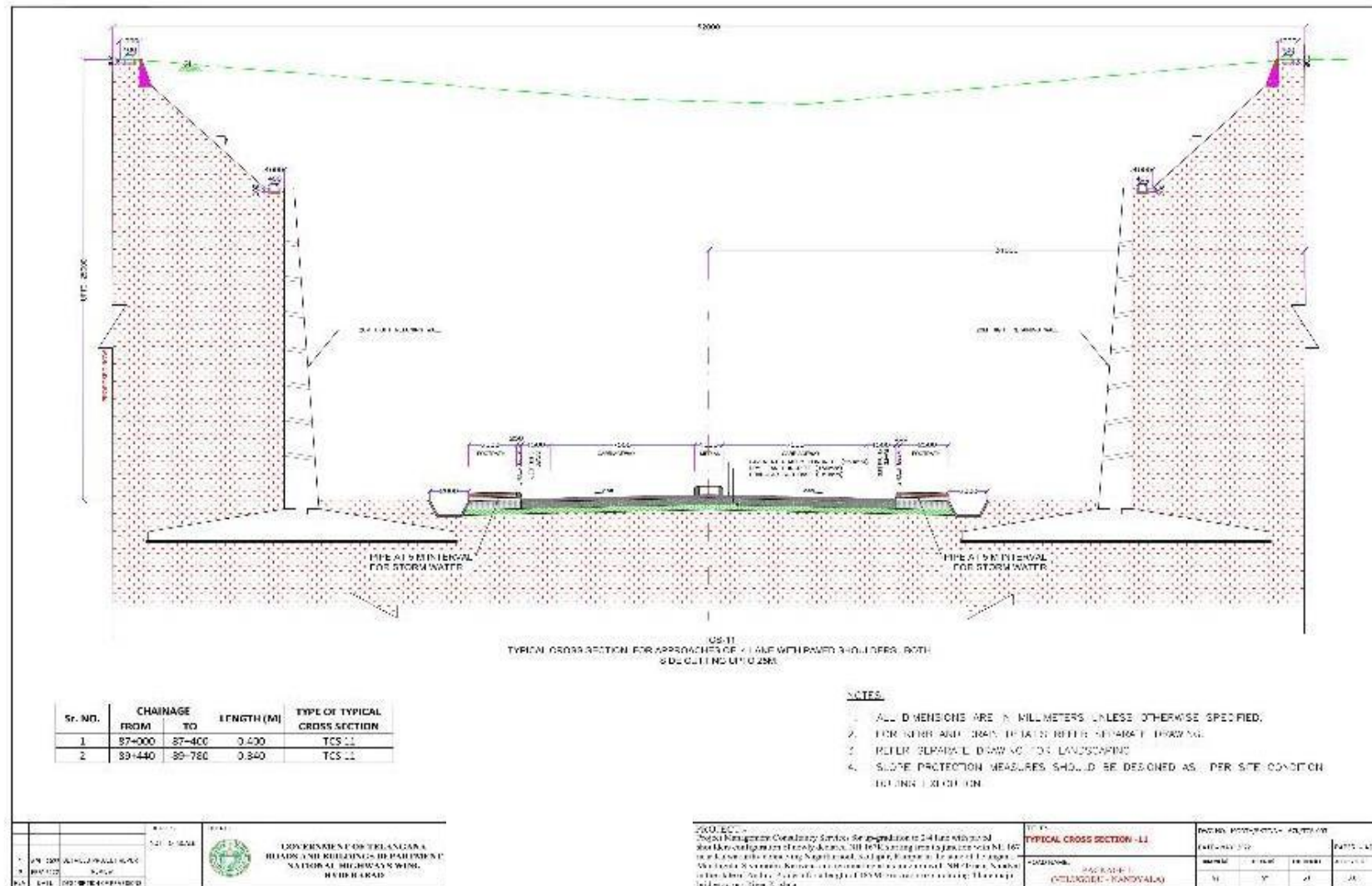
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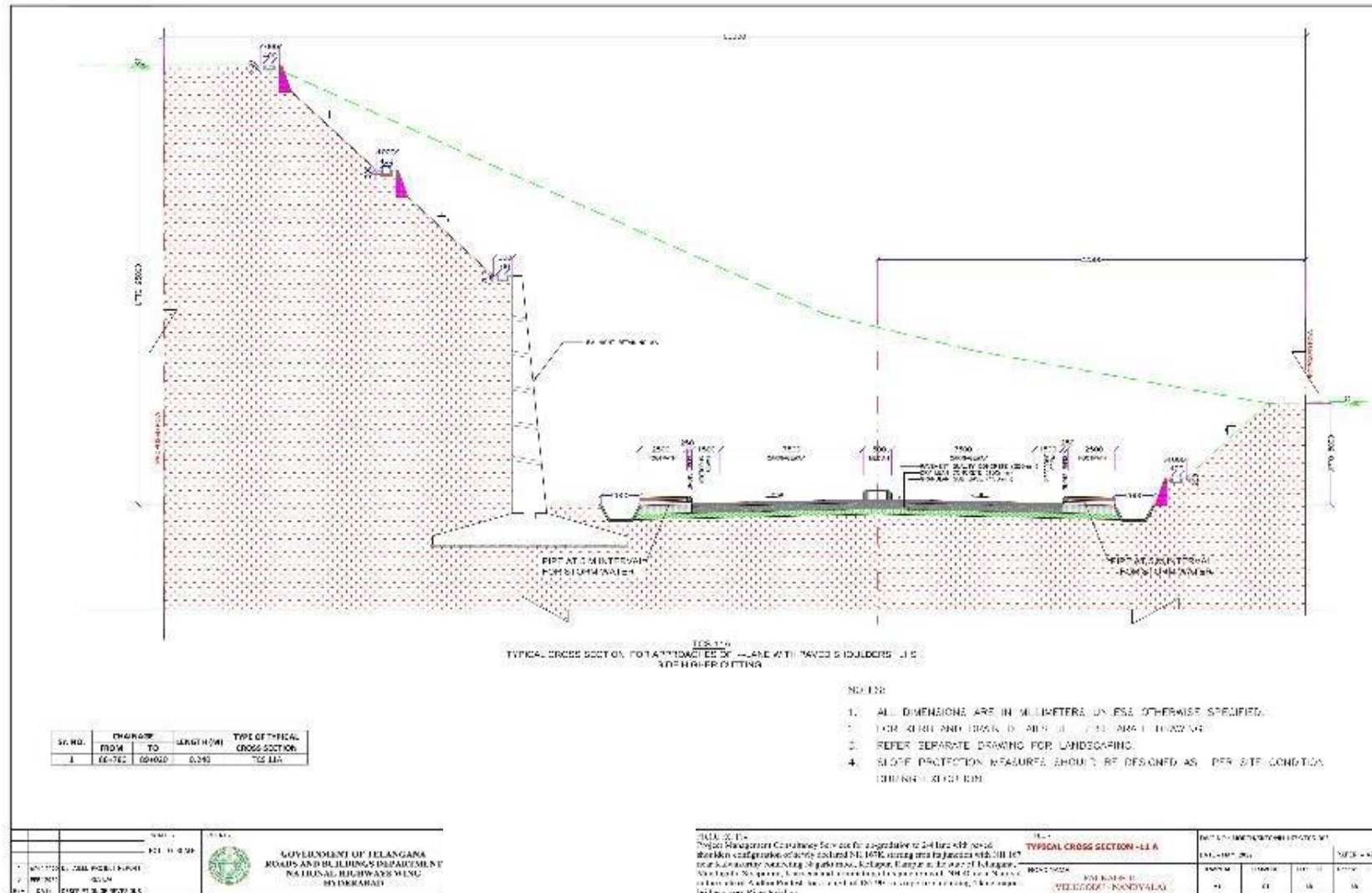
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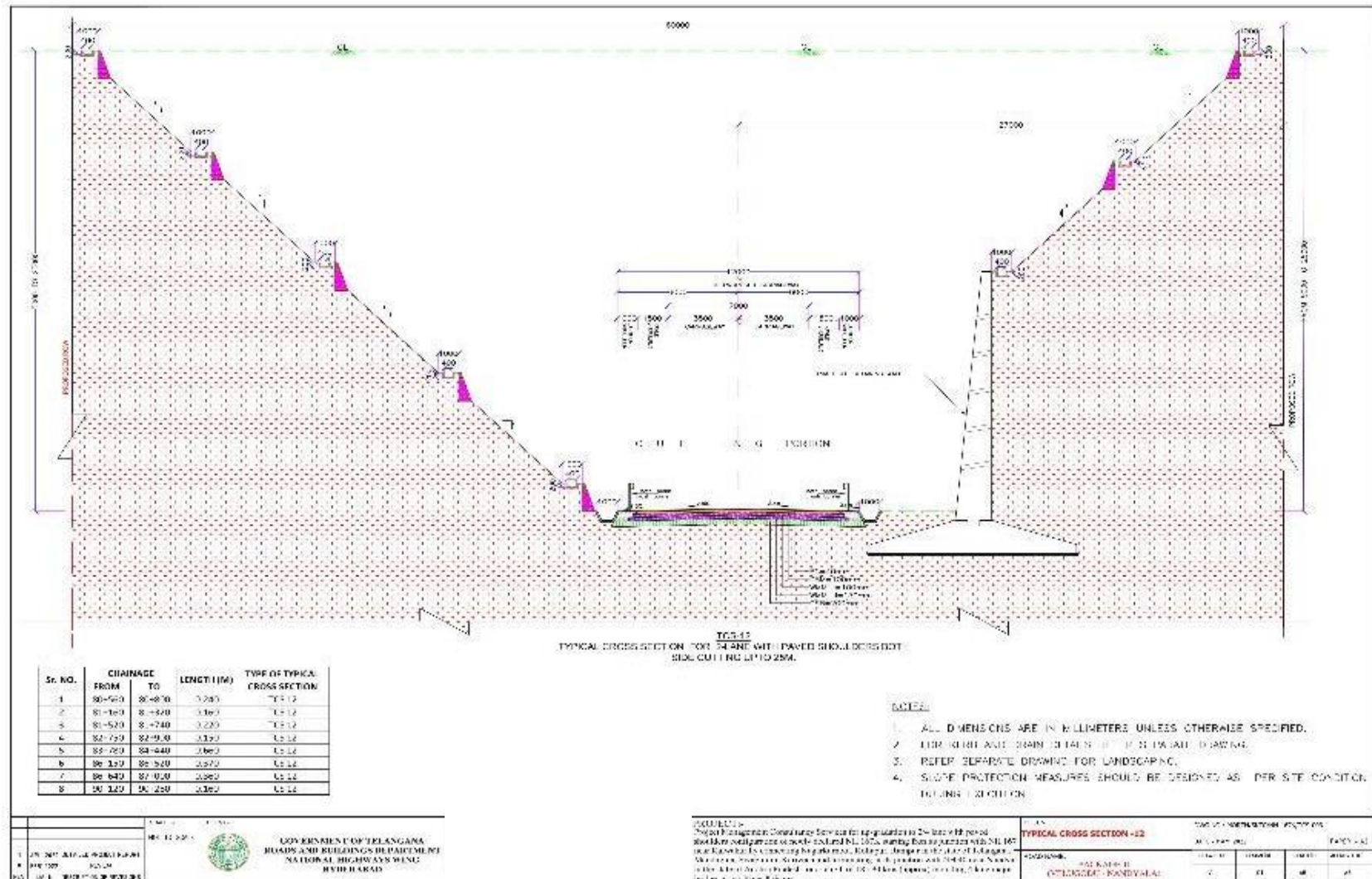
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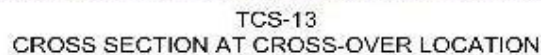
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Sr. NO.	CHAINAGE		LENGTH (M)	TYPE OF TYPICAL CROSS SECTION
	FROM	TO		
1	87+400	88+400	1.000	TCS 13

		FORM NO. 1 (A)			
		21.11.2019			
1. 27.11.2019		2. 28.11.2019			
3. 29.11.2019		4. 30.11.2019			
5. 01.12.2019		6. 02.12.2019			
7. 03.12.2019		8. 04.12.2019			
9. 05.12.2019		10. 06.12.2019			
11. 07.12.2019		12. 08.12.2019			
13. 09.12.2019		14. 10.12.2019			
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FIGURE 1 Project Management Consulting Services for reconstruction of 24 km section of the Haryana section of the National Highway NH-104, starting from the junction with NH-22 at Bawal to the junction with National Highway, at Jind, through the village of Langar (Muktsar), Muktsar, Sampla, Bawal, Sampla, Langar, Jind, and Jind (NH-104) section, including the section of the National Highway, at Jind (NH-104) section, including the section of the	FIGURE 2 Project Management Consulting Services for reconstruction of 24 km section of the Haryana section of the National Highway NH-104, starting from the junction with NH-22 at Bawal to the junction with National Highway, at Jind, through the village of Langar (Muktsar), Muktsar, Sampla, Bawal, Sampla, Langar, Jind, and Jind (NH-104) section, including the section of the National Highway, at Jind (NH-104) section, including the section of the	FIGURE 3 Project Management Consulting Services for reconstruction of 24 km section of the Haryana section of the National Highway NH-104, starting from the junction with NH-22 at Bawal to the junction with National Highway, at Jind, through the village of Langar (Muktsar), Muktsar, Sampla, Bawal, Sampla, Langar, Jind, and Jind (NH-104) section, including the section of the National Highway, at Jind (NH-104) section, including the section of the	FIGURE 4 Project Management Consulting Services for reconstruction of 24 km section of the Haryana section of the National Highway NH-104, starting from the junction with NH-22 at Bawal to the junction with National Highway, at Jind, through the village of Langar (Muktsar), Muktsar, Sampla, Bawal, Sampla, Langar, Jind, and Jind (NH-104) section, including the section of the National Highway, at Jind (NH-104) section, including the section of the	FIGURE 5 Project Management Consulting Services for reconstruction of 24 km section of the Haryana section of the National Highway NH-104, starting from the junction with NH-22 at Bawal to the junction with National Highway, at Jind, through the village of Langar (Muktsar), Muktsar, Sampla, Bawal, Sampla, Langar, Jind, and Jind (NH-104) section, including the section of the National Highway, at Jind (NH-104) section, including the section of the
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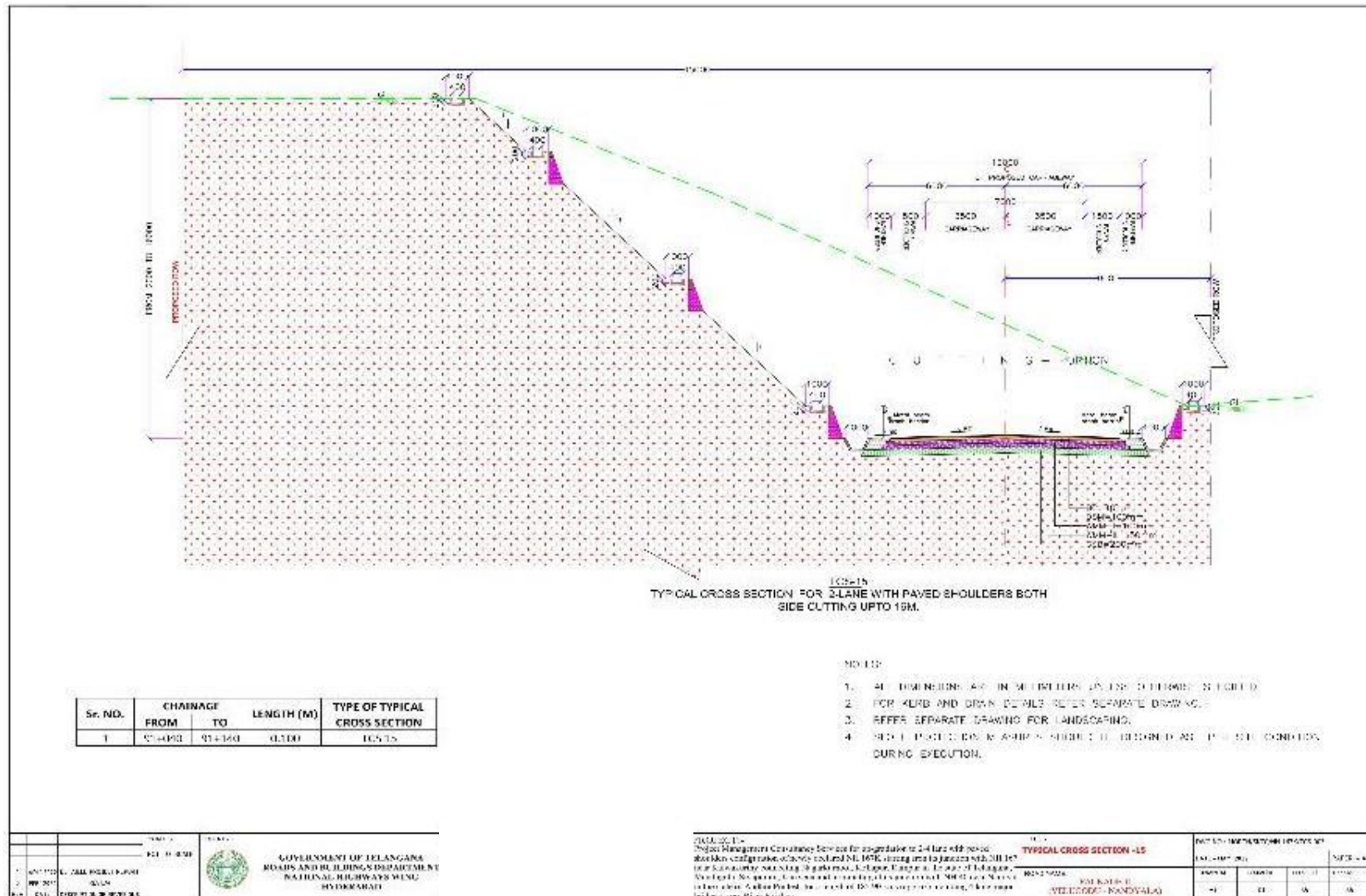
Volume-1 Main
Report



Up-Gradation To 2/4 Lane With Paved Shoulders Configuration Of Newly Declared NH 167K Starting From Its Junction With Nh-167 Near Kalwakurthy Connecting Nagarkurnool, Kollapur, Rampur In The State Of Telangana, Mandugula, Sivapuram, Karivena And Terminating At Its Junction With Nh 40 Near Nandyal In The State Of Andhra Pradesh For A Length Of 185.90 Kms (Approx) Including Four Lane Major Bridge Across River Krishna

Volume-1 Main Report

Package -2- Construction of Iconic Hybrid Cable Stayed and Suspension Bridge Across Krishna River On NH -167K (Design Chainage 87+360 To 88+437 In The State Of Telangana And Andhra Pradesh Under EPC Mode Under NH(O)



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