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1.0 INTRODUCTION

1.1 GENERAL

The **National Highways Authority of India (NHAI)** was constituted by an act of Parliament, the National Highways Authority of India Act, 1988. It is responsible for the development, maintenance and management of National Highways entrusted to it for matters connected or incidental thereto. The Authority started operations in February 1995 soon after appointment of full time Chairman and Board Members.

NHAI is mandated to implement **National Highways Development Project (NHDP)**, which is:

- India's Largest ever highways project
- World-class roads with uninterrupted traffic flow
- Major initiative for capacity enhancement of National Highways
- Four/ Six Laning of around 13,146 Km
- Total Cost Rs. 54, 000 crores

In addition to implementation of National Highways Development Projects, the NHAI is also responsible for implementing projects on National Highways, which are not part of NHDP, whose length is around 1000 km.

1.2 NHAI'S ORGANIZATION

NHAI is headed by Chairman and governed by the Ministry of Road Transport and Highways, Government of India. The following are the full time Board Members of NHAI:

- Chairman, NHAI
- Member (Admin), NHAI
- Member (Finance), NHAI
- Member (Tech.-I), NHAI
- Member (Tech.-II), NHAI
- Secretary (MOSRT&H),
- Director General (Road Development) & Additional Secretary (DGRD & AS), MOSRT&H and
- Secretary (Expenditure)

1.3 NHAI'S ACTIVITIES

Major Activities of NHAI are listed below:

(A) Time and Cost bound implementation of **National Highways Development Project (NHDP)** through host of funding options including from external multilateral agencies like World Bank, Asian Development Bank, JBIC etc. Work mainly comprises of strengthening and four / six laning of high-density corridors covering around 13,146 km. The Components are:

- **Golden Quadrilateral** – 5,846 km connecting Delhi-Kolkata-Chennai-Mumbai
- **North-South-East-West Corridors –** 7,300 km connecting Kashmir to Kanyakumari (including Salem to Kochi Spur) and Silchar to Porbandar (Saurashtra).

(B) Providing Road connectivity to major Ports.

(C) Involving the private sector in financing the construction, maintenance and operation of National Highways and wayside amenities.

(D) Improvement, maintenance and augmentation of the existing national Highways network.

(E) Implementation of road safety measures and environmental management.

(F) Introducing Information Technology in Construction, maintenance and all operations of NHAI.

1.4 NATIONAL HIGHWAYS DEVELOPMENT PROJECT (NHDP) PROGRAM

This program is a major initiative for capacity enhancement of the National Highways of India. As National Highways comprise about 2% of the total road length in the country and yet carryover 40% of total traffic, the first and the foremost task mandated to the NHAI is the implementation of NHDP- comprising of the Golden Quadrilateral and North-South & East-West Corridors (Refer Figure - 1.2).

In addition to the projects under NHDP, the NHAI is also currently responsible for taking up about 1,000 km of certain important highways under non NHDP program and also highways connecting major Ports.

1.5 THE DETAILS OF NHDP AND OTHER NHAI PROJECTS

The details of NHDP and other NHAI Projects under progress are presented in **Table-1.1**.

Table-1.1:Status of NHDP and Other NHAI Projects (As on: June30, 2010)

	GQ	NS-EW Ph I& II	NHDP Ph III	NHDP Ph V	NHDP Ph VI	NHDP Ph VII	SARDP- NE	NHDP Ph IV	NHDPTotal	Port connectivity	Others	Total
Total Length (Km.)	5,846	7,300	12,109	6,500	1000	700	388	14,799	48,642	380	965	49,987
Already 4- Lane (Km.)	5,793	5,172	1,778	301	-	-	-	-	12,895	289	917	14,250
Under Implementation (Km.)	53	1,476	5,060	1,999	-	41	112	176	9,066	85	28	9,030
Contracts Under Implementation (No.)	13	113	73	17	-	2	2	1	221	6	6	233
Balance length for award (Km.)	-	494	5,271	4,200	1000	659	276	14,623	26,523	6	20	26,549

1.6 PROJECT FINANCING

Financing of any highway construction project is generally undertaken by the following:

- By the International Funding Agencies like World Bank, ADB etc. through giving loan to the Client on the guarantee of Government or through direct equity participation in the project; and

- By the Private Sector participation on BOT or Annuity basis in which they arrange capital investment themselves.

As per NHAI, the total cost of NHDP has been estimated to be Rs. 54,000 crores or US$ 13.2 billions whose components and various likely funding sources are as given in the **Table-1.2.**

Table-1.2: NHDP's likely Funding Sources (on 1999 Prices)

Likely Sources	**Funds Required**	
Cess on Petrol and Diesel	Rs. 20,000 Crores	US$ 4.90 billions
External Assistance	Rs. 20,000 Crores	US$ 4.90 billions
Market Borrowings	Rs. 10,000 Crores	US$ 2.40 billions
Private Sector	Rs. 4,000 Crores	US$ 1.00 billions
Total Cost	**Rs. 54,000 Crores**	**US$ 13.2 billions**

1.7 COST RECOVERY MECHANISM

There are limited options available with the client for this project as far as cost recovery mechanism is concerned, as present traffic is low and general trends of growth of the project influence area are not very much encouraging.

Because of low density traffic, high initial capital requirements, lesser future prospects of the industrialization of project influence area, no place of major tourist attraction, difficult terrain and approach, unfavorable weather conditions for more than 6 months, disturbances due to local tribal internal clashes, local problems in collecting toll etc. the possibilities of attracting Private Sector on Built-Operate-Transfer (BOT) basis may be very difficult.

On Annuity Basis, covering all the risks involved in the project, private developers may be attracted for implementation; operations and maintenance of the project road. In that case, the developer shall arrange capital investment.

In both the cases i.e. Annuity or BOT basis, the cost recovery has to be done through toll collection only as there is no potential of cost recovery from developing other commercial establishments along the project road like commercial complexes, amusement parks, wayside amenities etc.

On the basis of our previous experience, we recommend that this project should be developed by the client from either internal resources or through annuity basis on social grounds as the project area remained less privileged as far as developments are concerned since independence and cost may be recovered through cess on petrol and diesel. Cost recoveries though toll will be insignificant particularly in the initial stage say about 10 years or so, after completion.

1.8 PROJECT BACKGROUND

The Ministry of Shipping Road Transport & Highways (MOSRT&H), Government of India has embarked upon the National Highway Development Programme (NHDP), consisting of development of the Golden Quadrilaterals connecting the four metros of India i.e. Delhi, Mumbai, Chennai and Kolkata and North-South-East-West (NSEW) corridors i.e. from Kashmir to Kanyakumari (North-South) and Silchar to Saurashtra (East-West).

National Highways Authority of India (NHAI) has been entrusted to implement the development of stretches of NH under NHDP phase IVB on BOT mode / EPC mode.

SMEC JV with RODIC Consultants Pvt. Ltd.havebeen awarded Consultancy Services for Preparation of Detailed project Report for Rehabilitation and Upgradation of NH Stretches under

NHDP – IV B (Group B – Package No JH/DPR/NHDP-IV/05) for the following Project Highway Sections:

(i) Govindpur – Dhanbad - Chas – West Bengal border section of NH-32
(ii) Chas – Bokaro – Gola – Ramgarh section of NH-23
(iii) Jamshedpur-Kharagpur section of NH-33 & NH-6

This report pertains to Section – (ii): Chas – Bokaro – Gola – Ramgarh section of NH-23 only- "The Project Highway" (for location refer*Figurse-1.1 to 1.3).*



Figure-1.1: Location of Jharkhand State in India



Figure-1.2: Location of Bokaro and Ramgarh Districts in Jharkhand

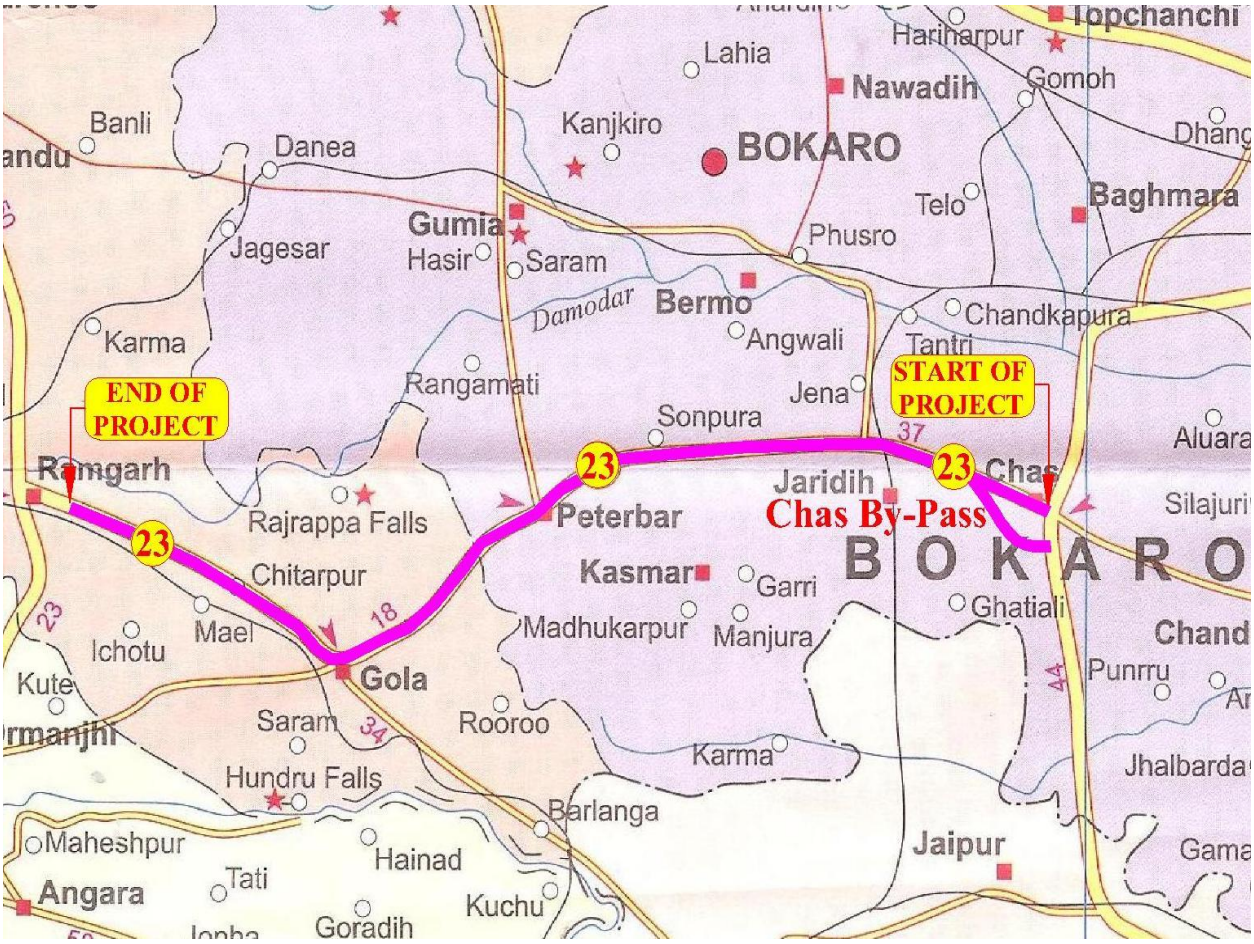


Figure-1.3: Index Map of theProject Highway

1.9 The Project Highway

NH-23 (Chas – Bokaro – Gola - Ramgarh)

Project Highway comprises the section of National Highway 23 commencing from Km 0+000 junction of NH-32 at Chas and ends at Km 80+275 proposed Ramgarh By-pass of NH-33, in the state of Jharkhand.***It also includes 6.90 kms long Chas bypass from proposed Chainage 0.000 to Ch. 6.900.***

The project highway NH-23 passes through so many towns/ villages namely Chas, Bokaro, Balidih, Tadwalidih, Tand Mohan Pur, Jaina More, Jeridih, Bandhdih, KrishNasa, KochaGonda, Kalyanpur, Dantu, Utamara, Lukaya, Pordag, Petarwar, Dundiyajora, Mangpur, Hupu, Khariyamara, Khuniyawa, Chhiturpur, Lari, Khothar, Paradih, Kaitha, Bazar Samaiti and Ramgarh.



Start of the Project of NH-23 Km 0+000 at Chas



General View of NH-23 Km 82+862 at Ramgarh

1.10 OBJECTIVES THE PROJECT

The objective of the projective as per the contact:

i) To established the technical economical and financial viability of the project and prepare detailed project report for rehabilitation and up gradation of existing road to 2 lane with paved shoulderconfiguration
ii) The viability of the project shall be established taking into account the requirement with regard to re habitation up gradation and improvement based on highway design pavement design provision of service road wherever necessary type of intersection rehabilitation and widening of existing and /or construction of new bridge and structure road safety features
iii) The detailed project report would inter alia include detailed highway design of pavement and overlay with option for flexible and rigid pavement design of bridge and cross drainage structure and grade separator structure design of service road quantities of various items detailed working drawings detailed cost estimate economic and financial viability analyses environmental and social feasibility social and environmental action plans as appropriate and document required for tendering the project on commercial basis for international / local competitive bidding
iv) The DPR consultant should ensure detailed project preparation incorporating aspect of value engineering quality audit and safety audit requirement in the design and implementation
v) The DPR should clearly bring out through financial analysis the mode (BOT/Government ofIndia funding) on which the civil work for the stretches are to be taken up

1.11 SCOPE OF SERVICES

The Scope of services covered the following major task

- The widening /improvement work to 2 lane with paved shoulder within the existing ROW avoiding land acquisition except for location having inadequate width the road alignment correction improvement of intersection are considered necessary and practicable and cost effective
- Finalization of location and design of toll plaza wayside amenities required on the tolled highway.
- To implement "Good for Construction" drawings prepared
- Carried out and prepared Environmental Impact Assessment, Environmental Management Plan and Rehabilitation and Resettlement studies.
- Wherever required Consultant liaised with concerned authorities and arranged all clarification approval of all drawing including approvals of GAD and detail engineering drawings from the railways
- Assisted the Authority on bidding process on technical issues.
- Consultant obtained all types of necessary clearance required for implementation of the project on the ground from the concerned agencies
- Consultant examined suitability of all new materials/technologies accredited by IRC approved /accredited in the country of origin and based on those the global practice in the industry and their suitability with respect to Indian condition their initial cost and life cycle cost as well as lane closure time.

1.12 METHODOLOGY FOR DETAIL PROJECT REPORT

The methodology as proposed in the inception report has been followed for the Detailed Project Report briefly the following primary tasks have been undertaken:

i. Review of all available reports and published information about the project road and the project influence area;

ii. Environmental and social impact assessment, including such as related to cultural properties, natural habitants, involuntary resettlement etc.

iii. Public consultation, including consultation with Communities located along the road, NGOs working in the area, other stake-holders and relevant GovernmentDepartments at all the different stages of assignment (such as inception stage, feasibility stage, preliminary design stage and once final designs are concretized).

iv. Detailed reconnaissance;

v. Identification of possible improvements in the existing alignment and bypassing congested locations with alternatives, evaluation of different alternatives comparison on techno-economic and other considerations and recommendations regarding most appropriate option;

vi. Traffic studies including traffic surveys and Axle load survey and demand forecasting for next thirty years;

vii. Inventory and condition surveys for road;

viii. Inventory and condition surveys for bridges, cross-drainage structures and drainage provisions;

ix. Detailed topographic surveys using Total Stations and GPS;

x. Pavement investigations;

xi. Sub-grade characteristics and strength: investigation of required sub-grade and sub-soil characteristics and strength for road and embankment design and sub soil investigation;

xii. Identification of sources of construction materials;

xiii. Detailed design of road, its x-sections, horizontal and vertical alignment and design of embankment of height more than 6m and also in poor soil conditions and where density consideration require, even lesser height embankment.

xiv. Detailed design of structures preparation of GAD and construction drawings and cross-drainage structures and underpasses etc.

xv. Identification of the type and the design of intersections;

xvi. Design of complete drainage system and disposal point for storm water

xvii. Value analysis / value engineering and project costing;

xviii. Economic and financial analyses;

xix. Contract packaging and implementation schedule.

xx. Strip plan indicating the scheme for carriageway widening, location of all existing utility services (both over- and underground) and the scheme for their relocation, trees to be felled and planted and land acquisition requirements including schedule for LA: reports documents and drawings arrangement of estimates for cutting of trees and shifting of utilities from the concerned department;

xxi. To find out financial viability of project for implementation under BOT and suggest the mode on which the project is to be taken up i.e. either on BOT or under funding from Government of India..

xxii. Preparation of detailed project report, cost estimate, approved for construction drawings, rate analysis, detailed bill of quantities, bid documents for execution of civil works through budgeting resources.

xxiii. Design of toll plaza and identification of their numbers and location and office cum residential complex including working drawings

xxiv. Design of weighing stations, parking areas and rest areas.

xxv. Any other user oriented facility enroute toll facility.

xxvi. Tie-in of on-going/sanctioned works of MORT&H/ NHAI/ other agencies.

xxvii. Preparation of social plans for the project affected people as per policy of the lending agencies/ Govt. of India R & R Policy.

1.13 PROJECT DELIVERABLES

The following are the major deliverables of the project as per the requirement of Terms of Reference

- Inception Report
- Feasibility report
- Detailed Project Report (DPR)

1.14 STRUCTURE OF DETAILED PROJECT REPORT

- Volume - I : Main Report

  Appendix to Main Report

- Volume-II : Design Report

  Part-A : Road Features

Part-B : Structures

- Volume-III : Materials Report
- Volume-IV : Environmental Assessment Report including Environmental Management Plan (EMP) & Resettlement Action Plan (RAP)
- Volume-V : Technical Specifications
- Volume-VI : Rate Analysis
- Volume-VII : Cost Estimates
- Volume-VIII : Bill of Quantities
- Volume-IX : Drawings

  Part-A : Road Features

  Part-B : Structures

  Part-C : Detailed Cross-Sections
- Volume-X : Civil Works Contract Agreement
- Volume-XI : Project Clearances

2.0 SOCIO-ECONOMIC PROFILE OF THE PROJECT INFLUENCE AREA

2.1 JHARKHAND STATE AT A GLANCE

2.1.1 General

Jharkhand (Hindi: झारखंड, pronounced [' dʒ ʱ a: rk^{h} əɳ ɖ] is a state in eastern India. It was carved out of the southern part of Bihar as 28th state of the Indian Union and was brought into existence by the Bihar reorganization Act on November 15, 2000- the birth anniversary of the legendary BhagwanBirsaMunda.(***Figure-2.1***)

Jharkhand shares its border with the states of Bihar to the north, Uttar Pradesh and Chhattisgarh to the west, Orissa to the south, and West Bengal to the east. It has an area of 28,833 sq mi (74,677 km²). The industrial city of Ranchi is its capital while Jamshedpur is the largest city of the state. Some of the other major cities and industrial centres are Dhanbad, Bokaro and Hazaribagh.

The name "Jharkhand" means "The Land of Forests".

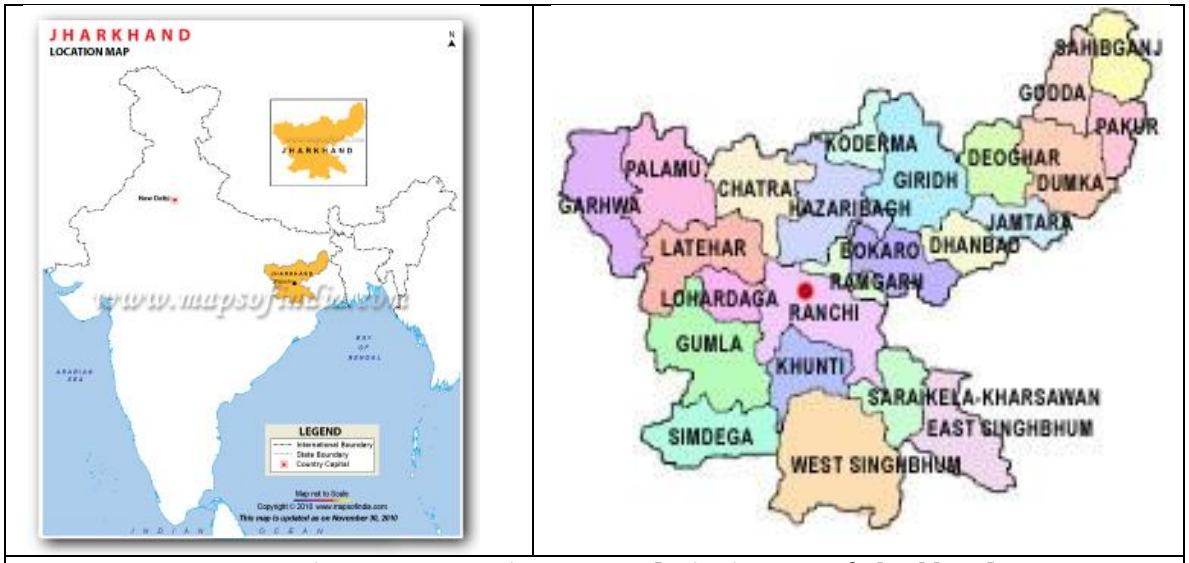


Figure-2.1: Location Map and District Map of Jharkhand

Jharkhand has 24 districts, 211 blocks and 32, 620 villages out of which only 45% are electrified while only 8,484 are connected by roads. Jharkhand is the leading producer of mineral wealth in the country, endowed as it is with vast variety of minerals like iron ore, coal, copper ore, mica, bauxite, graphite, limestone, and uranium. Jharkhand is also known for its vast forest resources.

This paradoxical development profile of Jharkhand is combined with the fact that distortions in distribution and access to resources have made little difference to lives of ordinary people. However, the people of the region are politically mobilized and self-conscious and are actively seeking better bargains for the state. The people in Jharkhand have the advantage of being culturally vibrant, as reflected in the diversity of languages spoken, festivals celebrated, and variety of folk music, dances, and other traditions of performing arts.

Jharkhand is famous for its rich mineral resources like Uranium, Mica, Bauxite, Granite, Gold, Silver, Graphite, Magnetite, Dolomite, Fireclay, Quartz, Fieldspar, Coal (32% of India), Iron, Copper (25%of India) etc. Forests and woodlands occupy more than 29% of the state which is amongst the highest in India.

2.1.2 Fact Sheet Jharkhand

➢ Date of Formation		Nov 15, 2000
➢ Size		79,714 sq km
➢ **Capital**		**Ranchi**
➢ Rivers		Damodar, Subarnarekha
➢ Forests & National Park		Betla (Palamau), NP, Hazaribagh WS
➢ Languages		Hindi, Urdu, Santhali
➢ Neighbours State		Bihar, Uttar Pradesh, West Bengal, Orissa, Chhattisgarh
➢ State Animal		Elephant
➢ State Bird		Asian Koel
➢ State Tree		Sal
➢ State Flower		Palash
➢ Population	:	2,69,09,428 as per 2001 Census
➢ Male Population	:	1,38,61,277 as per 2001 Census
➢ Female Population	:	1,30,48,151 as per 2001 Census
➢ Per Capita Income	:	Rs. 4161.00
➢ Density of Population	:	338 persons / Sq. KM
➢ No. of Districts	:	24
➢ No. of Sub divisions	:	35
➢ No. of Blocks	:	212
➢ No. of Villages	:	32620
➢ No. of Villages Electrified	:	14667 (45 % of total)
➢ No. of Villages connected by Road	:	8484
➢ National Highways	:	1006 KMs
➢ State Highways	:	4662 KMs
➢ Health Centers	:	506
➢ Schools	:	21386
➢ Universities	:	5 Incl. One Deemed University
➢ Total Geographical Area	:	79.70 Lakh Hect
➢ Cultivable Land	:	38.00 Lakh Hect
➢ Net Sown Area	:	18.04 Lakh Hect (25% of total area)
Net Irrigated Area	:	01.57 Lakh Hect (8% of net shown area)
➢ Forest	:	29% of total area

2.1.3 Geography and Climate

Most of the state lies on the Chota Nagpur Plateau, which is the source of the Koel, Damodar, Brahmani, Kharkai, and Subarnarekha rivers, whose upper watersheds lie within Jharkhand. Much of the state is still covered by forest. Forest preserves support populations of tigers and Asian Elephants.

Soil content of Jharkhand state mainly consist of soil formed from disintegration of rocks and stones, and soil composition is further divided into:

- **Red soil**, found mostly in the Damodar valley, and Rajmahal area
- **Micacious soil** (containing particles of mica), found in Koderma, Jhumeritilaiya, Barkagaon, and areas around the Mandar hill
- **Sandy soil**, generally found in Hazaribagh and Dhanbad
- **Black soil**, found in Rajmahal area
- **Laterite soil**, found in western part of Ranchi, Palamu, and parts of SanthalParganas and Singhbhum

2.1.4 Economy

Jharkhand's gross state domestic product for 2004 is estimated at $14 billion at current prices. Born out of partition from old Bihar state in 2000, Jharkhand produces about 70% of the output of the old Bihar state. Since it is rich in minerals, the state per capita income is likely to increase in the coming years.

Jharkhand has a concentration of some of the country's highly industrialized cities such as Jamshedpur, Ranchi, Bokaro Steel City and Dhanbad. It also has several firsts in India, including:

- Largest fertilizer factory of its time in India (since shut down) at Sindri, Dhanbad
- First Iron & steel factory at Jamshedpur
- Largest Steel plant in Asia, Bokaro steel plant, Bokaro.
- Biggest explosives factory at Gomia, Bokaro.
- First methane gas well at Parbatpur, Bokaro.

2.1.5 Major Industrial Units in Jharkhand

- Bokaro Steel Plant, Bokaro.
- Tata Steel Plant, Jamshedpur.
- Tata Motors, Jamshedpur
- Heavy Engineering Corporation, Ranchi.
- Patratu Thermal Power Station, Ramgarh.
- Chandrapura Thermal Power Station, Bokaro.
- Bokaro Thermal Power Station.
- Tenughat Thermal/Hydro Power Station, Bokaro.
- Jindal Steel Plant, Patratu.
- Electrosteel Plant, Bokaro.
- Usha Martin, Ranchi.
- Central Coalfields Limited.
- Bharat Coaking Coal Limited.
- Eastern Coalfields Limited.

2.1.6 Upcoming Mega Projects

Jharkhand has several towns and innumerable villages with civic amenities. Urbanization ratio is 22.25% and the per capita annual income is US$ 1,490. Jharkhand also has immense mineral resources: minerals ranging from (ranking in the country within bracket) from ironore (1st), coal (3rd), copper ore (1st), mica (1st), bauxite (3rd), Manganese, limestone, china clay, fire clay, graphite (8th), kainite (1st), chromite (2nd), asbestos (1st), thorium (3rd), sillimanite, uranium (Jaduguda mines, NarwaPahar) (1st) and even gold (Rakha Mines) (6th) and silver and several other minerals. Large deposits of coal and iron ore support concentration of industry, in centers like Jamshedpur, Bokaro and Ranchi.

Tata Steel, a S&P CNX 500 conglomerate has its corporate office in Jharkhand. It reported a gross income of ₹. 204,910 million for 2005. NTPC will start coal production from its captive mine in state in 2011-12, for which the company will be investing about Rs 1,800 crore.

2.2 BOKARO DISTRICT AT A GLANCE

2.2.1 General

The District Bokaro of the Jharkhand State was created in the year 1991 by carving out one subdivision consisting of two blocks from Dhanbad District and six blocks from Giridih District.

The District Headquarter B S City is having latitude of 23.29 and longitude of 86.09. The District Bokaro has a Geographical area of 2861 sq Km and 357663.36 Hectares of Land. The Average altitude of the Land is 210 mts from mean sea level. Situated in the Chhotanagpur Plateau, the vast rolling topography of the city is typical, strewn by graded valleys and winding streams. In this setting, within a short period of two decades, a new city with a strong multi-dimensional economic base, has blossomed into a regional urban centre of around 8.0 lakh people drawn from different parts of the country, giving the city the character of Mini India.



2.2.2 Profile of District Bokaro

Bokaro is a small river which flows into the Konar, a tributary of Damodar. A village by the name of Bokaro lies on the northern bank of the Konar. It is here that Bokaro Thermal Power Station of the Damodar Valley Corporation (DVC) is located which is at a distance of 28 Kms west of the Chandrapura Thermal Station also of DVC, on the northern bank of Damodar. The Tenughat Dam, which is the source of industrial water for the steel plant rises on the Damodar. The Dam on the Garga the source of drinking water for the steel city is due south of tenughat at an aerial distance of about 27 Kms. BSL is located on the site where formerly a village by the name of Maraphari existed. It was connected to a railway station also known as Maraphari on the MuriChandrapura line on the south eastern railways. With the coming up of the Steel Plant the station was renamed as Bokaro Steel City. The Govt. Of India & Bihar and Bokaro Steel Limited at a meeting on Sep12, 1964 decided to name the steel township as Bokaro Steel City.

The nearest small town to the steel city is ***Chas***, lying at the south-eastern tip of the site on the junction of the Dhanbad-Ramgarh-Ranchi and Dhanbad-Purulia-Tatanagar roads. ***Chas*** derives its name from the predominant agriculture occupation of its inhabitants. ***Chas*** came to some notice during World War II, when a prisoner of the war camp was located here. It is a commercial centre of Agriculture produce of the area. ***Chas*** is the Headquarters of the subdivision.

The BokaroDistrict may be categorized into three natural formations:

- Central plateau
- Lower plateau
- Damodar, Ganga &Tenughat Valley

2.2.3 Physical Data

- Climate : Extreme
- Height above sea level : 210 mts
- Annual Rain Full : Min-157 cms/max-195cms
- Temperature : Min-2°C winter/max 45°C Summer
- Wind Direction : South West to North east

2.2.4 Climate & Rainfall

The district falling in tropic monsoon region has broadly three pronounced seasons:

- Cool season : Oct to Feb.
- Hot season : Mar to May.
- Rainy season : Jun to Sept.

2.2.5 Education & Literacy

- No. of Literate :9,42,078
- Illiterate :8,33,883
- Schedule Cast :1,97,365
- Schedule Tribe :1,77,123
- No. of COLLEGES :9
- No. of HIGHER SECONDAYS SCHOOLS :29 :
- No. of Secondary Schools :73
- No. Of Upper Primary Schools :165
- No. of primary schools :702

2.2.6 Large Industries

Bokaro is known as Steel city, because the largest steel plant our our country in situated here. The giant public sector SAIL has their steel plant situated at Bokaro Steel City known as BSL or Bokaro Steel Plant.About 40 thousand people are working in this plant day & Night. The steel plant is well organised concern having rich infrastructure in Bokaro Steel City.

The Damodar Valley Corporation(DVC), a public sector is having their two big power captive plants situated at Bokaro Thermal &Chandanpurarespectively.Both these units have huge infrastructures.

The Coal India Limited, a public sector has their 2 subsidiaries in this district i.e.. CCL & BCCL respectively located at Bermo, Dugda&Chandankiyari area respectively.Both these subsidiaries are having rich infrastructure in the area.

JSEB, State public sector has their one power captive plant located at Lalpania near Tenughat. This unit is also having rich infrastructural support in the area.

The multinational private sector ICI has their explosive unit at Gomia. This unit has also huge infrastructural support in Gomia.

Bokaro industrial area is located in Bokaro steel city established by state public sector BIADA(Bokaro Industrial Area Development Authority). The several organised SSI units are situated in this industrial area and they are having good infrastructural support.

2.2.7 Nearest Air Base

- Commercial Air Base Ranchi (130 km)
- Private Air Base Bokaro Steel City
-

2.2.8 Nearest Military Base

- Ramgarh 80km
- Ranchi 135km
- Gaya 250km Top

2.2.9 Ground Water

The principal source of ground water recharge in the district is rainfall. However, return flow of irrigation water seepage from canals, influent seepage from streams are the additional source of recharge of ground water body. Most of the rivers and rivuletsare effluent in greater part of the year and these do not significantly re-charge.

2.2.10 Ground Water Data

➢ Total ground water resources	238.10 mcm
➢ Utilizable ground water resources for irrigation	202.41 mcm
➢ Quantity of ground water resources for PHED and industrial use	35.69 mcm
➢ Net ground water draft	1.88 mcm
➢ Ground water balance	200.53 mcm

2.2.11 Agriculture & Land Utilization

The district being mostly covered by hills & forest the soil generally is rocky & sandy while it is alluvial near the riverbed (about 23% of the geographical) area of the district.

Kharif Season : Total Land(Unit Hectare) 123924.12
Irrigated 1129.64
Un-irrigated 122794.48

Rabi Season : Total Land(Unit Hectare) 123924.12
Irrigated 5335.90
Un-irrigated 118588.22

Forest cover : 24%

2.2.12 Rural and Urban Water Supply

Out of six prominent township in the district , only two i.e.Bokaro steel city and Chas are having very limited but organised ground water supply for domestic purposes, through shallow bore wells, deep bore wells, hand pumps etc.

The other sources of water supply at Bokaro steel city and Chas is through Tenughat dam and Garga dam. The rest of township depends on surface water resourcescanals, hand pumps etc. The rural areas of the district depend on dug-wells, hand-pumps, rivers, ponds, canals etc. for domestic water purposes.

2.3 RAMGARH DISTRICT AT A GLANCE

2.3.1 General

Some important information of Ramgarh District

- **Ramgarh district** is carved out of erstwhile district of Hazaribagh on 12th September 2007.

- **The Latitude and Longitude of District Headquarter** is 23^0 38' and 85^0 34' respectively.
- **Ramgarh district** has **one Sub-division** namely Ramgarh and **four Block's** namely Ramgarh, Gola, Mandu and Patratu.
- **The present boundary of Ramgarh district** is in North – Hazaribagh district, South – Ranchi district, East – Ranchi and West - Bokaro district.
- **The district headquarter is at Ramgarh town.** It is situated on National Highway 33, 46 Km away from state's capital, Ranchi on Northern side and 52 Km away from Hazaribagh on southern side.
- **The total area of Ramgarh district** is 1360.08 Sq. Km, out of which 487.93 Sq.Km is forest area.
- **Ramgarh district has 351 revenue village** of which 334 is Chiragi and 17 is be-chiragi.



2.3.2 Population

The population of Ramgarh district as per 2001 censes

- *Total Population : 839482,*
- *Total Male Population : 443982,*
- *Total Female Population : 395500*

Name of Block	Male	Female	Total Population	SC		Total SC Population	ST		Total ST Population
				Male	Female		Male	Female	
Ramgarh	135516	118597	254113	11431	10467	21898	17658	16806	34464
Gola	63552	61924	125476	5084	4938	10022	18269	18004	36273
Mandu	118734	106110	224844	16078	14670	30748	22899	21740	44639
Patratu	126180	108869	235049	16500	13905	30405	28267	26744	55011
Total	***443982***	***395500***	***839482***	***49093***	***43980***	***93073***	***87093***	***83294***	***170387***

2.3.3 Land

Name of Block	Geographical Area (in Acre)	Agricultural Land (in Acre)	Irrigated Land (in Acre)	Un-irrigated Land (in Acre)	Baron Land (in Acre)	Forest Land (in Acre)
Ramgarh	72567.53	21360.66	3638.80	17721.86	842.98	8160.46
Gola	82981.76	40197.57	5201.57	34996.00	377.37	18650.00
Mandu	109224.62	10073.70	1032.37	9041.33	1858.55	45086.85
Patratu	80059.30	11737.09	1062.52	10674.57	5393.78	25524.78
Total	***344833.21***	***83369.02***	***10935.26***	***72433.76***	***8472.68***	***97422.09***

2.3.4 Details of Revenue village and Panchayat

Name of District	**No. of Panchayat**	**No. of Revenue Halka**	**No. of Revenue Village**	
			Chiragi	**Be-chiragi**
Ramgarh	143	36	334	17

2.3.5 Health

Name of District	**PHC**	**APHC**	**PHSC**	**Referral Hospital**
Ramgarh	04	05	55	01

2.3.6 Education

Name of District	College	High School	Middle School	Primary School	Upgraded High School	Upgraded Middle School	Upgraded Primary School
Ramgarh	10	28	69	181	14	106	272

- **Main National Highways crossing the district are NH-33 and NH-23.**
- **Main rivers passing through the district are Damodar, Gomti, Swarnarekha.**
- **In Ramgarh district Central / State Govt. and Public Sector undertaking are as follows:**

1. C.C.L. Rajrappa Project / Barka-Sayal area /Kujju area / Araggadda area / charahi area (Part)
2. IFCO, Marar, Ramgarh.
3. Bharat Refractaries Ltd. Ranchi Road .
4. D.V.C. Office, Naisarai, Ramgarh.
5. Central Repair Work Shop, C.C.L. Barkakana.
6. Mines Rescue Building ,Ramgarh.
7. Patratu Thermal Power Station, Patratu (PTPS) with total capacity of 840 MW.

In Ramgarh District the important Thermal Power Station is in Patratu. The Symbol of Indo-Russian relationship the Patratu Thermal Power Station was established in the decade of sixties on the area of 24 villages.

- **In Ramgarh District some of the important private collieries /Industries are as follows:**

1. TISCO, West Bokaro Colliery, Ghatotand
2. Jindal Power and Steel Ltd. Balkudra, Patratu.
3. Indo-Ashahee Glass Company, Bhadaninagar,

On the boundary of Ramgarh and Ranchi district Nalkari Dam is established upon NalkariBarkiRiver.

3.0 ENGINEERING SURVEYS, INVESTIGATIONS AND ANALYSIS

3.1 GENERAL

This chapter brings out the salient features in respect of the major field studies, surveys and investigations taken up and salient findings of those to determine the rehabilitation / construction requirements for the Project Road.

Project Highway comprises the section of National Highway 23 commencing from Km 0+000 junction of NH-32 at Chas and ends at Km 78+192proposedRamgarh By-pass of NH-33, in the state of Jharkhand.

The following activities were performed during the field investigations:

- Reconnaissance survey;
- Road Alignment Inventory;
- Road and Pavement Conditions survey;
- Topographical Surveys;
- Benkelman Beam deflection survey
- Axle Load survey
- Material Investigations and Surveys;
- Inventory of Bridges, Culverts & Structures;
- Condition Survey of Bridges & Structures
- Hydrological Investigations;

The basic data collected from different engineering surveys is presented separately as "***Appendices to Main Report*** ".

3.2 RECONNAISSANCE SURVEY

As part of initial recognizance Consultant's team of experts visited the project road stretch during on 3rd April 2010 to 9th April 2010. The team comprises of Mr. A.K.Sinha (Senior Highway Engineer – cum-Team Leader), Mr. V.N.Mishra (Bridge Engineer), I.S. Manocha (Pavement Specialist) Mr. D.P.Singh (Highway Engineer), Biswajeet Kumar Yadav (Sr. Survey Engineer),Mr. SubahjitLahiri (Traffic Engineer) and supporting staffs who have inspected the site in detail and special emphasis were given to important location like rail level crossings, ROB's and important junctions. In general, following were studied during detailed reconnaissance.

- Topography of the area.
- Traffic patterns and traffic survey locations.
- Geometrics of the existing alignment.
- Available Right of way.
- Land use condition (agricultural, build-up, forest land, etc.).
- Environmental/Social Sensitive features.
- Availability of materials.
- Identify PWD officials responsible for the project stretch and open up communication.
- Collection of secondary data and maps from PWD.
- Collection of Forest, District and Village maps.

In this regard, consultant would like to extend the gratitude to all the stakeholders including Revenue department, Irrigation department, Forest department and Police for their cooperation. Detailed Project appreciation is being presented in the following sections.

3.2.1 Site of the Project

The Site of the Two-Lane Project Highway comprises the section of National Highway 23 commencing from existing Km 0+000 (Design Chainage 0+000) of NH-23 at junction of NH-32 at Chas and ends at existing Km 81.225 (Design Chainage 78+192) of NH-23 at crossing of proposed Ramgarh By-Pass of NH-33 in the state of Jharkhand.

The total project length is 78+192 (Proposed Chas By-pass 6+900 km &Jaina More Bypass 4+900) and Existing 81+225 km).

The land, carriageway and structures comprising the Site are described below.

3.2.2 Land

The Site comprises the land described below:

Sl.No	ExistingChainage (Km)		Length (Km)	Existing ROW (m)	Remarks
	From	To			
1	0+000	1+000	1.00	25.10	
2	1+000	2+000	1.00	23.90	
3	2+000	3+000	1.00	27.50	
4	3+000	4+000	1.00	27.80	
5	4+000	5+000	1.00	26.40	
6	5+000	6+000	1.00	25.00	
7	6+000	7+000	1.00	23.30	
8	7+000	8+000	1.00	24.90	
9	8+000	8+900	1.00	24.20	
10	8+900	10+000	1.00	22.00	
11	10+000	11+000	1.00	22.00	
12	11+000	12+000	1.00	18.00	
13	12+000	13+000	1.00	20.00	
14	13+000	14+000	1.00	30.00	
15	14+000	15+000	1.00	24.00	
16	15+000	16+000	1.00	26.00	
17	16+000	17+000	1.00	16.00	
18	17+000	18+000	1.00	20.00	
19	18+000	19+000	1.00	16.00	
20	19+000	20+000	1.00	24.00	
21	20+000	21+000	1.00	18.00	
22	21+000	22+000	1.00	22.00	
23	22+000	23+000	1.00	19.00	
24	23+000	24+000	1.00	18.00	
25	24+000	25+000	1.00	20.00	
26	25+000	26+000	1.00	24.00	
27	26+000	27+000	1.00	24.00	
28	27+000	28+000	1.00	26.00	
29	28+000	29+000	1.00	24.00	

30	29+000	30+000	1.00	12.00	
31	30+000	31+000	1.00	24.00	
32	31+000	32+000	1.00	21.00	
33	32+000	33+000	1.00	24.00	
34	33+000	34+000	1.00	26.00	
35	34+000	35+000	1.00	18.00	
36	35+000	36+000	1.00	22.00	
37	36+000	37+000	1.00	23.00	
38	37+000	38+000	1.00	28.00	
39	38+000	39+000	1.00	18.00	
40	39+000	40+000	1.00	26.00	
41	40+000	41+000	1.00	19.00	
42	41+000	42+000	1.00	24.00	
43	42+000	43+000	1.00	20.00	
44	43+000	44+000	1.00	24.00	
45	44+000	45+000	1.00	34.00	
46	45+000	46+000	1.00	30.00	
47	46+000	47+000	1.00	26.00	
48	47+000	48+000	1.00	36.00	
49	48+000	49+000	1.00	24.00	
50	49+000	50+000	1.00	22.00	
51	50+000	51+000	1.00	25.00	
52	51+000	52+000	1.00	27.00	
53	52+000	53+000	1.00	28.00	
54	53+000	54+000	1.00	17.00	
55	54+000	55+000	1.00	21.00	
56	55+000	56+000	1.00	26.00	
57	56+000	57+000	1.00	19.00	
58	57+000	58+000	1.00	22.00	
59	58+000	59+000	1.00	22.00	
60	59+000	60+000	1.00	20.00	
61	60+000	61+000	1.00	26.00	
62	61+000	62+000	1.00	16.00	
63	62+000	63+000	1.00	20.00	
64	63+000	64+000	1.00	24.00	
65	64+000	65+000	1.00	23.00	
66	65+000	66+000	1.00	22.00	
67	66+000	67+000	1.00	19.00	
68	67+000	68+000	1.00	25.00	
69	68+000	69+000	1.00	25.00	
70	69+000	70+000	1.00	22.00	
71	70+000	71+000	1.00	19.00	
72	71+000	72+000	1.00	22.00	
73	72+000	73+000	1.00	22.00	
74	73+000	74+000	1.00	24.00	

75	74+000	75+000	1.00	19.00	
76	75+000	76+000	1.00	17.00	
77	76+000	77+000	1.00	17.00	
78	77+000	78+000	1.00	21.00	
79	78+000	79+000	1.00	27.00	
80	79+000	80+000	1.00	24.00	
81	80+000	81+000	1.00	21.00	
82	81+000	81+200	0.20	22.00	

3.2.3 Total number of structures

There are total 128number of structures on the Project Highway as below:

The total number of structures (128 Nos) on the Site are noted below:

(a)	No. of Major Bridges	-	02
(b)	No. of Minor Bridges	-	12
(c)	No. of Railway Over Bridge (ROB)	-	Nil
(d)	No. of Railway under Bridge (RUB)	-	03
(e)	No. of Grade Separators	-	Nil
(f)	No. of Pipe Culverts	-	23
(g)	No. of Box / Slab Culverts	-	88
(h)	No. of Arch Culverts	-	Nil

3.2.4 Major Bridges

The site includes the following Major Bridge:

Sr. No.	Existing Chainage	Design Chainage	Type of structure			Span Details		Width of Carriageway between Kerbs (m)	Proposal
			Foundation	Sub Structure	Super Structure	No	Length of span (m)		
1	3+850	NA	Well	RCC	RCC	7	15.00	7.50	To be Retained
2	64+230	61+500	Well	RCC	RCC	3	25.00	11.00	To be Retained

3.2.5 Minor Bridges

The site includes the following Minor Bridges:

Sr. No.	Existing Chainage	Design Chainage	Type of structure			Span Details		Width of Carriageway between Kerbs	Proposal
			Foundation	Sub Structure	Super Structure	No	Length of span (m)		
1	9+480	7+503	Open	BW	RCC	1	7.50	11.50	To be Retained

Sr. No.	Existing Chainage	Design Chainage	Type of structure			Span Details		Width of Carriageway between Kerbs	Proposal
			Foundation	Sub Structure	Super Structure	No	Length of span (m)		
2	11+705	9+823	Open	Stone	RCC	1	7.60	11.50	To be Retained
3	19+135	17+260	Open	RCC	RCC	1	16.50	7.50	To be Retained
4	32+650	30+430	Open	RCC	RCC	4	13.50	8.00	To be Retained
5	45+742	43+440	Open	RCC	RCC	2	14.50	7.50	To be Retained
6	47+248	44+945	Open	BW	RCC	1	9.70	11.00	To be Retained
7	48+835	46+460	Open	RCC	RCC	1	16.00	10.50	To be Retained
8	56+976	54+265	Open	RCC	RCC	1	6.50	11.50	To be Retained
9	**72+484**	**69+650**	**Open**	**BW**	RCC	**2**	**6.70**	**7.00**	**New Const.**
10	76+015	73+100	Open	BW	RCC	1	10.00	7.00	To be Retained
11	**78+300**	**75+720**	**Open**	**RCC**	RCC	**3**	**6.90**	**7.00**	**New Const.**
12	79+970	77+065	Open	RCC	RCC	1	14.70	11.50	To be Retained



Bhera River Major Bridge at Chainage 64+230



Minor Bridge at Ch- 32+321

3.2.6 Railway Over Bridge (ROB) & Railway under Bridge (RUB)

- ROB - Nil
- RUB - 3 Nos.

Sr. No.	Existing Chainage	Design Chainage	Type of Structure	Existing Span	Width of Carriageway	Proposal
1	11+933	9+997	RUB	1 x 12.70m	12.00	To be Retained
2	12+400	10+462	RUB	1 x 12.20m	12.00	To be Retained
3	69+913	67+120	RUB	1 x 17.00m	12.00	To be Retained

3.2.7 Grade Separators

Nil.

3.2.8 Culverts

There are total 111 numbers of culverts consisting of 76Slab, 12Box and 23Hume Pipe culverts. The condition of most of these CD structures is fair to good. In built-up areas, many culverts are found in choked condition due to silting or accumulation of waste and garbage. Poor maintenance has led to improper functioning of the culverts. Adequate maintenance of the culverts can result in proper functioning of the culverts.

The common defects that have been observed in the culverts are as follows:

- Parapet / handrail cracked or broken in almost all cases.
- Vegetation growth on part of the structural element.

- Vent way choked.
- Bed flooring absent or damaged in many cases.

Sr. No.	Existing Chainage	Proposed Chainage	Existing Span(M)	Existing Type	Existing Condition	Proposed Type	Proposal
1	0+377	NA	1 x 1.55	Slab	Good	Slab	Retain
2	2+200	NA	1 x 5.50	Slab	Good	Slab	Retain
3	6+100	NA	1X900mm	HP	Good	HP	Retain
4	8+815	6+885	3X3	Box	Good	Box	Widening
5	10+287	8+395	1X2.5	Slab	Good	Slab	Retain
6	11+270	9+383	1X3.7	Slab	Good	Slab	Retain
7	11+505	9+615	1X2.6	Slab	Good	Slab	Retain
8	12+838	10+903	1X3.65	Slab	Good	Slab	Retain
9	17+050	15+077	1X1000mm	Pipe	Poor	Box	New Const.
10	17+435	15+497	1X1.2	Slab	Good	Slab	Widening
11	18+145	16+244	2X3	Slab	Poor	Box	New Const.
12	18+800	16+838	1X900mm	HP	Poor	Box	New Const.
13	22+428	20+523	1X4.65	Slab	Good	Slab	Retain
14	23+161	21+035	1X1.70	Slab	Good	Slab	Retain
15	23+538	21+413	1X1.60	Slab	Good	Slab	Widening
16	23+850	22+057	1X1.70	Slab	Poor	Slab	Retain
17	24+225	22+096	1X1000mm	HP	Good	HP	Retain
18	24+586	22+458	1X1000mm	HP	Good	HP	Retain
19	25+172	23+028	1X1000mm	HP	Good	HP	Retain
20	26+163	24+022	1X1.5	Slab	Good	Slab	Retain
21	26+710	24+572	1X1.70	Slab	Good	Slab	Widening
22	27+340	25+137	1X1000mm	HP	Good	HP	Retain
23	28+135	25+896	1X1.60	Slab	Good	Slab	Retain
24	29+980	27+771	1X1.70	Slab	Good	Slab	Retain
25	30+570	28+343	1X1000mm	HP	Good	HP	Retain
26	31+129	28+905	1X1.3	Slab	Good	Slab	New Const.
27	31+420	29+212	1X3	Slab	Good	Slab	Retain
28	31+900	29+656	1X1.70	Slab	Good	Slab	Retain
29	32+242	30+007	1X1.60	Slab	Good	Slab	Retain
30	32+500	30+276	2X1000mm	HP	Good	HP	Retain
31	33+330	31+071	1X1.60	Slab	Good	Slab	Widening
32	34+020	31+757	1X1.30	Slab	Good	Slab	Retain
33	34+475	32+512	1X1.80	Slab	Good	Slab	Retain
34	35+100	33+147	1X1.80	Slab	Poor	Box	New Const.
35	36+450	34+157	2X1000mm	HP	Good	HP	Retain

Sr. No.	Existing Chainage	Proposed Chainage	Existing Span(M)	Existing Type	Existing Condition	Proposed Type	Proposal
36	36+830	34+502	1X2.2	Slab	Good	Slab	Retain
37	37+030	34+726	1X2.10	Slab	Good	Slab	Retain
38	37+165	34+857	1X1.75	Slab	Good	Slab	Retain
39	37+650	35+426	1X1	HP	Good	HP	Retain
40	37+850	35+436	1X1.2	Slab	Good	Slab	Retain
41	38+020	35+697	1X1.2	Slab	Good	Slab	New Const.
42	38+725	36+418	1X1000mm	HP	Good	HP	Retain
43	39+350	37+030	1X1.25	Slab	Good	Slab	Retain
44	40+008	37+685	1X1.60	Slab	Good	Slab	Widening
45	46+650	44+325	4X1000mm	HP	Poor	Box	New Const.
46	47+026	44+727	1X1.05	Slab	Good	Slab	Retain
47	47+125	44+827	1X1.15	Slab	Good	Slab	Retain
48	47+250	45+296	1X1.16	Slab	Good	Slab	Retain
49	47+800	45+498	5X1000mm	HP	Good	HP	Retain
50	48+400	46+018	1X1000mm	HP	Good	HP	Retain
51	48+600	46+216	1X1000mm	HP	Good	HP	Retain
52	49+230	46+996	1X1.22	Slab	Good	Slab	New Const.
53	49+425	47+237	1X1000mm	HP	Good	HP	New Const.
54	49+700	47+306	1x2.05	Box	Good	Box	New Const.
55	50+020	47+448	1X1	HP	Good	HP	Retain
56	50+175	47+625	1X1000mm	HP	Good	HP	Widening
57	50+630	48+076	1X1.2	Slab	Good	Slab	Retain
58	50+700	48+137	1X1.12	Slab	Good	Slab	Retain
59	50+810	48+242	1X1.15	Slab	Good	Slab	Retain
60	51+050	48+463	1X1000mm	HP	Good	HP	Widening
61	52+125	49+550	1X1.4	Slab	Good	Slab	Retain
62	52+305	49+735	1X1.5	Slab	Good	Slab	Widening
63	52+900	50+283	1X1.2	Slab	Good	Slab	Retain
64	53+180	50+564	1X1.5	Slab	Good	Slab	Retain
65	53+585	50+936	1X1.7	Slab	Good	Slab	Retain
66	53+840	51+223	1X1.45	Slab	Good	Slab	Retain
67	54+260	51+584	2X3	Slab	Good	Slab	New Const.
68	55+500	52+897	2X1000mm	HP	Good	HP	Retain
69	56+425	53+733	2X1000mm	HP	Good	HP	Retain
70	56+675	53+975	1X1.45	Slab	Good	Slab	Retain
71	57+045	54+326	1X1.55	Slab	Good	Slab	Retain
72	57+760	55+045	1X1.65	Slab	Good	Slab	Retain
73	57+980	55+263	1X1.52	Slab	Good	Slab	Retain

Sr. No.	Existing Chainage	Proposed Chainage	Existing Span(M)	Existing Type	Existing Condition	Proposed Type	Proposal
74	58+510	55+790	1X1.45	Slab	Good	Slab	Retain
75	58+613	55+887	1X1.13	Slab	Good	Slab	Retain
76	58+970	56+174	1X1.6	Slab	Good	Slab	Retain
77	59+340	56+550	6X1200mm	HP	Good	HP	Retain
78	60+948	58+201	3X1200mm	HP	Poor	HP	Retain
79	61+120	58+374	1X1000mm	HP	Poor	HP	Retain
80	61+420	58+686	1X1.85	Slab	Poor	Slab	Retain
81	61+710	58+963	1X1.9	Slab	Poor	Slab	Retain
82	62+008	59+270	1X12.4	Slab	Good	Slab	New Const.
83	62+200	59+430	1X1.6	Slab	Good	Slab	New Const.
84	62+288	59+522	1X1.52	Slab	Good	Slab	Widening
85	63+240	60+472	1X1.45	Slab	Good	Slab	Retain
86	65+702	62+888	1X1.5	Slab	Good	Slab	Retain
87	66+238	63+418	1X1.5	Slab	Good	Slab	Retain
88	66+468	63+648	1X1.2	Slab	Good	Slab	Retain
89	67+520	64+665	1X1.15	Slab	Good	Slab	Retain
90	67+700	65+740	1X1.15	Slab	Poor	Box	New Const.
91	69+300	66+640	1X1000mm	HP	Poor	Box	New Const.
92	70+028	67+236	1X1.92	Box	Good	Box	Retain
93	70+152	67+355	2X2.2	Slab	Good	Slab	Retain
94	71+522	68+040	1X900mm	HP	Poor	Box	New Const.
95	73+134	70+390	1X2.3	Slab	Good	Slab	Retain
96	73+725	70+883	1X1.17	Slab	Good	Slab	Widening
97	74+250	71+405	4X1000mm	HP	Good	HP	Retain
98	74+470	71+618	1X1.65	Slab	Good	Slab	Widening
99	74+510	71+716	1X1000mm	HP	Poor	Box	New Const.
100	75+100	72+268	1x1.45	Slab	Good	Slab	Retain
101	76+510	73+595	1 x 1.6	Slab	Good	Slab	Retain
102	76+810	73+966	1 x 1.6	Slab	Good	Slab	Retain
103	77+292	74+560	1x1.4	Slab	Good	Slab	Retain
104	77+875	74+990	1x1.7	Slab	Good	Slab	New Const.
105	77+985	75+100	1x1.85	Slab	Good	Slab	Retain
106	78+285	75+500	1x0.5	Slab	Good	Slab	Retain
107	79+425	76+626	1X1.2	Slab	Good	Slab	Retain
108	80+250	77+344	1X1.2	Slab	Good	Slab	Retain
109	80+955	78+040	1X1.3	Slab	Good	Slab	Retain

Sr. No.	Existing Chainage	Proposed Chainage	Existing Span(M)	Existing Type	Existing Condition	Proposed Type	Proposal
110	81+020	78+115	1X1.2	Slab	Good	Slab	Retain
111	81+112	78+230	1X1.7	Slab	Good	Slab	Retain

Detailed inventory and condition of individual culverts are given in ***Appendix-3.1***of this report.

3.2.09 Permanent Bridge, Bypass or Tunnel costing Rs. 50 crores or more

Nil

3.2.10 The existing & proposed chainage:

The existing & proposed chainageareas follows:

Sl.No	ExistingChainage (Km)		DesignChainage (Km)		Length (Km)	Existing ROW (m)	Proposed ROW(m)
	From	To	From	To			
1	NA	8+900	0+000	6+900	6+900	Bypass	60
2	8+900	12+140	6+900	10+200	3+300	28.8	45
3	12+140		10+200	13+130	2+930	22.5	60
4	15+150	18+405	13+130	16+500	3+370	21.5	45
5	18+305	18+292	16+400	16+900	0+500	21.0	120
6	18+292	NA	16+900	19+300	2+300	NA	60
7	NA	NA	19+300	19+800	0+500	NA	45
8	NA	NA	19+800	21+600	1+800	NA	60
9	NA	25+810	21+600	23+550	1+950	NA	45
10	25+810	26+513	23+550	24+250	0+700	22.8	30
11	26+513	28+960	24+250	26+600	2+350	22.8	45
12	28+960	30+940	26+600	28+600	2+000	22.3	30
13	30+940	31+685	28+600	29+350	0+750	23.0	45
14	31+685	32+465	29+350	30+100	0+750	22.7	30
15	32+465	33+630	30+100	31+250	1+150	21.8	45
16	33+630	35+605	31+250	33+200	1+950	22.0	30
17	35+605	36+455	33+200	34+050	0+850	22.1	45
18	36+455	38+583	34+050	35+150	1+100	21.9	30
19	38+583	38+187	35+150	35+750	0+600	21.8	45
20	38+187	43+092	35+750	40+650	4+900	22.2	30
21	43+092	51+658	40+650	48+950	8+300	22.3	45
22	51+658	53+977	48+950	51+100	2+150	22.5	30
23	53+977	54+571	51+100	51+750	0+650	22.6	45
24	54+571	59+000	51+750	56+080	4+330	22.8	30
25	59+000	59+744	56+080	56+880	0+800	22.1	45
26	59+744	61+858	56+880	59+000	2+120	22.8	30

27	61+858	62+688	59+000	59+800	0+800	21.7	45
28	62+688	64+000	59+800	61+100	1+300	21.3	30
29	64+000	65+320	61+100	62+380	1+280	21.4	45
30	65+320	71+408	62+380	68+450	6+070	21.9	30
31	71+408	71+922	68+450	68+950	0+500	22.7	80
32	71+922	73	68+950	70+050	1+100	22.8	30
33	73+015	73+305	70+050	70+400	0+350	22.5	45
34	73+305	81+200	70+400	78+192	7+792	22.5	30

Design Length of the Project Road: 78+192 Km

3.2.11 Sections of Land use

Sl.No.	ExistingChainage(Km)		Design chainage (Km)		Length(Km)	NameofVillages/ City
	From	To	From	To		
1	0+000	8+800	NA	6+900	6+900	Chas city
2	8+800	11+842	6+900	9+900	3+000	Azad Nagar
3	16+312	18+834	14+400	16+900	2+300	Siwandih
10	30+132	32+014	27+800	29+650	1+850	Bahadurpur
11	34+990	37+025	32+600	34+600	2+000	Kamalapur
14	40+044	41+043	37+600	38+600	1+000	Lukuiya
15	42+035	42+043	39+600	40+600	1+000	Sadama
19	56+940	58+045	54+100	55+200	1+100	SosoKhurd
20	61+958	64+000	59+100	61+100	2+000	Gola
23	72+865	74+071	69+100	71+100	1+200	Muruband
24	76+620	77+780	NA	NA	NA	Barlong
25	78+080	79+530	NA	NA	NA	Chhatarmandu
26	80+780	81+200	NA	NA	NA	Chhatarmandu
TOTALLENGTH(KM)					15+315	

3.3 ROAD INVENTORY

A detailed road inventory survey has been carried out by the Consultant in the month of May 2010. Detailed Road Inventory covers data pertaining to terrain gradient, junctions, land-use, roadside drainage (if available), earthworks – cut or fill. The data have been collected in sufficient detail, compiled & presented in tabular format. The data have been stored in computer files using utility packages, such as EXCEL etc. The same has been presented as Appendix 1 to this Report.

The entire length of project road has a carriageway width varying from 6.0 m – 7.0 m. Earthen/Morum shoulder of varying width from 0.75 - 2.0 m exists along both the sides of the road. Earthen/Morum shoulder details described in Appendix 1. The project road traverses through plain and rolling terrain. The soil strata along the project road are generally Clay/Sandy soil. The land-use pattern for the major part of the project road is agricultural. The embankment height varies from 0.0 m to 3.0 m. The facilities such as road side drainage are available at some locations and service roads were not available. The road has some submergence stretches. According to local inquiries it has been found that no submergence occurred in the rainy seasons. Fifth Km stone has been found in entire project stretch.

The major junction is at Chas, where NH-23 and NH-32 meets and where NH 23 crosses proposed Ramgarh bypass of NH 33.

The project road connects with SH & PMGSY road at various locations, described in ***Appendix-1***.



Junction of NH-23 and NH-32



Road condition at Km 84.986 on NH-23



Shoulder thickness



Improper Junction

3.4 PAVEMENT CONDITION SURVEY

The existing pavement condition survey was carried out by visual means supplemented by measurement as per the guide lines mention in IRC SP-19-2001 detailed field study included pavement condition shoulder condition, embankment condition drainage condition etc.

The existing pavement condition was identified and result has been summarized for every 200 m interval section length of the project roads.

The condition of existing roads was measured for Cracks, reveling potholes patching and presence of Rut and pavement edge drop.

The ridging quality is measured in terms of:

(i) Speed (in km/hr.)
(ii) Surface Quality (Good, fair, Poor, Very poor)

Rut depth was measured transversely across the outer wheel paths using 3 m long straight edge.

Shoulder and embankment condition were observed by visual means and existence of distress its cause and extent were recorded.

The field data for pavement condition survey is given in ***Appendix-4.1***



Paved shoulder at km 48.296 of NH-23



Block Cracking at km 72.350 NH-23



Patching at km 23+000 of NH-23



Block cracking at km 82.986 of NH-23

3.5 PAVEMENT CONDITION AND EVALUATION

The project road under this contract for preparation of detailed project report starts from km 0+000 at Chas on NH -23 and ends km 82+862 at Ramgarh. Existing road is a 2 lane bituminous road. The project involves widening & strengthening of existing road to two lanes with paved shoulder configuration. Provision of Flexible Pavement is therefore the only feasible proposition for widening and strengthening. Following are the types of defects are generally seen in the pavements.

3.5.1 Transverse and Longitudinal Cracking

Surface cracking is by far the most common defect found in pavements. Cracks can run perpendicular (transverse), parallel (longitudinal) to the direction of traffic or in a meandering random pattern across the surface.

Transverse, thermal cracks caused by cold temperature contraction of the surface layer will occur to some degree in all asphalt pavements.

Longitudinal cracks can be caused by opening of paving lane joints or by repeated over-stressing of the wheel path area by heavy traffic.Just because a pavement is cracked does not mean that it has failed. A pavement is only considered to have failed when the cracking has become so severe that the structural integrity of the surface is jeopardized or the cracking creates a roughness problem

3.5.2 Alligator Cracking

Alligator cracking is a very serious load-associated defect normally found in the aircraft wheel paths. It is caused by severe structural overloading and poses an immediate FOD hazard. In the initial stages, only fine hairline cracks may be evident. As development of the defect progresses, the cracks will widen and begin to interconnect to form a series of small polygons resembling the hide of an alligator. Spacing between cracks is usually 60 to 200 mm

3.5.3 Map Cracking

Map cracking is identified by large scale patterned cracks intersecting at a spacing of 400 mm to 2.5 meters. Map cracking occurs only in the wheel paths (load associated) - otherwise the defect is block cracking Map cracking may be accompanied by wheel path rutting or settlement. Map cracking is caused by excessive deflection of the pavement under load. It is similar to alligator cracking but the yielding layer is at a much deeper level in the pavement, most likely in the sub grade.

3.5.4 Block Cracking

Block cracking is identified by intersecting transverse and longitudinal cracks forming rectangular blocks that may vary in size with a spacing of up to 2 by 3 meters. Block cracking may appear to be similar to alligator cracking but it is not limited to wheel path locations (i.e. block cracking is not load-related) and will frequently occur throughout the entire pavement surface. Block cracking is normally found in older asphalt surfaces.

3.5.5 Raveling

Raveling is the disintegration and subsequent loss of the asphalt surface. It is evidenced by the pop-out of surface aggregates and/or the loss of surface fines from the asphalt mix. Severe cases of raveling are characterized by loose gravel and fine pavement material lying on the surface

3.5.6 Rutting

Rutting is a load-related depression found in the wheel path area. Depending on the failure mode, rutting may be seen simply as the consolidation of pavement layers in the wheel path or may be made worse by the upheaval of the pavement area adjacent to the wheel path. A visual check for rutting can be made by placing a straight-edge across the wheel path area. Rut depths exceeding 40 mm are considered excessive.

The individual distress was noted for section of 500 m length each. The severity and extent of the pavement distresses were noted for each section and the results were averaged for each Section.

Finally the results are drawn in form of graphs for different defects types as below.

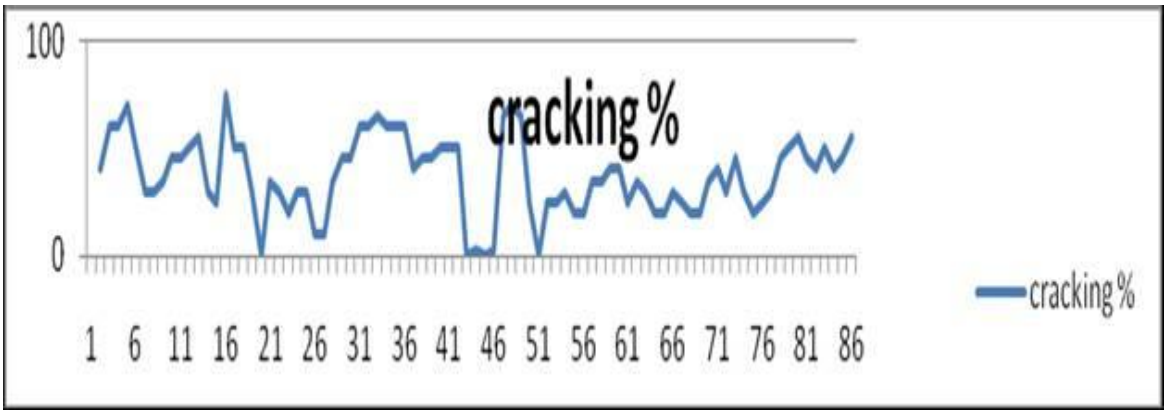


Fig-1: Cracking

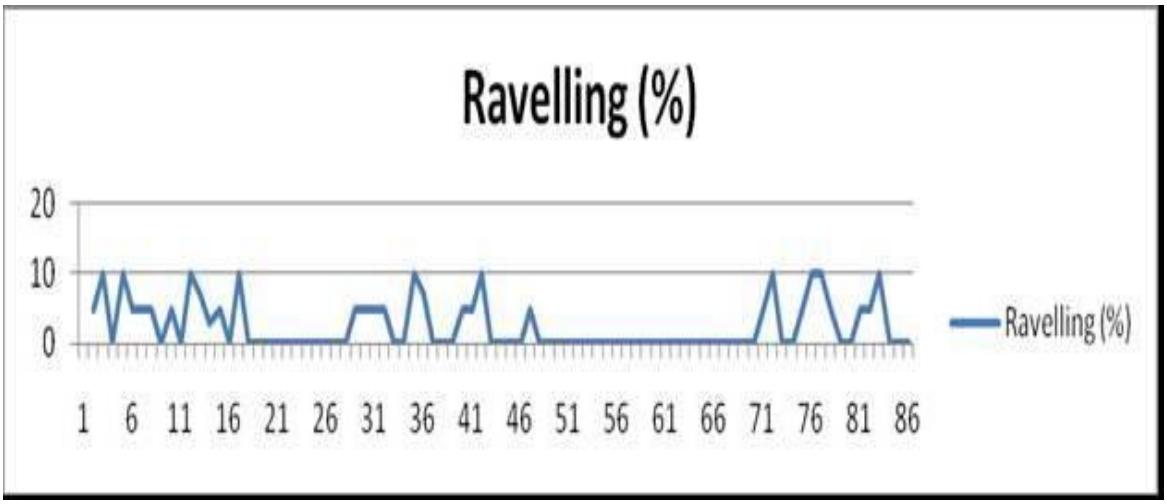


Fig-2: Ravelling

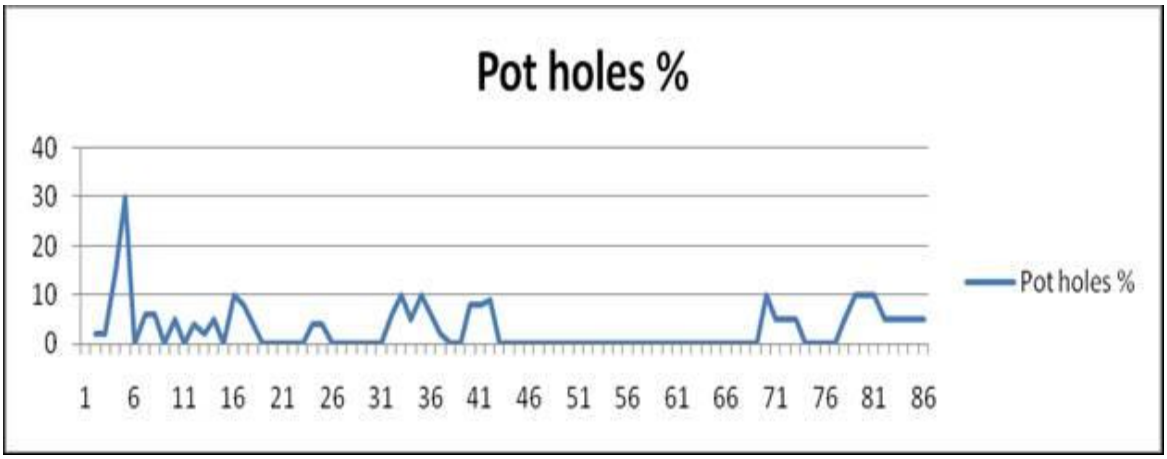


Fig-3: Potholes

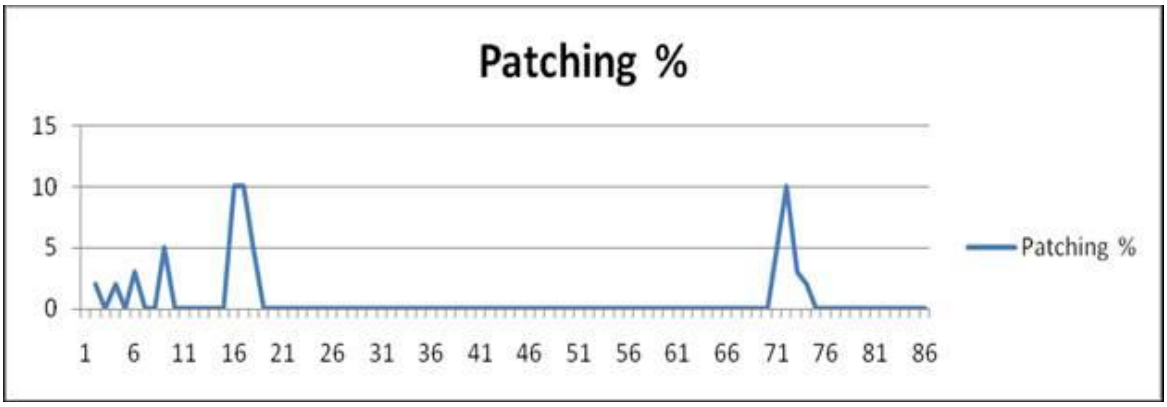


Fig-4: Patching

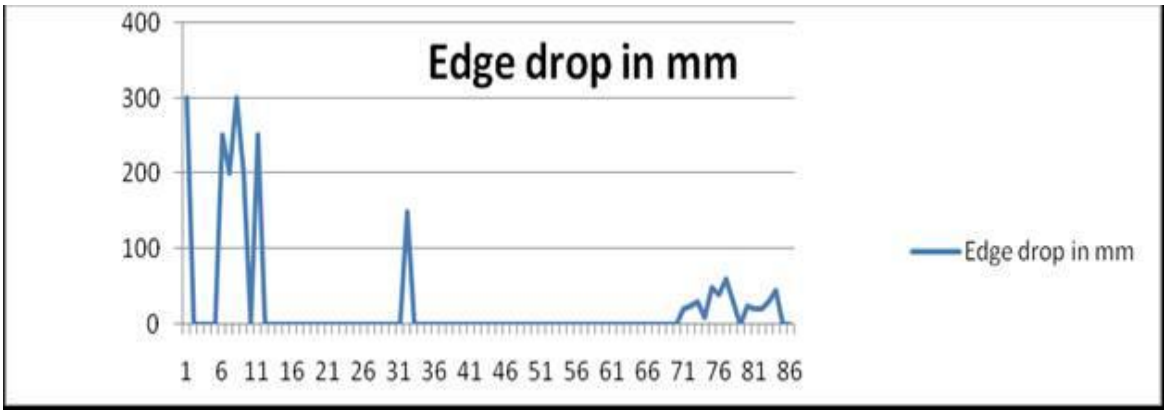


Fig-5: Edge Drop

3.6 HOMOGENEOUS SECTIONS

On the basis of severity of different distresses present on the road, NH-23 is divided into various homogeneous sections.

Project Corridor is divided into 5 homogeneous sections on basis of pavement conditions as under:

P1	:	from km. 0+000	to	km. 20+000
P2	:	from km. 20+000	to	km. 29+000
P3	:	from km. 29+000	to	km. 46+000
P4	:	from km. 46+000	to	km. 71+000
P5	:	from km. 71+000	to	km. 85+000

The severity of the various pavement defects were classified into five set of indices as set out in **Table -3.1**

3.7 CLASSIFICATION SYSTEM OF PAVEMENT DEFECTS

Table-3.1: Classification System of Pavement Defects

Distress Type	I	II	III	IV	V
Cracking	0-5%	5 -10 %	10 -15%	15 -25%	>25%
Raveling	0-5%	5 -10 %	10 -15%	15 -25%	>25%
Rutting	0-5mm	5-10 mm	10-15 mm	15 -25 mm	>25mm
Potholes	0-5%	5-10%	10 -15%	15 -25%	>25%
Patching	0-5%	5-10%	10 -15%	15 -25%	>25%

3.8 SECTION-WISE DETAILS OF SEVERITY OF DEFECTS

Each homogeneous section **of** the road is then marked with different severity indices.

Table-3.2: Rating severity indices (NH-23)

Homogeneous section for Pavement condition	**P1**	**P2**	**P3**	**P4**	**P5**
Rating value	**V**	**III**	**IV**	**II**	**V**

Looking at the severity indices, it is seen that all the part of pavement falls more than I which indicates condition of the existing road is not good and certainly require some immediate measures of rehabilitation.

Table - 3.3: Pavement condition of NH-23

Chainage(km)	**Pavement Condition**
0+000 to 20+000	poor
20+000 to 29+000	fair
29+000 to 46+000	poor
46+000 to 71+000	fair
71+000 to 85+000	poor

3.9 EXISTING PAVEMENT COMPOSITION

The existing pavement structure mostly comprises three flexible pavement layer Bituminous surfacing layer, Base course and sub base course. The pavement composition of NH-23 is given in **Appendix-8.1.**

The summary of existing pavement composition is shown in **Table-3.4**.

Table-3.4: Pavement composition summary

Road	**Bituminous Course (mm)**		**Granular thickness (mm)**	
	Min	Max	Min	Max
NH-23	60	180	120	280

3.10 BENKELMAN BEAM DEFLECTION SURVEY

The test was carried out in accordance with the IRC: 81-1997 “Guidelines for Strengthening of Flexible Road Pavements using Benkelman Beam Deflection Technique (First Revision)”. For measuring pavement deflection, the C.G.R.A procedure that is based on testing under static load was adopted. A standard truck having a rear axle weighing 8170 kg fitted with dual tyre inflated to a pressure of 5.60 kg/sq.cm was used for loading the pavement. The beam was calibrated using metal plates of known thickness prior to testing. The dual wheels of the truck are centered above the selected point.

The pavement deflections were measured by Benkelman Beam at 50m intervals at 0.6 m from the pavement edge in staggered manner continuously for entire project stretch. Pavement temperature was recorded at every one hour during the testing period by inserting a thermometer in a standard hole (approximately 5 cm deep and 10 mm diameter) on the pavement after filling the hole with glycerol.

At any deviation of the pavement temperature during deflection measurements from the standard temperature of 35^{o}C, temperature correction factor was applied to the deflection measurements in accordance with the procedure described in IRC: 81-1997. Seasonal correction was carried out using the moisture correction factors given in Figures 2 to 7 in IRC: 81-1997. PI and moisture content of the sub grade were established from test pits, which were excavated simultaneously with the Benkelman Beam tests. The values so observed are given at **Appendix -10.1**.

The analysis reveals that at present there is general deficiency in pavement crust and pavement of certain selected stretches has distress enough requiring full depth repair. Cracks in existing pavement (especially in wearing course) can effectively sealed by profile corrective course itself. Just to corroborate deflections with the existing crust, the pavement composition so found is given at **Appendix -8.1.**

Homogeneous sections have been derived based on cumulative deflection approach as defined in AASHTO pavement design manual.

3.11 TOPOGRAPHIC SURVEY

The basic objective of the topographic is to capture essential ground features along the alignment in order to consider improvements and for working out improvements.. This includes existing road and its alongside features. The Topographic Survey is carried out using high precision instruments i.e. Total Stations. The data from the topographic Surveys is available in (x,y,z) format for use in a sophisticated digital terrain model (DTM). The detailed field surveys would essentially include the following activities:

- GPS pillars established at an interval of 5 km all along the project corridor.
- Temporary Bench Marks (TBMs) are created @ 250m interval along the project road. Temporary bench mark is connected with GPS which is done @ 5km interval.
- Reference pillar and Bench Mark / Reference Pillar of size 15 cm X 15 cm X 45 cm are cast in RCC of grade M 15 with a nail fixed in the center of the top surface. The reference pillars are embedded in concrete up to a depth of 30cm with CC M10 (5cm wide all around). The spacing of reference pillar is 250m apart, incase Bench Mark pillar coincides with reference Pillar, only one of the two is provided.
- Established bench-Marks at site are connected to GTS Pillars at an interval of 250m on Bench Marks pillars made of RCC as above with RL and BM No. marked on it.

The topographical survey data was used to set-up a Digital Terrain Model (DTM) of the area up to the Proposed ROW boundary as necessary.

3.11.1 Topographic Surveys along the Right of Way (RoW)

Running a continuous open Traverse along the existing road and realignments, wherever required, and fixation of all cardinal points such as horizontal intersection points (HIP's), center points and

transit points etc. and properly referencing the same with a pair of reference pillars fixed on either side of the center-line at safe places within ROW.

3.11.2 Width of Survey Corridor

For existing road the width covered is 30m either side from the existing center line. Width of the survey corridor is widened appropriately where developments and/or encroachments have resulted in a requirement for adjustment in the alignment, or where it is felt that the existing alignment can be improved upon through minor adjustments.

3.11.3 Longitudinal Section Levels

It is taken all along the existing center line at every 25m interval, smaller interval at the location of curve points, small streams, intersections and locations of change of elevation.

3.11.4 Cross - Sections

They are taken at every 50m interval in full extent of survey covering sufficient number of spot levels on existing carriageway and adjacent grounds for plain and rolling terrain. At curves cross sections are taken at closer intervals.

3.11.5 Topographical Survey for Cross-Roads

Longitudinal levels are taken for 120m length from project center line. Where existing roads cross the alignments, the survey extended a minimum of 120m either side of the centerline of the cross-road.

3.11.6 Longitudinal and Cross-Sections for Major and Minor Bridges

For Major bridges levels of stream cross-sections are taken for 300m for both in upstream and downstream sides and for minor bridges taken for 100m both in upstream and downstream side. Longitudinal levels of the centerline of the streams are taken at 25m intervals for 300m for major bridge and 100m for minor bridge both in up and down stream sides.

3.11.7 Other Physical Features

They normally include buildings and structures, monuments, burial grounds, cremation grounds, places of worship, railway lines, stream/river/canal, water mains, severs, gas oil pipes, crossings, trees, plantations, utility services such as electric, telephone lines (O/H & U/G) and poles, optical fiber cables etc.

3.12 AXLE LOAD SURVEY

Several factors such as gross load, tyre pressure, type of load, number of wheels and type of wheel configuration, number of repetitions, subgrade properties, climatic conditions and type of material used in pavement, etc. affect the design and performance of pavements. Knowledge of axle loading and the spectrum of axle loads of vehicles using a highway system are necessary in the development and application of realistic pavement design and maintenance procedures.

Axle Load Surveys conducted at two locations i.e. km. 21+000 Jena More and km. 70+000 Chitpur of Project Highway (NH-23). The surveys were conducted for a period of 24hours using axle load pads. The survey covered trucks, 3-axle truck, LCV's.

Origin destination details of the sample-surveyed vehicles were also recorded along with the axle loads.

Axle load survey analysis has been performed as per IRC standards for the assessment of VDF for the project highway. The results of the axle load survey have been presented in **Table-3.5.**

Table-3.5:Average VDF

Type of Vehicle	Average VDF
Bus	0.320
LCV	0.150
2-Axle	3.360
3-Axle	2.780
Multi Axle	5.840

3.13 SUBGRADE INVESTIGATIONS

Subgrade investigations were carried out along the existing road stretches. The appraisal of the quality of the sub grade soil beneath existing pavement base was accomplished in two steps, namely:

(a) review of existing subgrade soil information,
(b) Supplementary soil investigation to fully characterize the subgrade soils.

Review of available soil information indicated that the characteristic of existing sub grade varies along the alignment. It appears that in almost complete stretch, the materials in the existing embankments have been taken from the side cuts along the road and therefore material qualities underneath existing pavement are similar to that of the adjacent natural ground.

Sub grade investigations comprises of the following operations:

- Making test pits of 1.0 m x 1.0 m and depth up to 0.800 m on the existing road surface. Test pits were located towards the road edges (0.3 m inside the wearing course) evenly distributed towards the left and right side from the center of the road formation; (This was done for pit at every 5km interval)
- Visually identifying the pavement material/soils exposed in the test pit and measuring the thickness of the layers on the sides of the test pit; (This was done for pit at every 500 m interval)
- Determining the in-situ bulk-density of subgrade by using the sand replacement method; (This was done for pit at every 5km interval)
- Collection of subgrade samples in sealed tins for field moisture content determination; (This was done for pit at every 5km interval)
- Collection of subgrade samples (in bags) for carrying out laboratory tests. (This was done for pit at every 5km interval)

The subgrade samples in sealed tins were tested in the laboratory for determining the field moisture contents of the subgrade.

Subgrade investigations in test pits which included in-situ field density determination using the sand replacement method/core cutter apparatus were carried out on test pits at every 5 km resulting in a total of 17 test pits for NH-23. Representative samples were collected from the test pits and tested in the laboratory as per relevant standards. Field and laboratory tests of samples collected from test pits are discussed as under. The types of existing sub grade soils present all along NH-23 is represented as Fig-6.

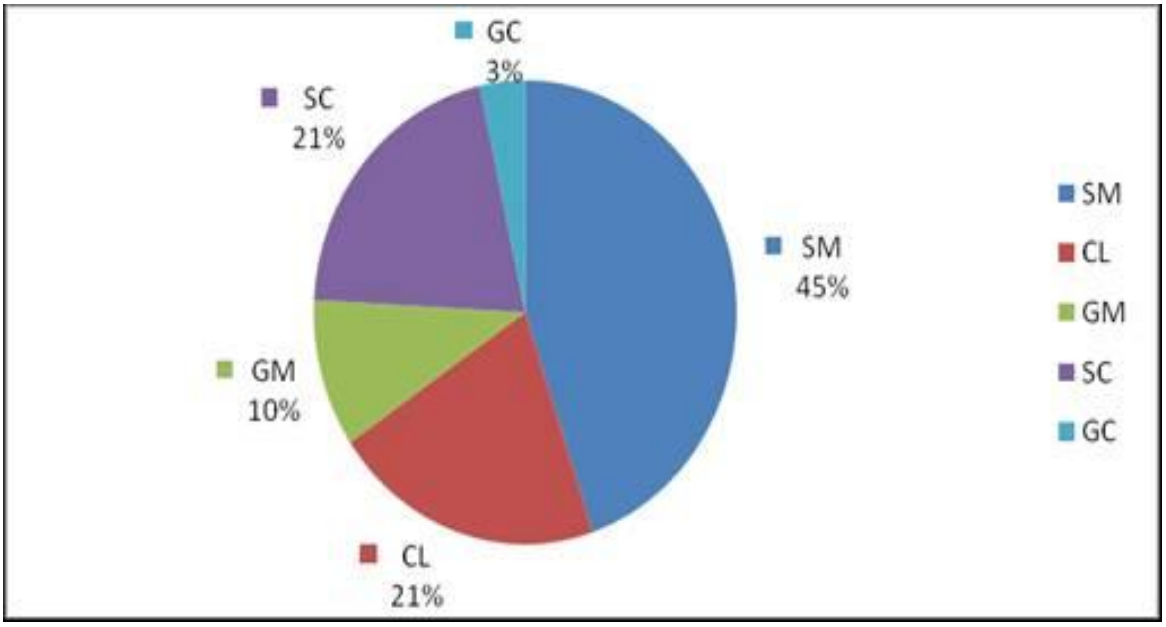


Fig-6: Sub grade soil for NH-23

The study of 17 samples of NH-23 Soil Classification System (IS:1498-1970), plotted as pie chart above shows;

- 58.82% is silt, sand, gravel and little bit of clay (SM). It is a poorly graded mixture. Varies from non-plastic to plastic. Plastic soil has PI of 3
- 0.18% is inorganic clays (CL), sandy silty clay and kankarof low plasticity and compressibility. PI value is about 15
- 29.41% is silty sand kankar and some % of clay (SM-SC). Is poorly graded sand clay mixture, sand with appreciable amount of silt. PI values varies from 5-6
- 5.71 % is silty sand with some % of clay (ML), poorly graded sandsilt and clay mixtures, with PI of 3.
- 5.88% is silt sand and gravel (SW-SM), poorly graded gravel, sand and silt mixture. It is non plastic.

The laboratory maximum dry density varies from 1.94 to 2.04 gm/cc with the corresponding optimum moisture content in the range of 2.30 to 14.35 percent. There is big variation in the soaked CBR of the soil, which vary from 10 to 12.1. The swelling ratio carried out on suspected sample is in the range of 5.00 to 15.15 percent. It is seen from the data that the degree of compaction of the subgrade is well above the specified requirement (97 percent of maximum laboratory density) as per MORT&H Specification Table 300-2: Compaction requirements for embankment and sub grade.

The results of subgrade investigations for NH-23 are compiled in **Appendix. 7.1**

3.14 MATERIALS INVESTIGATIONS

A number of sources of natural soil deposits, morrum,gravel, sand, and potential quarries for production of crushed rock aggregate to be used in the construction of pavement layers and highway structures had been located and surveyed. Engineering properties of these materials are being tested in the laboratory. The procedure of investigation and results thereof are discussed below:

3.14.1 Borrow Areas

Suitable soil conforming to MORT&H specifications in huge quantities will be required to construct embankment, sub grade and earthen shoulder. An investigation to identify potential soil borrow sources have confirmed the availability of suitable soil at number of locations along the project road corridor.

A total of Seventeen (17) soil sources for Project Highway have been studied in detail and the same are plotted in a linear borrow chart as shown in **Figure-7**.

Soils of similar nature are also available from a multitude of other sources, for which negotiations with private owner(s) may be required during execution phase of the project.

Table – 3.6 provides a summary description of results of investigated sources.

It is evident that soil of CBR more than 7% is available all along existing project road NH-23. From each source, bulk samples of soil were obtained from purposefully excavated trial pits for laboratory testing. The soil samples are tested to laboratory classification tests, moisture-density relationship tests and CBR tests. The results indicated that the soil types are predominantly silty sand. Optimum moisture content varies from 11.3% to 15.2% and maximum dry densities varies from 1.917 to 1.986 gm/cc when tested for heavy compaction as per IS:2720 (Part 8). Strength in terms of soaked CBR varies from 10% to 12.6%. From test results it is observed that the materials from all borrow area is suitable for embankment and well as sub grade construction also. Fly ash is available within the vicinity of the project area as spelt out in TOR.

3.14.2 Aggregates and Sand Quarry

The objective of this investigation had been to identify, inspect and evaluate the aggregate sources, which would supply pavement (bituminous & non-bituminous courses) and concrete quality aggregate in sample quantities. Existing and known quarries/crushing plants and other potential extraction sources of materials in the project vicinity have been inspected.

3.14.3 Aggregate/ Stone Metal Quarries

Detailed survey was carried out to locate potential sources of hard stone metal required for the construction of Wet Mix Macadam, Dense Bituminous Macadam, Bituminous Concrete and Cement Concrete Works. After thorough survey of the area and discussions with the Engineers of NH Division,Dhanbad it revealed that three potential stone metal quarries are available on or near the project road which are given below:

- Narayanpur Quarry at km 3 of NH-23
- Khuntari Stone/metal, chips, boulder at km 21 of NH 23
- Chutupalu Quarry at km 12 of NH 33. 12 km from NH 23 end point

All stone samples were collected from above mentioned quarry. The detailed of the locations are given in ***Table-3.7.***

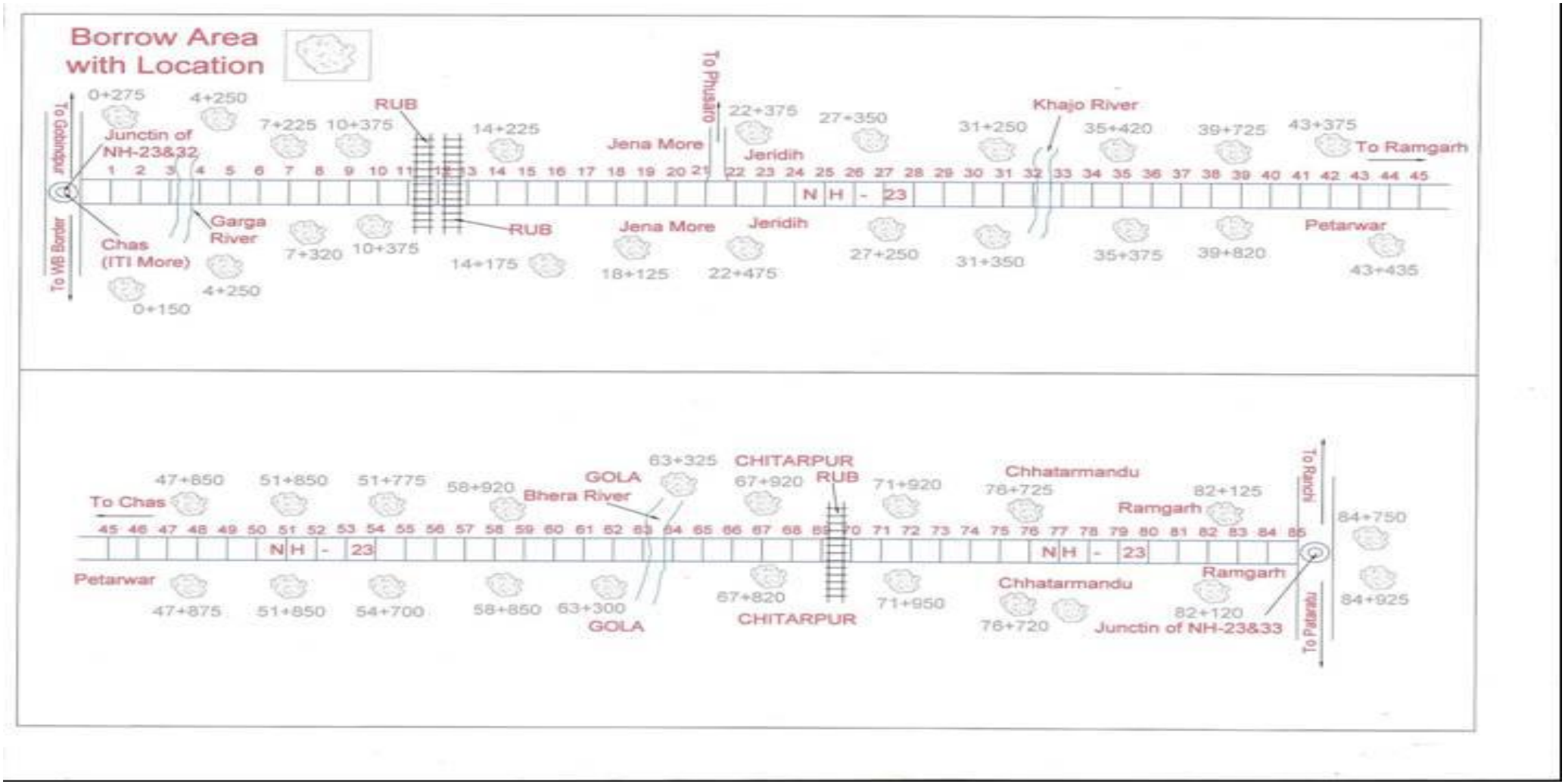
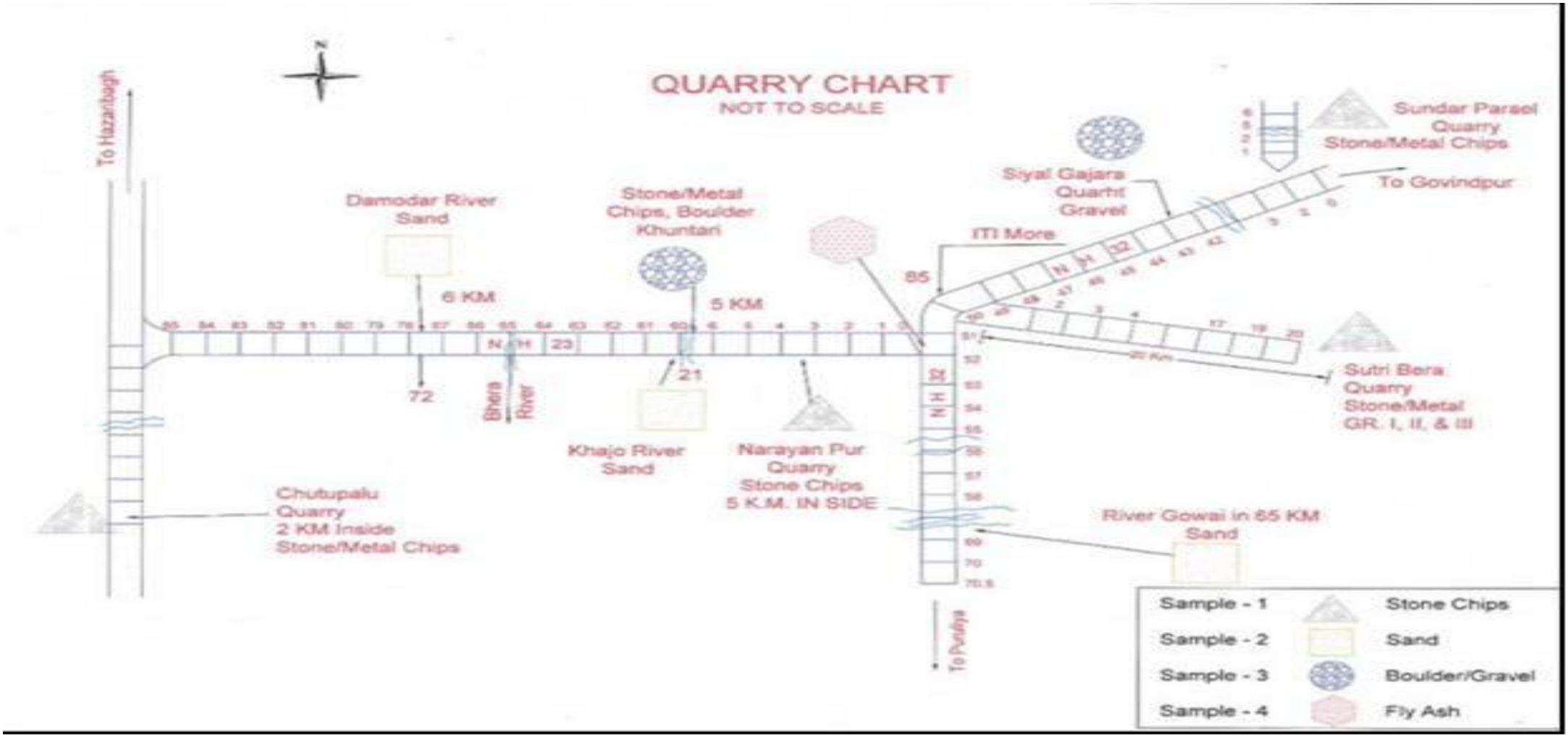


Fig:-7 Borrow Area Location Chart

Fig-8: Quarry Chart



Few of the photographs are attached herewith for better apprehensions of quarry areas:



Stone Quarry



Stone Quarry



Stone Crusher



Moorum Quarry

Table-3.7: Details of Stone Quarry

Sample No.	Chainage (km)	Left/ Right side of the road (LHS/RHS)	Name of Quarry	Lead from nearest chainage (km)	Remarks
S1	03, (NH-23)	LHS	Narayanpur	5.0	
S2	21,(NH-23)	RHS	Khuntari	5.0	
S3	21, (NH-33)	LHS	Chutupalu	12.0	

The following tests were conducted in the laboratory

- Sieve Analysis (for the samples collected from crushers)
- Aggregate Impact Value
- Flakiness & Elongation Index

- Specific Gravity
- Water Absorption Percent
- Coating and Stripping of Bitumen aggregate mixture
- Soundness (only done if water absorption Percent is less than 2)

The **Table-3.8** show the specified property of stone aggregates which can be used for Surfacing and Base course as per MORT&H.

Table-3.8: Physical requirements for coarse aggregate for dense graded bituminous macadam

Property	Test	Specification
Cleanliness(dust)	Grain size analysis	Max 5% passing 0.075mm sieve
Particle Shape	Flakiness and Elongation Index (Combined)	Max 30 %
Strength	Loss Angeles Abrasion Value	Max 35 %
	Aggregate Impact Value	Max 27%
Durability	Soundness: Sodium Sulphate Magnesium Sulphate	 Max 12 % Max 18 %
Water Absorption	Water absorption	Max 2 %
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures	Minimum retained coating 95 %
Water Sensitivity	Retained Tensile Strength	Min 80 %

Table-3.9: Physical requirements of aggregates for Wet mix macadam for sub-base/base courses

Test	Test Method	Requirements
Aggregate Impact value	IS:2386 (Part-4) Or IS:5640	30 per cent (Max.)
Combined Flakiness and Elongation indices (Total)	IS:2386 (Part-1)	30 per cent (Max)

Table-3.10 below shows the properties of the stone Samples collected from the survey.

Table-3.10: Test results of the stone samples

Quarry location	Elongation Index	Flakiness Index	AIV	Water Absorption	Specific Gravity
Narayanpur	14.20	12.10	17.17	0.74	2.61
Khuntari	27.55	28.65	27.21	1.01	2.57
Chutupalu	13.50	11.35	17.69	0.75	2.60

3.14.4 Analysis of Aggregates Test Results

- ***Aggregate Impact Value (AIV)***

  Aggregate Impact Value gives a relative measure of the resistance of an aggregate to sudden shock or impact. From the results of the samples, it is seen that the aggregates satisfied the limits specified by MORT&H.

- ***Flakiness and Elongation Index***

  In pavement construction, flaky and elongated particles are to be avoided, particularly in surface course else strength will be adversely affected due to possibility of breaking down of aggregates under traffic. From the results of samples given in the above Table 6, it is seen that combined values of Flakiness & Elongation Index of stone sample near Khuntari (56.20%) is more than the specified value by MORTH (30%) These aggregates in the present form are not suitable for construction works as per MORT&H requirement. However the combined values of Flakiness Index & Elongation Index of aggregates can be achieved within specified limits less than 30 percent by appropriate selection of crushing plant, and rectifying the screens of component units.

- ***Specific Gravity***

  The specific gravity of all the four samples was tested and reported as above.

- ***Water Absorption***

  The water absorption of stone metal samples was determined in the laboratory after immersing the samples under water for 24 hours. The results are detailed in Table above. A perusal of results shows that water absorption of all the sample is from 0.74 to 1.01 percent. Hence the stone metal is suitable for construction works.

- ***Soundness***

  Since the water absorption values for aggregates are lesser than 2 %, so the porosity of aggregates are not of any concern and hence it is not required to carry out the soundness test on aggregates.

3.14.5 Source of Sand

KhajoRiverandDamodar Rivers are main source of the sand in the project road. Two location of the sand is identified on / near the project road which is given in **Table-3.11**. These areas are also available in the approved quarry chart for NH Division Dhanbad.

- Khajo River at km 21.000
- Damodar River at km 72.000

Table-3.11: Detail of Sand Quarry

Sample No.	Source of Sand	Chainage (km)	Left /Right	Offsetfrom nearest Chainage(km)	Remarks
1	Khajo River	Km 21on NH-23	Left	03	
2	Damodar River	Km 72 on NH - 23	R	06	

3.14.6 Analysis of Test Results of Sand

It is seen from the test results that the Fineness Modules (FM) of the sand is 2.85 and it lies in Zone II. As per Clause 1008: Sand / Fine Aggregates the FM of sand should be in the range of 2.0 to 3.5.

The details of the test results of the sand are given in the ***Appendix***.



Sand Quarry of Damodar River

3.15 DYNAMIC CONE PENETRATION (DCP) TESTS

At the bottom of each of the test pits made, DCP test was carried out to a depth of 800 mm below the exposed subgrade level. The DCP test, involves driving 20 mm diameter hardened metal conical tip fitted to a 1 meter long rod into the ground by a falling hammer of 8 Kg weight (Fig. 1) dropping from a height of 575mm. Number of blows and corresponding values of penetration in mm were recorded up to a depth of 930 mm.

The in-situ strength of the soil driven into the subgrade is expected to be inversely related to the rate of penetration (in mm per blow of hammer) achieved, which might well vary, even at the same location, at different depths. For example, if a relatively firm subgrade, is underlain by a soft layer, this will be indicated by a low rate of penetration at shallow depth, followed by a faster rate of penetration at greater depths. If the rate of penetration decreases with depth, this is indicative of ground strength increasing with depth.

The rate of penetration (mm/blow) in DCP test has been correlated with the field CBR by several investigators and the following relationship has been suggested as per TRRL (UK) Road Note No. 31.

Log10 (CBR) = 2.48 – 1.057 x log10 (penetration rate in mm/blow)

Test data for twenty nine test locations in the form of cumulative penetration depth-vs-cumulative blows plot (derived using the TRRL relationship given above) are included **Appendix-7.1.** It might be seen from the depth-vs-CBR plots that the DCP-CBR might fluctuate a good deal with depth, which could be due to stratifications within the soil mass. However isolated high CBR values might also be due to the DCP probe hitting an isolated hard material like a boulder. The average percentage values of DCP-CBR are also presented.

Varying DCP-CBRs within short depth intervals might be combined, taking into account the overall trend of variation of DCP-CBR with depth. For this purpose, the following relationship (reference of Japanese pavement design guidelines) might be used.

Effective CBR of successive combined layers of thickness T1, T2……..Tn having individual CBR's of CBR1, CBR2……. CBRn

= ((T1 x CBR10.33 + T2 x CBR20.33 + Tn x CBRn0.33))3 / (T1, + T2……..+ Tn)3

Using this relationship, the varying point-to-point DCP-CBR's have been combined for all the depth ranges for each test location. The field density test results and location-wise interpreted DCP-CBR values so derived are abstracted. It could be seen that the DCP-CBR values tend to increase from 7.69 to 76.15 percent.

3.17 HYDROLOGY FOR BRIDGES

The Hydrological inputs are most important parameters dealing with planning of cross drainage works as well as water resources projects. These hydrological parameters are evolved based on hydro meteorological observations at the work site as well as upstream or downstream location of project site on the same river. The feasibility of a bridge project very much depends on this study.

Design discharge is one of the important parameter used to fix the water way as well as Highest Flood Level for planning and design of a cross drainage work across a stream in case of road as well as Railway Bridge.

3.17.1 Determination of Design Discharge

Criteria

Design discharge at bridge site as per IRC: 5-1998
The design discharge, for which water way of bridge is to be designed, shall be based on maximum flood discharge of 50 years' return cycle. In case where requisite information is not available, design discharge shall be the maximum estimated discharge determined by consideration of the following or any other rational formula.

1. From the records available, if any, of discharge observed in the stream at the site of bridge, or at any other site in its vicinity.
2. From the rainfall and other characteristics of the catchment:
   - By the use of empirical formula applicable to that region, or
   - By a recognized method, provided it is possible to evaluate for the region concerned the various factors employed in that method.
3. By the area velocity method with the help of hydraulic characteristics of the channel.
4. By unit hydrograph method, as per CWC sub zonal report.

Fixing design discharge, IRC SP: 13-2004
The value of the discharge computed from different approaches should be compared. The highest of these values should be adopted as the design discharge Q, provided it does not exceed the next highest discharge by more than 50 per cent. If it does, restrict it to that limit.

The necessity for this elaborate procedure for fixing Q arises for sizable structures. As regard small culverts, Q may be taken as the discharge determine from runoff formula.

3.17.2 Methodology adopted for Design Discharge Computation

3.17.2.1Rational formula

IRC SP:13-2004 "Guidelines for the Design of Small Bridges and Culverts" have given ration formula for the computation of peak discharge and same has been used for the computation of peak run-off at most of the bridges sites. The detail of formula is given below:

$$Q = 0.028\,PfAI_C$$

Where;

Q	Maximum run-off in m^3/s
A	Area of catchment in hectares
I_c	Critical intensity of rainfall in cm/hr
P	Co-efficient of run-off for catchment characteristics
f	Arial factor to account for the rainfall intensity with spread of storm

3.17.2.2Physiographic information

Physiographic information like Catchment area A, Stream length L, fall of level from critical point to the structure H and Land Use information LU have been computed from Survey of India 1:50000 topographical sheets of the concerned region. Soil type as well as land use information have also been gathered from CWC sub zonal report of the region concerned. For the smaller catchments the information regarding general terrain slope have been collected from the CWC sub zonal report.

Principal factors governing Co-efficient of run-off for catchment characteristics 'P' are : (1) porosity of soil, (2) area shape and size of catchment, (3) vegetation cover, (4) initial state of wetness of soil and (5) surface storages. Considering various factors, gathered information from topographical sheets, CWC sub zonal report and previous experience the value of P for most of the bridges have been considered in the range of 3-4.

3.17.2.3Meteorological information

Meteorological information like 25 year and 50 year return period 24 hr rainfall values have been computed from the records available in concerned CWC sub zonal report. Conversion factor for 24 hr rainfall to one hour rainfall has also been referred from CWC sub zonal report to get one hour 25 & 50 year rain fall value I_o

.

3.17.2.4Estimating concentration time of a catchment

Concentration time depends on (1) distance from critical point to the structure; and (2) the average velocity of flow. The slope, the roughness of the drainage channel and depth of flow govern later. For reasonable estimate the proposed formula for the computation of concentration time $t_c$in hour is as under:

$$t_c = \left[0.87\frac{L^3}{H}\right]^{0.385}$$ (IRC SP: 13-2004)

Concentration time of catchment above 25 sq km have also been computed from CWC sub zonal report of the concerned region and the same have been compared with the value given by above formula suggested by IRC SP:13-2004 and some correction are made where the need is felt.

4.0 TRAFFIC SURVEYS, ANALYSIS AND DEMAND FORECASTS

4.1 TRAFFIC SURVEYS

As required, in order to assess the existing traffic characteristics on the project road, the following traffic surveys were carried out at the following locations. The traffic on the project road is characterised by a high degree of motorised vehicles, which consist of passenger vehicles such as cars, two wheelers (scooters/motor cycles), and Auto rickshaws Public transport such as mini buses, government / private buses and commercial vehicles such as light commercial vehicles (LCVs) and trucks, agricultural tractor and tractor with trailers. Non-motorised vehicles, in the traffic stream, consist mostly of bicycles with negligible number of animal drawn vehicles

- 7- days Continuous Classified Traffic Volume Count at 3 locations
- 1 day - Origin – Destination Surveys at 2 Locations
- Axle load survey in 2 location

4.2 OBJECTIVE OF THE TRAFFIC SURVEYS

The main objectives of the traffic surveys are:

- To assess the volume of traffic flows along the project road and their characteristics.
- To assess the origin and destination of passenger flow by mode.
- To assess the axle load distribution and estimate the Vehicle Damage Factor (VDF) used in the pavement design.

Based on the analysis of traffic surveys and secondary data collected from various sources, traffic growth on the project road and projections of traffic volumes are made over the design period.

4.3 SURVEY METHODOLOGY

4.3.1 Classified Traffic Volume Counts

All the survey locations were determined in consultation with client after the site reconnaissance survey and carried out manually by a team of trained locally employed enumerators under the supervision of experienced technical site staff and traffic engineers of us. The locations were selected based on the following considerations:

- Traffic homogeneity based on major traffic generation and dispersal locations along the project road; and
- Identification of suitable practical locations for traffic surveys

Manual traffic surveys were conducted in both directions for seven consecutive days by means of hand tally marks. The count data was recorded at 15 minute intervals for each vehicle category. The field staffs having been made aware of their responsibilities and field safety before the start of field surveys was continuously monitored by their supervisor and an on-site traffic engineer. For the purpose of counting, each day was divided into two shifts of 12 hours each and separate enumerators with a supervisor were assigned for each shift.

For recording vehicle classification information mode-wise, vehicles were grouped under the categories as shown below in **Table-4.1.**

Table-4.1: Vehicle Classification System adopted

Motorised Traffic		**Non motorised traffic (NMT)**
Passenger vehicles	2 wheelers / Auto Rickshaw / Passenger Car : Car, Jeep, Taxi / Van / Tempo	Bicycle, Cycle Rickshaw/ Rickshaw Van / Animal Drawn/ Hand Cart
Public Transport	Mini Bus / Government Bus / Private Bus / School Bus	
Commercial Vehicles	Light Commercial Vehicle (LCV) / 2 – Axle Truck / 3 – Axle Truck / Multi Axle Truck - Semi Articulated & Articulated (MAV)	
Agri Tractor	Tractor, Tractor with Trailer	

4.3.2 Origin-Destination Survey

The Origin-Destination (OD) survey was carried out for motorised passenger and goods vehicles at important signalised junctions within the project corridor. Motorized vehicles (Car, Bus and Trucks) were stopped and their drivers interviewed. The objective of this survey is to study the travel pattern of passenger and goods traffic within the study corridor, and the results are useful in determining the traffic interaction with surrounding regions and in estimating traffic growth rates and tollable traffic on a smaller more local scale.

Each OD survey was conducted for one continuous 24 hour period at the two locations as detailed in Table 7.6. and was undertaken concurrently with the classified volume counts in order to assess the captured sample size and expansion factor thereafter.

The willingness to pay survey is done to know the opinion of the road users about the existing road condition and the requirement and assessing the willingness to pay the toll for the improved facilities. The introduction of tolls on the project road is likely to divert traffic to alternative routes and in turn have an impact on the project revenue from tolls. Thus, willingness to pay toll and its level is to be assessed from the data obtained for the purpose.

4.3.3 Turning Movement Survey

This survey was conducted to obtain information on directional movement of traffic at five major intersections along the project road during one continuous 24 hour period. A sufficient number of trained enumerators to record all individual turning movements were stationed at each intersection. The data for peak period directional movements will assist in revealing traffic leakage and subsequently in intersection design.

4.3.4 Axle load survey

For design of pavements, the intensity of traffic loading is an important parameter. The intensity of traffic loading is defined in terms of cumulative number of standard axle load repetitions in a given period of time. IRC 37/2001 provides a scientific method for design of flexible pavements based on the concept of Equivalent Standard Axle (ESA) and Vehicle Damage Factor (VDF).

4.4 ANALYSIS OF CLASSIFIED TRAFFIC VOLUME COUNT SURVEY DATA

The analysis of the directional classified traffic volume counts observed at all 3 count stations was conducted to determine following traffic characteristics:

- Average Daily Traffic (ADT)
- Hourly variation
- Daily variation in traffic volume
- Directional distribution
- Traffic composition
- Annual Average Daily Traffic (AADT)

Data collected at the site was computerised for further analysis. The various vehicle types having different size and characteristics were converted into passenger car equivalents. Passenger Car Unit (PCU) equivalent values as suggested in IRC-64-1990 Guidelines for Capacity of Roads in Rural Areas were adopted. The PCU equivalent values are presented in **Table – 4.2**.

Table-4.2: PCU Factors Adopted for Study

Fast Vehicles	PCU	Slow Vehicles	PCU
Car	1.0	Agricultural Tractor	1.5
Mini Bus	1.5	Agricultural Tractor &	
Standard Bus	3.0	Trailer	4.5
LCV	1.5	Animal Drawn	6.0
2 Axle Truck	3.0	Cycle	0.5
3 Axle Truck	4.5	Cycle Rickshaw	1.5
MAV	4.5	Hand Drawn Cart	3.0
Two Wheeler	0.5		
Auto Rickshaw	1.0		
Van/Tempo	1.0		

Source: IRC: 64-1990

4.4.1 Average Daily Traffic (ADT)

The Average Daily Traffic (ADT) has been estimated by averaging the 7 days counts (as specified in the schedule). Traffic volume obtained over the period of survey has been averaged to obtain the ADT. And the location wise detailed ADT calculations are given in the ***Appendix-11.1***

4.4.2 Seasonal Correction Factor (SCF)

Petrol and fuel sales data were collected from the petrol pumps for last 1 year and seasonal variation factor was calculated accordingly.

Table-4.3: Calculation of Seasonal Correction Factor

Month	Diesel (L)	Seasonal Variation	Petrol (L)	Seasonal Variation	Total Sales(L)	Seasonal Variation
Apr. 09	42361	1.5558	2534	1.4219	44895	1.5483
May. 09	61884	1.0650	3944	0.9136	65828	1.0559
June. 09	43832	1.5036	2895	1.2446	46727	1.4876

Month	Diesel (L)	Seasonal Variation	Petrol (L)	Seasonal Variation	Total Sales(L)	Seasonal Variation
July. 09	47126	1.3985	3840	0.9383	50966	1.3639
Aug. 09	71975	0.9157	3633	0.9918	75608	0.9193
Sep. 09	73625	0.8952	3200	1.1260	76825	0.9048
Oct. 09	65778	1.0020	3140	1.1475	68918	1.0086
Nov. 09	66228	0.9952	3445	1.0459	69673	0.9977
Dec. 09	80544	0.8183	3654	0.9861	84198	0.8256
Jan. 10	77176	0.8540	4800	0.7507	81976	0.8479
Feb. 10	82587	0.7980	3355	1.0740	85942	0.8088
Mar. 10	78090	0.8440	4701	0.7665	82791	0.8396
Apr. 10	65585	1.0049	3700	0.9738	69285	1.0032
Average	**65907.00**	**1.05**	**3603.15**	**1.03**	**69510.15**	**1.05**

For our study purpose it has been considered 1.05

4.4.3 Annual Average Daily Traffic (ADT)

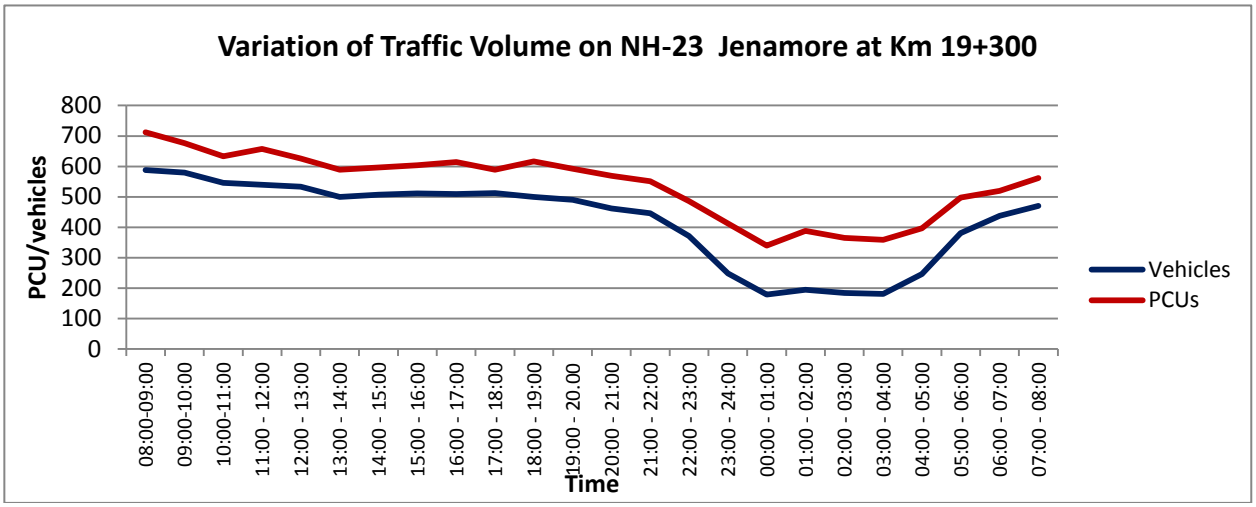
The Annual Average Daily Traffic (ADT) has been estimated by multiplying ADT with seasonal variation factor.

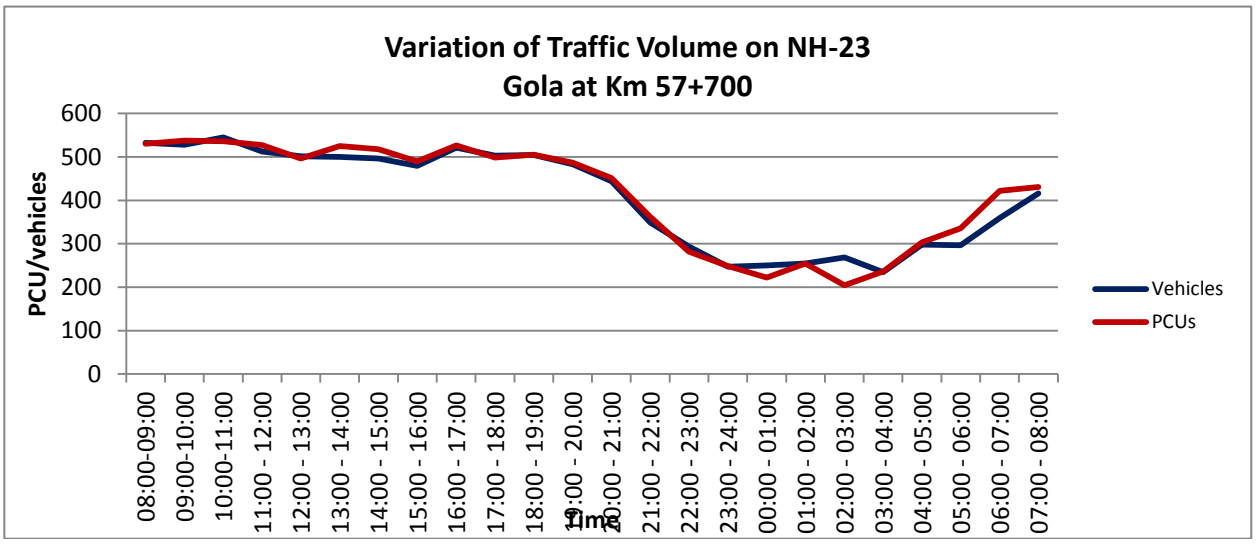
Location wise ADT, AADT are given in **Table-4.4**

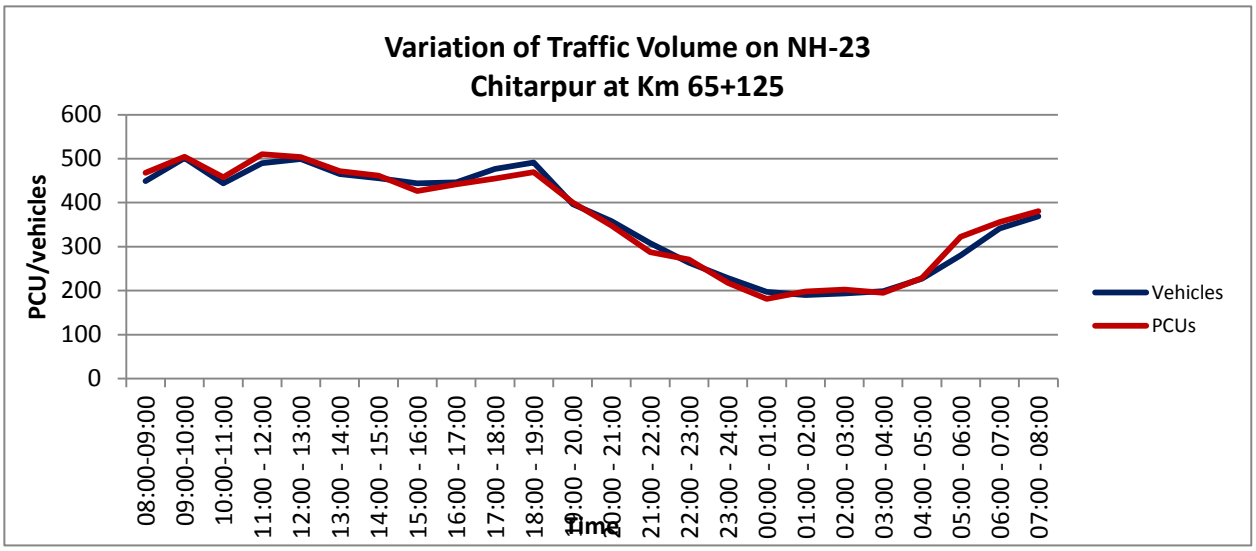
Table-4.4: Mode-wise Distribution of Base Year Traffic (2012)

Mode	Km 19+300 (Jena More)		Km 57+700 (Gola)		Km 65+125 (Chitarpur)	
	ADT	AADT	ADT	AADT	ADT	AADT
Car	3297	3462	2281	2395	1831	1922
2W	2992	3068	5075	5329	3017	3168
Auto Rickshaw	619	650	548	576	1347	1414
Govt. Bus	11	11	3	3	48	51
Mini Bus	173	181	204	214	256	269
Pvt Bus	279	293	221	232	209	219
LCV	537	564	444	466	440	462
2Axle Truck	749	786	380	399	110	116
3 Axle Truck	491	515	298	313	99	104
Multi-Axle Truck	262	275	148	156	121	127
Tractor without Trailer	12	13	2	2	47	49
Tractor with Trailer	69	72	19	20	32	34
Cycle	633	633	160	160	960	960
Rickshaw	70	70	33	33	167	167
Hand drawn cart	-	-	-	-	-	-
Animal drawn cart	-	-	-	-	-	-
Total	**10194**	**10593**	**9816**	**10298**	**8684**	**9062**

4.4.4 Hourly Variation of Traffic

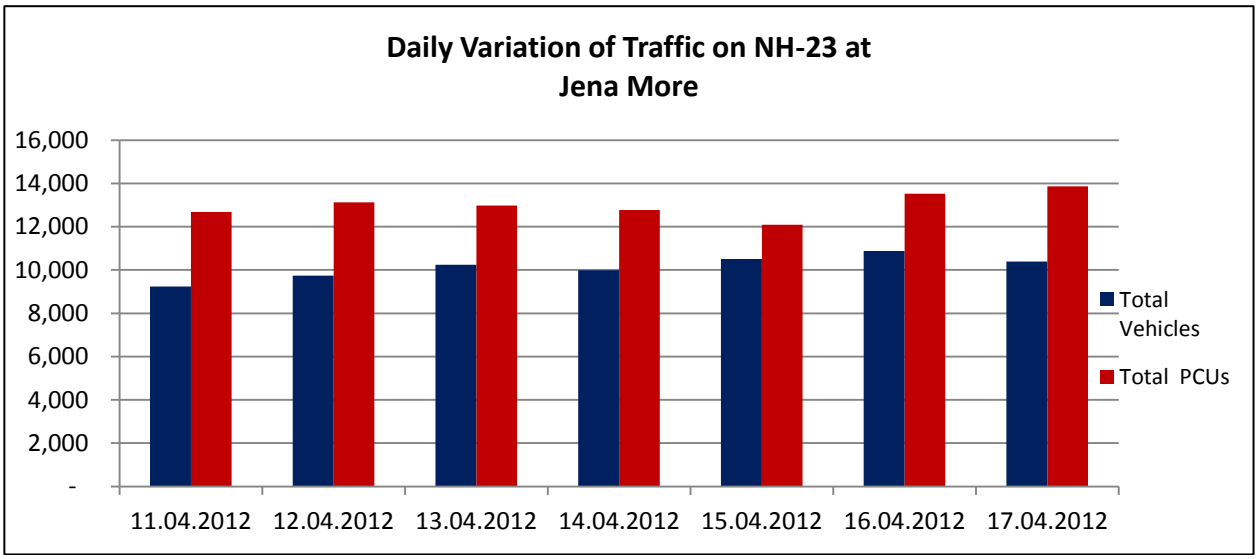


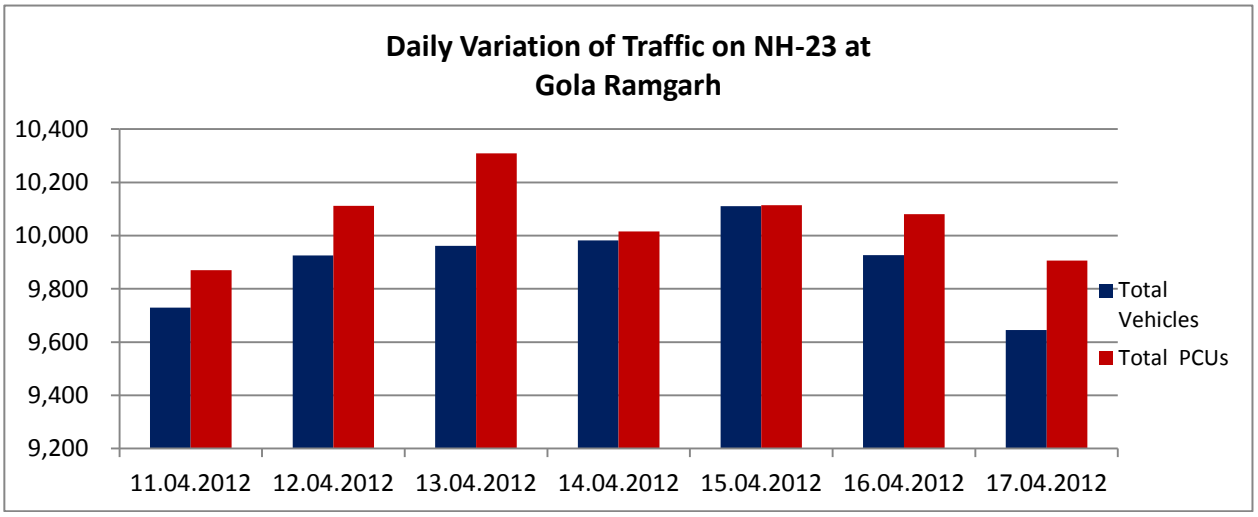


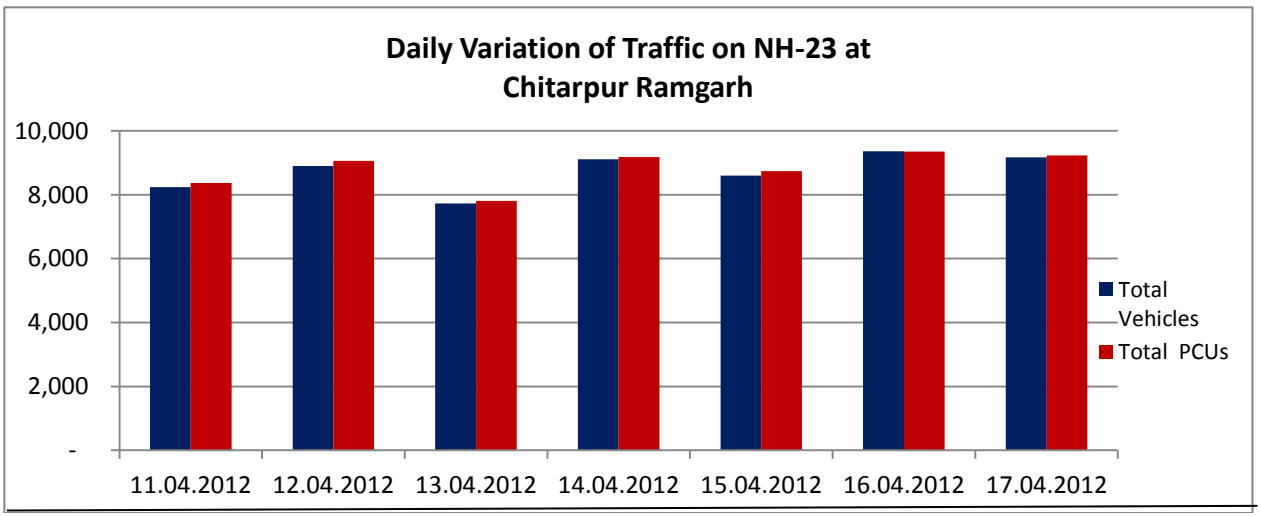


- Vehicle movement in the morning is high and vehicle movement in the night goes down. It start picking up after morning 5 AM
- Uniform flow of traffic is observed all along the corridor the all through the day / night
- Major traffic movement is seen in between 11 AM – 1 PM and in the evening time it is seen in between 6pm – 8 pm.

4.4.5 Daily Variation of Traffic



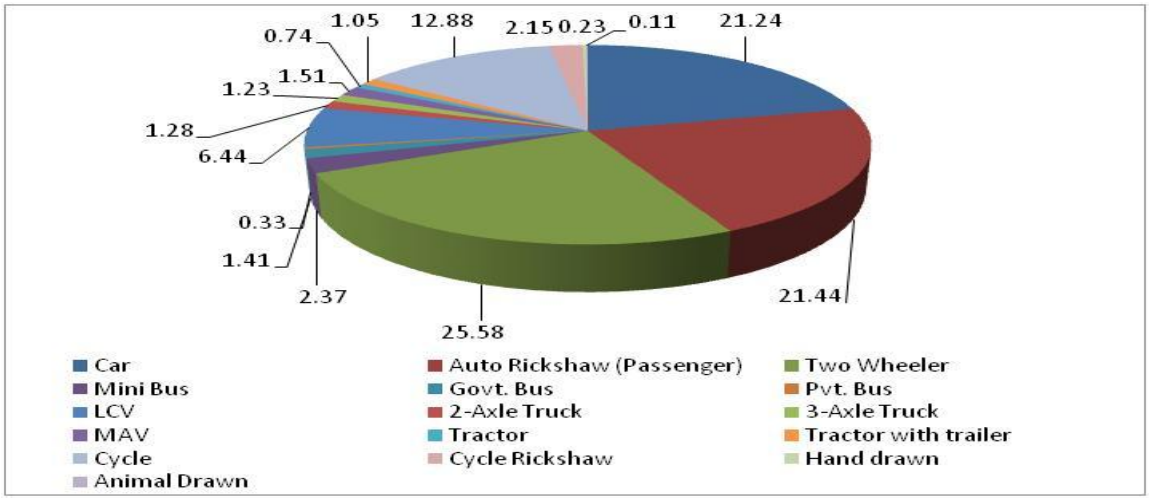




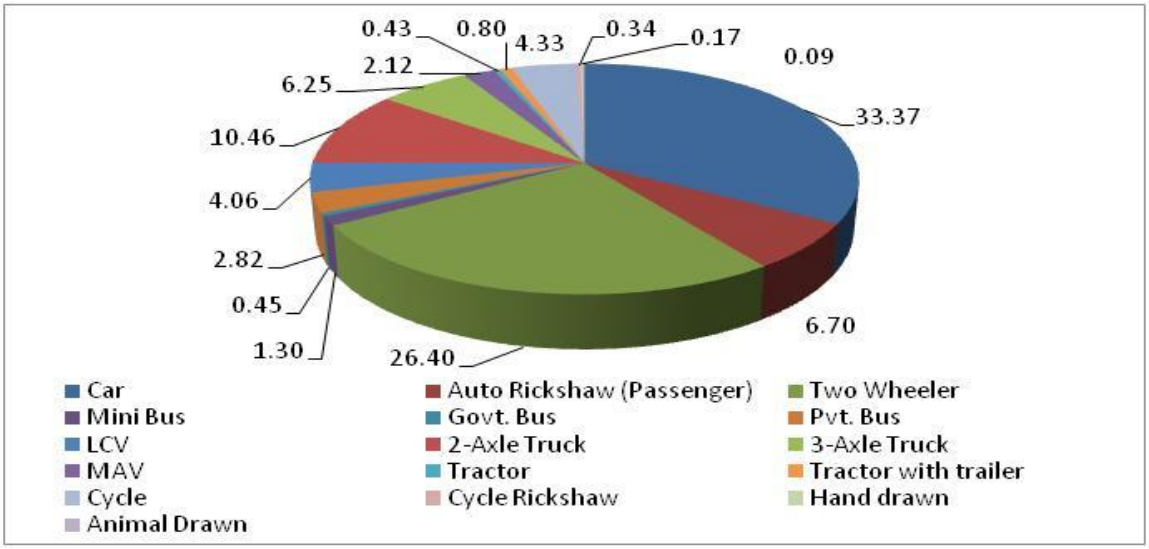
- It is observed that holidays attract less traffic in compare with the normal working days.

4.4.6 Vehicle Composition

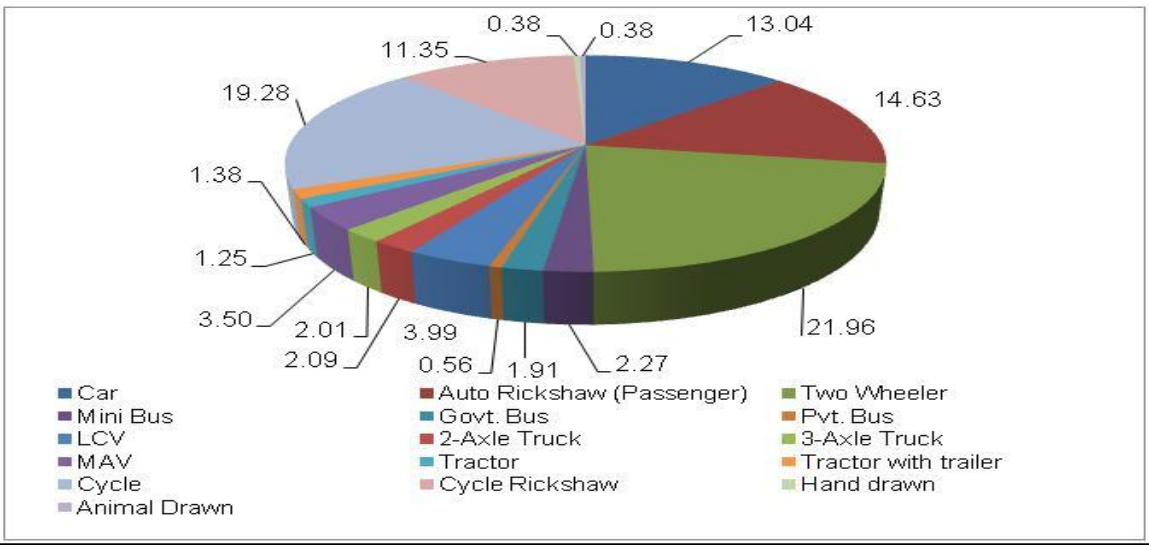
AT GOLA



AT JENA MORE

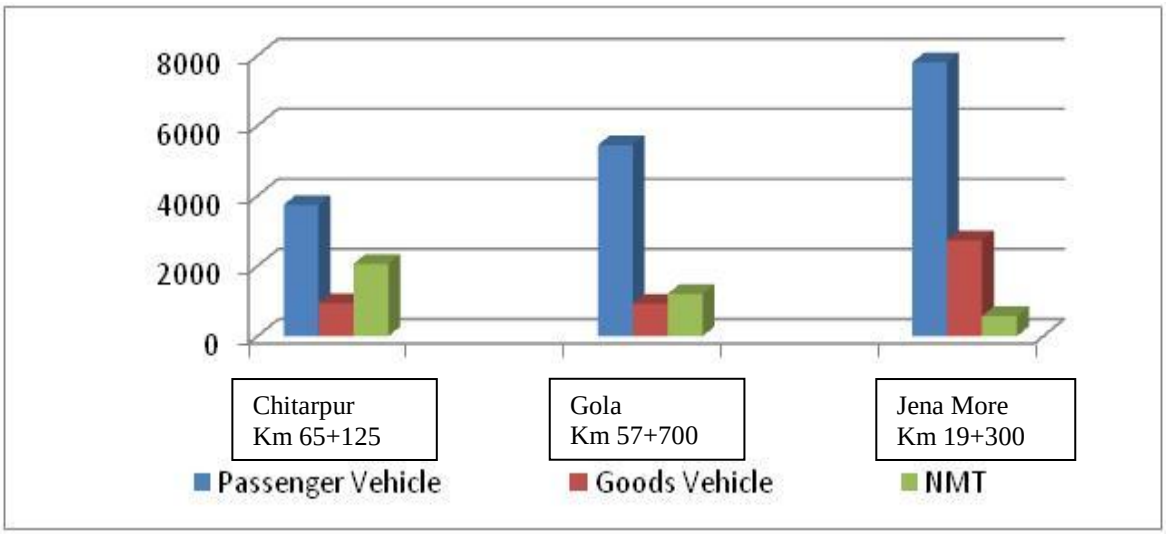


AT CHITARPUR



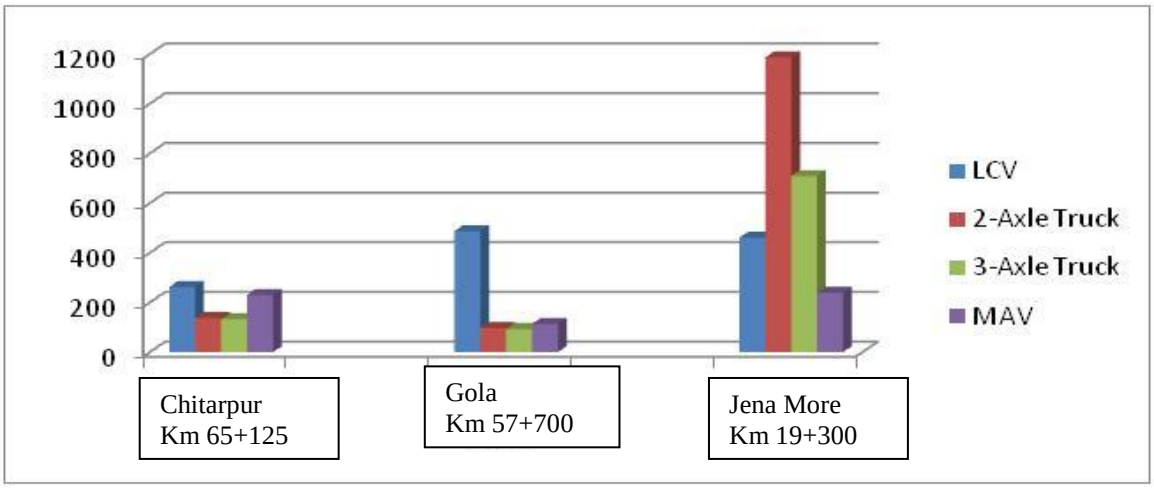
- It is observed that 2 Wheeler share the major percentage about 25% of the total traffic and it is followed by Cars (about 22%)
- About 16% traffic is the truck traffic moves along the corridor
- At Tetratoli considerable movement of slow moving traffic it is observed (about 31%)
- About 21% of 3 wheeler movement is observed at Mael and is followed by about 14% 3 Wheeler movements at Tetratoli. But at Jena more area the 3w movement is less (about 6%)
- Bus traffic comprises only 4% traffic on the project corridor

4.4.7 Mode Wise Traffic Movement Comparison



- It is observed that passenger vehicles share the major portion of traffic movement all along the project road. Near Jena More its contribution is highest and in Tetratoli it is lowest
- In Tetratoli and in Mael Goods vehicle movement is almost same but near Jena more it is high in compare with rhe other locations
- In Tetratoli area Non motorised traffic (NMT) is highest while it is lowest near Jena More

4.4.8 Location-wise Truck Traffic Classification



- It is observed that in Tetratoli location all goods vehicles have almost same share
- Near Mael LCV shares the highest percentage
- Near Jena more 2 Axle truck shares the highest percentage and is followed by 3 Axle truck and MAV

4.5 ANALYSIS OF ORIGIN-DESTINATION (OD) SURVEY DATA

4.5.1 Survey Conduct

In order to understand the travel pattern on the corridor, Origin and Destination (O-D) Surveys were carried out at 2 locations on the project road. The O-D survey was carried out on a weekday, over a full 24 hours, by the roadside interview method as described in IRC: 102-1988. Police assistance was arranged for the successful carrying out of this survey. Passenger vehicles were stopped on a random sampling basis and interviewed. Public transport vehicles (Mini-Buses and Buses) were not interviewed directly but their OD pairs were noted by visual examination of their display plates.

Trained enumerators under the supervision of transport planners collected the trip characteristics using the survey forms designed for this purpose. The information collected during roadside interviews was analysed to obtain the trip distribution based on a zoning system suitably designed for the study. The collected sample is expanded to average daily traffic by vehicle type at different survey locations to get expanded OD matrices.

4.5.2 Zoning System

For analysis of O-D data and preparation of trip tables for studying the regional interaction, a zoning system was developed. The zoning system took into consideration the project influence area and trip generating and attraction points. In all, a 17 zone system was developed. The list of traffic zones is presented below in **Table-4.5.**

Table-4.5: Zoning System

Zone No	Zone
1	Ramgarh
2	Hazaribagh
3	Gola
4	Dhanbad,Petawar
5	Sonupurs
6	North of Jharkhand
7	south of Jharkhand
8	East of Jharkhand
9	West of Jharkhand
10	North of India
11	South of India
12	East of India

Zone No	Zone
13	West of India
14	Ranchi
15	Bokaro
16	Chas
17	Jena

4.5.3 O-D Matrix for Jena More Location (Km 19+300)

O-D Matrix for Car

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	5	25	0	0	2	0	2	15	0	2	0	2	81	22	5
2	0	0	0	10	0	0	0	0	2	2	0	0	0	0	76	34	0
3	2	0	0	0	0	0	0	0	0	0	0	5	0	0	7	10	0
4	37	12	12	0	0	2	2	0	10	2	0	0	0	116	89	74	17
5	0	0	0	2	0	0	0	0	0	0	0	0	0	2	2	0	0
6	7	2	5	2	0	0	0	0	0	0	0	0	0	2	0	0	5
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	2	0	0	0	0	0	0	0	2	0	0	10	0	0	0
9	2	0	0	2	0	0	0	0	0	0	0	0	0	7	2	0	0
10	2	0	2	5	0	0	0	0	0	0	0	0	0	0	15	12	2
11	0	0	0	2	0	0	0	0	0	0	0	0	0	5	0	0	0
12	7	5	0	10	0	0	0	0	2	0	0	0	0	5	7	0	5
13	5	0	0	5	0	0	0	0	0	0	2	0	0	0	84	25	0
14	5	0	2	64	0	5	0	10	7	0	2	2	0	0	128	52	0
15	150	150	111	125	0	0	0	17	12	12	15	0	7	189	0	12	192
16	42	30	32	22	0	2	0	0	2	0	10	0	0	47	10	0	113
17	5	0	2	30	0	5	0	0	2	5	0	2	0	0	155	204	0

O-D Matrix for Bus

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	0	2	0	0	0	0	0	0	0	2	0	0	11	5	0
2	0	0	2	2	0	0	0	0	0	0	0	0	0	0	11	2	0
3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0
4	3	0	0	0	0	0	0	0	0	0	2	0	0	57	10	3	2
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	8	0	0	0	0	0	0	0	0	0	0	0	2	5	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	8	2	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0
11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	2	0	2	3	0	0	0	0	0	0	0	0	0	5	2	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	10	0	2	44	0	2	0	5	5	2	0	5	0	0	41	2	0
15	34	10	2	5	0	2	0	0	6	3	3	0	5	34	0	0	5
16	0	2	0	2	0	0	0	0	0	0	2	0	0	0	2	0	0
17	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5	8	0

O-D Matrix for Goods Vehicle

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	4	10	26	2	8	0	2	4	12	0	6	0	0	93	20	4
2	0	0	0	10	2	2	0	0	0	2	0	0	0	0	44	18	0
3	2	0	0	8	0	2	2	0	2	2	0	2	0	4	12	2	2
4	40	22	40	0	0	16	0	8	18	10	2	8	2	140	24	49	8
5	4	0	2	2	0	0	0	0	0	0	0	0	0	2	6	2	10
6	8	0	6	10	0	0	0	0	0	0	0	0	0	8	0	0	2
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	6	2	4	0	0	0	0	0	0	0	0	0	0	6	0	0	0
9	2	0	0	2	0	4	0	0	0	0	0	0	0	2	2	4	0
10	2	2	2	6	0	18	0	2	18	0	0	18	0	6	49	18	2
11	0	0	0	2	0	0	0	2	0	0	0	2	0	2	4	2	0
12	24	2	10	8	0	0	0	0	2	0	0	0	0	8	10	0	2
13	10	0	0	10	2	0	0	0	4	2	0	10	0	2	24	22	0
14	42	12	67	0	0	12	12	0	2	4	0	2	0	0	89	28	0
15	59	32	67	24	0	2	0	6	12	14	2	2	2	91	0	6	61
16	28	42	101	0	0	0	0	0	0	0	0	0	0	28	4	0	51
17	4	0	0	12	0	2	0	0	2	0	0	0	0	0	65	24	0

- Major car movement is seen between Ramgarh – Bokaro, Hazaribagh _ Bokaro, Ranchi – Bokaro, Dhanbad – Bokaro, Bokaro – Gola, Chas – Jena and in Ranchi – Chas section. In between Jena and Bokaro there exist around 11% of passenger car traffic
- Major bus movement is seen between Zone 14 (Ranchi) – Zone 4 (Dhanbad) (About 25% of total traffic), in between Zone 15(Bokaro) – Zone 14 (Ranchi)(About 18% of total traffic) and in between Ramgarh – Bokaro (about 11% of total traffic)
- Major truck movement zone is in between Ramgarh – Bokaro, Ranchi – Bokaro and in between Dhanbad – Ranchi. It is also observed that around 6% of truck traffic moves in between Jena and Bokaro.

4.5.4 O-D matrix for ChitarpurLocation (Km 65+125)

O-D Matrix for Car

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	176	25	0	17	4	15	42	0	0	0	0	4	86	4	0
2	0	0	17	4	0	2	0	4	17	0	0	0	0	0	19	0	0
3	119	8	0	13	0	0	4	2	2	0	0	0	6	46	8	0	0
4	27	0	4	0	0	0	2	2	2	0	0	0	0	29	0	0	0
5	0	0	6	0	0	2	2	2	2	0	0	0	0	0	0	0	0
6	0	0	6	8	0	0	0	0	4	0	0	0	0	8	0	0	0
7	6	0	2	4	0	0	0	2	0	0	0	0	0	0	2	2	0
8	0	4	4	0	0	0	0	0	0	0	0	0	0	0	8	0	0
9	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	4	0	2	0	0	0	4	2	0	0	0	0	0	4	4	0	0
13	163	10	2	10	0	0	6	10	0	0	0	4	0	119	15	0	0
14	0	0	29	33	0	8	0	21	42	4	0	0	2	0	65	4	0
15	69	23	10	6	0	0	2	0	6	0	0	0	8	98	0	0	0
16	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

O-D Matrix for Bus

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	14	9	0	0	2	5	12	2	0	0	0	0	31	0	0
2	0	0	2	2	0	2	0	0	0	0	0	0	0	0	9	0	0
3	7	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
4	5	0	0	0	0	0	0	0	0	0	0	0	2	26	3	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	2	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0
13	9	0	0	0	0	0	0	2	0	0	0	0	0	12	3	0	0
14	2	0	5	31	0	5	0	3	9	0	0	0	2	0	26	2	0
15	19	5	0	2	0	0	0	0	0	0	0	2	0	17	0	0	0
16	0	0	0	2	0	0	0	0	2	0	0	0	0	0	2	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

O-D Matrix for Goods Vehicle

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	75	11	1	8	3	13	23	0	0	2	3	1	40	0	0
2	0	0	2	2	0	0	0	3	4	0	0	0	0	0	9	0	0
3	72	3	0	1	0	0	2	0	0	0	0	0	4	21	3	0	0
4	23	7	1	0	0	0	1	1	1	0	0	1	3	21	0	0	0
5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	2	0	3	0	0	0	0	3	6	0	0	0	0	0	3	0	0
7	2	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0
8	1	2	3	1	0	0	0	0	1	17	0	0	0	0	4	0	0
9	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	2	0	2	0	0	0	0	1	1	0	0	0	1	2	4	1	0
13	104	8	0	0	0	0	2	3	1	0	0	0	4	31	2	0	0
14	0	0	17	22	0	3	0	2	22	0	1	0	2	0	41	0	0
15	31	3	2	0	0	0	0	1	6	0	0	0	3	19	2	0	0
16	2	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Observations

- Major car movement zone is in between Gola – Ramgarh, Bokaro – Ramgarh, Dhanbad - Ramgarh
- Major bus movement is seen between Zone 14 (Ranchi) – Zone 4 (Dhanbad) (About 18% of total traffic) and in between Zone 15(Bokaro) – Zone 14 (Ranchi)(About 14% of total traffic). Other important zonal movement is seen in between Dhanbad – Ramgarh, Bokaro – Ramgarh and in between Bokaro - Hazaribagh
- Major truck movement zone is in between Zone 1(Ramgarh) and 3 (Gola) (about 18%). Other important zonal movement is seen in between Dhanbad – Ramgarh ,Bokaro-Ramgarh.

4.6 ANALYSIS OF AXLE LOAD SURVEY DATA

Axle load survey data has been analysed to find out the VDF for the project corridor and the VDF of different mode of vehicles are given in **Table-4.6.**

Table-4.6: Analysis of Axle Load Survey Data

Vehicle	VDF
Bus	0.32
LCV	0.15
2Axle truck	3.36
3 Axle truck	2.78
Multi Axle truck	5.84

4.7 TRAFFIC HOMOGENEOUS SECTIONS

After careful study of the traffic pattern on the project corridor, it has been divided into three traffic homogeneous sections.

- Section 1: From km 0+000 (Chas) to km 19+300 (Jena More)
- Section 2: From km 19+300 (Jena More) to km 57+700 (Gola)
- Section 3 From km 57+700 (Gola) to km 65+125 (Chitarpur)

4.8 TRAFFIC PROJECTIONS

4.8.1 Background

Traffic growth rates for the study, to be used subsequently for forecasting traffic on the project road, have been estimated by adopting the "Elasticity of Transport Demand" method which is a proven technique worldwide and is the preferred technique in India. The Elasticity Method relates traffic growth to changes in the related economic parameters. This method studies in an appropriate perspective, the changes in observed past traffic volumes in the context of changes in relevant economic indicators in the Project Influence Area (PIA), to which it was closely related in the past. Such parameters include Gross State Domestic Product (GSDP), Net State Domestic product (NSDP), population, per capita income, income accruing to the major sectors of the economy, etc. This method takes into account not only the past growth of the major economic indicators but also the future perspective.

4.8.2 Project Influence Area (PIA)

Outlining the project influence area is essential for the estimation of traffic growth rates; because the socio-economic indicators of the project influence area influence the traffic growth on the project road. The project influence area has been assessed based on the O-D data. The project road entirely lies in the state of Jharkhand. Therefore Economic indicators of Jharkhand have been studied for subsequent elasticity calculations for the determination of the growth rate of the project road.

4.8.3 Traffic Flow Pattern

The results of OD surveys show different traffic shares of passenger and freight vehicles on the project road.

4.8.4 Vehicle Registration

The vehicle registration data was collected from Economic and Statistical organisation, Jharkhand, RBI data sheet, Central Statistical organisation, New Delhi and from other government offices of the state.

From the data collected the annual growth rates are worked out and presented in ***Table-4.7.*** There is an increasing trend in the growth rates.

Table-4.7: Avg. Annual Growth Rate of Reg. Veh. in Jharkhand (2001-2006)

YEAR	CAR	2- WHEELER	BUSES	GOODS
2001	129762	703142	6399	42794
2002	140468	761157	6927	46325
2003	157170	851660	7750	51833
2004	173729	941390	8567	57294
2005	192962	1049303	9878	65662
2006	215719	1164854	10238	68915

4.8.5 Trend in Economy

The growth of various economic parameters of the PIA state is presented in ***Table-4.8***.

Table-4.8: Trend in Economy

Year	Jharkhand			
	PCI	GSDP	NSDP	Population
1999-2005	5.35	9.87	7.18	2.36

The next stage is to project the economic indicators for the desired period. Net State Domestic Product has been projected on the basis of past trend and future policies.

4.8.6 Transport Demand Elasticity

4.8.6.1 Past Values

As stated earlier, the Consultants used the elasticity approach for determining growth rates of future traffic. A database was compiled on the basis of time series data of vehicles, PCI and the NSDP of PIA States for the period 2001 to 2005. A regression analysis was carried out on the database to arrive at the transport demand elasticity for the PIA states with respect to economic indicators of the same state is given in ***Table-4.9.***

Table-4.9: Regression Analysis Results for Jharkhand

Category of Vehicles	Transport Elasticity	R^2
Car	1.44	0.906
Bus	4.673	0.990
2 Wheeler	1.456	0.904
Truck	1.26	0.92

The elasticity values shown in the above tables reflect a substantial co-relation between economic indicators and traffic growth rates as reflected in their R2 (The statistic R2 also known as the coefficient of determination, measures the proportion of variation in the dependent variable that is explained by the variation in the independent variable). Hence, it may be appropriate to consider the growth pattern that has emerged out of the economic model which related the economic growth with the growth in registration of vehicles.

4.8.7 Traffic Growth Rates

The traffic growth factors for each mode in the PIA states are averaged to derive a common growth factor for the project corridor. Based on the moderated perspective elasticity values and the growth rates of projected state income of PIA states, the future average annual compound traffic growth rates by vehicle type have been estimated by using the following relationship:

Tgr = (Economic gr) x E

Where,

Tgr – Traffic growth rate for mode
Eco.gr – growth rate of Respective economic parameter
E – Elasticity value for mode

The traffic growth rates for different modes of vehicles are presented in the ***Table-4.10.***

Table-4.10: Estimated Traffic Growth Rates for Project Highway (%)

Year	Car	2W	Bus	Truck
2010-2015	8.06	8.11	10.93	9.53
2015 - 2020	5.91	5.95	9.34	7.31
2020 - 2025	4.97	5.0	7.99	6.32
2025 - 2030	4.19	4.21	6.83	5.47
Beyond 2030	3.57	3.59	5.84	4.75

But as per directions of NHAI a uniform 5% growth rate is considered for all types of vehicles for the purposes of traffic projections.

4.8.8 Traffic Projection

- **Traffic Projection at Km 19+300 (Jena More)**

Traffic Projections: Jena More (At Km. 19+300)																		
No of Years	Years	TYPE OF VEHICLES																Growth Rate 5% TOTAL
		Car, Jeep& van	2-Wheeler	3-Wheeler	Minibus	Govt. Bus	Pvt. Bus	Light Commercial Vehicle	2-axle Truck	3-axle Turck	MAV (upto 6 axles)	Tractors		Cycles	Cycle Ricks-haw	Hand Drawn	Animal Drawn	In Numbers
												Without Trailer	With Trailer					
	2012	3462	3068	650	181	11	293	564	786	515	275	13	72	633	70	0	0	10593
	2013	3635	3222	682	190	12	308	592	825	541	288	14	76	665	73	0	0	11123
	2014	3816	3383	717	200	12	323	622	867	568	303	14	79	698	77	0	0	11679
1	2015	4007	3552	752	210	13	339	653	910	596	318	15	83	733	81	0	0	12263
2	2016	4208	3729	790	220	13	356	686	955	626	334	16	88	770	85	0	0	12876
3	2017	4418	3916	830	231	14	374	720	1003	658	351	17	92	808	89	0	0	13520
4	2018	4639	4112	871	243	15	393	756	1053	690	368	17	96	849	93	0	0	14196
5	2019	4871	4317	915	255	16	412	794	1106	725	386	18	101	891	98	0	0	14905
6	2020	5114	4533	960	268	16	433	834	1161	761	406	19	106	936	103	0	0	15651
7	2021	5370	4760	1008	281	17	455	875	1219	799	426	20	112	982	108	0	0	16433
8	2022	5639	4998	1059	295	18	477	919	1280	839	447	21	117	1032	113	0	0	17255
9	2023	5920	5247	1112	310	19	501	965	1344	881	470	22	123	1083	119	0	0	18118
10	2024	6216	5510	1167	325	20	526	1013	1412	925	493	23	129	1137	125	0	0	19023
11	2025	6527	5785	1226	342	21	553	1064	1482	972	518	25	136	1194	131	0	0	19975
12	2026	6854	6075	1287	359	22	580	1117	1556	1020	544	26	143	1254	138	0	0	20973
13	2027	7196	6378	1351	377	23	609	1173	1634	1071	571	27	150	1317	145	0	0	22022
14	2028	7556	6697	1419	396	24	640	1231	1716	1125	600	28	157	1382	152	0	0	23123
15	2029	7934	7032	1490	415	25	672	1293	1802	1181	630	30	165	1452	159	0	0	24279
16	2030	8331	7384	1564	436	27	705	1358	1892	1240	661	31	173	1524	167	0	0	25493
17	2031	8747	7753	1642	458	28	741	1426	1986	1302	694	33	182	1600	176	0	0	26768
18	2032	9185	8141	1725	481	29	778	1497	2085	1367	729	35	191	1680	185	0	0	28106
19	2033	9644	8548	1811	505	31	817	1572	2190	1435	765	36	201	1764	194	0	0	29512
20	2034	10126	8975	1901	530	32	857	1650	2299	1507	803	38	211	1853	204	0	0	30987
21	2035	10632	9424	1996	557	34	900	1733	2414	1583	844	40	221	1945	214	0	0	32537
22	2036	11164	9895	2096	584	36	945	1819	2535	1662	886	42	232	2042	224	0	0	34163
23	2037	11722	10390	2201	614	38	993	1910	2662	1745	930	44	244	2145	236	0	0	35872
24	2038	12308	10909	2311	644	39	1042	2006	2795	1832	977	46	256	2252	247	0	0	37665
25	2039	12924	11455	2427	677	41	1094	2106	2934	1924	1025	49	269	2364	260	0	0	39548
26	2040	13570	12027	2548	710	44	1149	2212	3081	2020	1077	51	282	2483	273	0	0	41526
27	2041	14248	12629	2675	746	46	1206	2322	3235	2121	1130	54	296	2607	286	0	0	43602
28	2042	14961	13260	2809	783	48	1267	2438	3397	2227	1187	56	311	2737	301	0	0	45782
29	2043	15709	13923	2949	822	50	1330	2560	3567	2338	1246	59	327	2874	316	0	0	48071
30	2044	16494	14619	3097	863	53	1397	2688	3745	2455	1309	62	343	3018	332	0	0	50475
31	2045	17319	15350	3252	907	56	1466	2823	3933	2578	1374	65	360	3168	348	0	0	52999

Traffic Projections:Gola (At Km 57+700)

No of Years	Years	TYPE OF VEHICLES																Growth Rate 5% TOTAL
		Car, Jeep& van	2-Wheeler	3-Wheeler	Minibus	Govt. Bus	Pvt. Bus	Light Commercial Vehicle	2-axle Truck	3-axle Turck	MAV (upto 6 axles)	Tractors		Cycles	Cycle Ricks-haw	Hand Drawn	Animal Drawn	In Numbers
												Without Trailer	With Trailer					
	2012	2395	5329	576	214	3	232	466	399	313	156	2	20	160	33	0	0	10297
	2013	2515	5595	605	224	3	244	489	419	328	163	3	21	168	35	0	0	10812
	2014	2641	5875	635	236	3	256	514	440	345	172	3	22	176	37	0	0	11353
1	2015	2773	6169	667	247	3	269	540	462	362	180	3	23	185	39	0	0	11921
2	2016	2911	6477	700	260	3	282	566	486	380	189	3	24	194	40	0	0	12517
3	2017	3057	6801	735	273	4	296	595	510	399	199	3	25	204	42	0	0	13142
4	2018	3210	7141	772	286	4	311	625	535	419	209	3	26	214	45	0	0	13800
5	2019	3370	7498	810	301	4	327	656	562	440	219	3	28	225	47	0	0	14490
6	2020	3539	7873	851	316	4	343	689	590	462	230	4	29	236	49	0	0	15214
7	2021	3716	8266	893	332	4	360	723	620	485	242	4	30	248	52	0	0	15975
8	2022	3902	8680	938	348	5	378	759	651	509	254	4	32	260	54	0	0	16773
9	2023	4097	9114	985	366	5	397	797	683	535	266	4	34	273	57	0	0	17612
10	2024	4301	9569	1034	384	5	417	837	717	561	280	4	35	287	60	0	0	18493
11	2025	4517	10048	1086	403	5	438	879	753	589	294	5	37	301	63	0	0	19417
12	2026	4742	10550	1140	423	6	460	923	791	619	308	5	39	317	66	0	0	20388
13	2027	4979	11078	1197	444	6	483	969	830	650	324	5	41	332	69	0	0	21408
14	2028	5228	11632	1257	467	6	507	1017	872	682	340	5	43	349	73	0	0	22478
15	2029	5490	12213	1320	490	7	532	1068	916	716	357	6	45	366	76	0	0	23602
16	2030	5764	12824	1386	514	7	559	1122	961	752	375	6	47	385	80	0	0	24782
17	2031	6053	13465	1455	540	7	587	1178	1009	790	393	6	50	404	84	0	0	26021
18	2032	6355	14138	1528	567	8	616	1237	1060	829	413	6	52	424	88	0	0	27322
19	2033	6673	14845	1604	595	8	647	1298	1113	871	434	7	55	445	93	0	0	28688
20	2034	7007	15588	1685	625	8	679	1363	1168	914	455	7	57	468	97	0	0	30123
21	2035	7357	16367	1769	657	9	713	1431	1227	960	478	7	60	491	102	0	0	31629
22	2036	7725	17185	1857	689	9	749	1503	1288	1008	502	8	63	516	107	0	0	33210
23	2037	8111	18045	1950	724	10	786	1578	1353	1059	527	8	67	541	113	0	0	34871
24	2038	8517	18947	2048	760	10	826	1657	1420	1112	554	9	70	568	118	0	0	36614
25	2039	8942	19894	2150	798	11	867	1740	1491	1167	581	9	73	597	124	0	0	38445
26	2040	9389	20889	2257	838	11	910	1827	1566	1225	610	9	77	627	130	0	0	40367
27	2041	9859	21933	2370	880	12	956	1918	1644	1287	641	10	81	658	137	0	0	42386
28	2042	10352	23030	2489	924	12	1004	2014	1726	1351	673	10	85	691	144	0	0	44505
29	2043	10870	24181	2613	970	13	1054	2115	1813	1419	707	11	89	725	151	0	0	46730
30	2044	11413	25390	2744	1019	14	1106	2221	1903	1490	742	11	94	762	159	0	0	49067
31	2045	11984	26660	2881	1069	14	1162	2332	1999	1564	779	12	98	800	167	0	0	51520

Traffic Projections: Chitarpur (At Km 65+125)

No of Years	Years	TYPE OF VEHICLES																Growth Rate 5%
		Car, Jeep& van	2-Wheeler	3-Wheeler	Minibus	Govt. Bus	Pvt. Bus	Light Commercial Vehicle	2-axle Truck	3-axle Turck	MAV (upto 6 axles)	Tractors		Cycles	Cycle Ricks-haw	Hand Drawn	Animal Drawn	TOTAL
												Without Trailer	With Trailer					In Numbers
	2012	1922	1414	3168	269	51	219	462	116	104	127	49	34	960	167	0	0	9063
	2013	2018	1485	3326	283	53	230	485	122	109	134	52	35	1008	176	0	0	9516
	2014	2119	1559	3493	297	56	242	509	128	115	140	54	37	1059	184	0	0	9992
1	2015	2225	1637	3667	312	59	254	535	134	121	147	57	39	1111	193	0	0	10492
2	2016	2336	1719	3851	327	61	267	561	141	127	155	60	41	1167	203	0	0	11016
3	2017	2453	1805	4043	343	65	280	589	148	133	163	63	43	1225	213	0	0	11567
4	2018	2576	1895	4245	361	68	294	619	155	140	171	66	45	1287	224	0	0	12146
5	2019	2705	1990	4458	379	71	309	650	163	146	179	69	47	1351	235	0	0	12753
6	2020	2840	2090	4681	398	75	324	682	171	154	188	73	50	1419	247	0	0	13390
7	2021	2982	2194	4915	417	78	340	716	180	161	198	77	52	1489	259	0	0	14060
8	2022	3131	2304	5160	438	82	357	752	189	170	207	80	55	1564	272	0	0	14763
9	2023	3287	2419	5418	460	86	375	790	198	178	218	84	58	1642	286	0	0	15501
10	2024	3452	2540	5689	483	91	394	829	208	187	229	89	61	1724	300	0	0	16276
11	2025	3624	2667	5974	507	95	414	871	219	196	240	93	64	1810	315	0	0	17090
12	2026	3806	2800	6272	533	100	434	914	230	206	252	98	67	1901	331	0	0	17944
13	2027	3996	2940	6586	559	105	456	960	241	216	265	103	70	1996	347	0	0	18842
14	2028	4196	3087	6915	587	110	479	1008	253	227	278	108	74	2096	365	0	0	19784
15	2029	4405	3242	7261	617	116	503	1059	266	239	292	113	77	2201	383	0	0	20773
16	2030	4626	3404	7624	648	122	528	1111	279	251	306	119	81	2311	402	0	0	21812
17	2031	4857	3574	8005	680	128	555	1167	293	263	322	125	85	2426	422	0	0	22902
18	2032	5100	3753	8406	714	134	582	1225	308	276	338	131	90	2548	443	0	0	24047
19	2033	5355	3940	8826	750	141	611	1287	323	290	355	137	94	2675	466	0	0	25250
20	2034	5623	4137	9267	787	148	642	1351	339	305	373	144	99	2809	489	0	0	26512
21	2035	5904	4344	9731	827	155	674	1419	356	320	391	152	104	2949	513	0	0	27838
22	2036	6199	4561	10217	868	163	708	1490	374	336	411	159	109	3097	539	0	0	29230
23	2037	6509	4789	10728	911	171	743	1564	393	353	431	167	114	3251	566	0	0	30691
24	2038	6834	5029	11264	957	180	780	1642	412	370	453	175	120	3414	594	0	0	32226
25	2039	7176	5280	11828	1005	189	819	1724	433	389	475	184	126	3585	624	0	0	33837
26	2040	7535	5544	12419	1055	198	860	1811	455	408	499	193	132	3764	655	0	0	35529
27	2041	7912	5822	13040	1108	208	903	1901	477	428	524	203	139	3952	688	0	0	37305
28	2042	8307	6113	13692	1163	218	948	1996	501	450	550	213	146	4150	722	0	0	39171
29	2043	8723	6418	14377	1221	229	996	2096	526	472	578	224	153	4357	759	0	0	41129
30	2044	9159	6739	15095	1282	241	1046	2201	552	496	607	235	161	4575	796	0	0	43186
31	2045	9617	7076	15850	1346	253	1098	2311	580	521	637	247	169	4804	836	0	0	45345

4.9 CAPACITY ANALYSIS

As per 2 lane manual of ministry the design service volume of the arterial road is 18000 PCU per day at LOS B which can be further increased by 40% (i.e..25200 PCU / day) in LOS C. LOS C is also a stable flow. The table below shows the year wise capacity analysis for the different section of the road. It is understood that section 1 warrants 4 lane after year 2025 and the other 2 section warrants 2 lane with paved shoulder for over 20 years period

Capacity Analysis for NH-23					
Section	**Start km**	**End km**	**Start Year**	**End year**	**Remarks**
Section 1	0+000	19+300	**Base year PCU 12954**		
			2013	2014	**Construction Period**
			2015	2018	2 lane with LOS B (PCU 17359)
			2019	2024	2 lane with LOS C (PCU 23263)
			After 2025 LOS C capacity exceeds		
Section 2	19+300	57+700	**Base year PCU 9929**		
			2013	2014	**Construction Period**
			2015	2024	2 lane with LOS B (PCU 17831)
			2025	2030	2 lane with LOS C(PCU 23895)
Section 3	57+700	65+125	**Base year PCU 8759**		
			2013	2014	**Construction Period**
			2014	2031	2 lane with LOS B (PCU 18045)

JENA MORE

Location: Km:19.300													Direction: To Ramgarh to Jena More						
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	1,066	277	1,441	62	9	55	239	448	354	98	19	59	274	57	-	-	4,458	6,071
Day 2: Thursday	12.04.2012	1,517	233	1,364	80	2	69	249	537	304	111	9	32	305	65	-	-	4,877	6,569
Day 3: Friday	13.04.2012	1,595	335	1,458	87	9	109	251	450	235	156	13	19	326	46	-	-	5,089	6,614
Day 4: Saturday	14.04.2012	1,786	221	1,606	97	4	107	328	338	257	109	10	62	103	8	-	-	5,036	6,414
Day 5: Sunday	15.04.2012	1,749	342	1,482	57	7	69	278	344	165	78	6	18	569	19	-	-	5,183	5,844
Day 6: Monday	16.04.2012	1,812	412	1,579	81	16	254	301	258	170	126	14	22	370	10	-	-	5,425	6,568
Day 7: Tuesday	17.04.2012	1,765	214	1,302	155	11	324	286	328	270	111	9	10	338	83	-	-	5,206	6,942
	ADT	**1,613**	**291**	**1,462**	**88**	**4**	**141**	**276**	**386**	**251**	**113**	**5**	**30**	**326**	**41**	**-**	**-**	**5,027**	**6,400**

Location: Km:19.300													Direction: To Jena More To Ramgarh						
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	1,524	313	1,437	60	15	81	149	431	313	182	6	48	153	65	-	-	4,777	6,607
Day 2: Thursday	12.04.2012	1,510	301	1,442	84	10	100	233	430	307	126	13	63	232	20	-	-	4,871	6,565
Day 3: Friday	13.04.2012	1,600	365	1,538	68	9	89	268	381	220	130	13	32	385	61	-	-	5,159	6,368
Day 4: Saturday	14.04.2012	1,844	188	1,397	89	13	89	322	351	200	118	6	84	236	14	-	-	4,951	6,363
Day 5: Sunday	15.04.2012	1,787	473	1,503	93	12	86	257	301	205	126	15	14	445	13	-	-	5,330	6,243
Day 6: Monday	16.04.2012	1,872	392	1,430	103	8	279	351	328	193	127	11	26	336	5	-	-	5,461	6,965
Day 7: Tuesday	17.04.2012	1,650	267	1,475	92	7	243	249	315	242	233	9	12	361	27	-	-	5,182	6,924
	ADT	**1,684**	**328**	**1,460**	**84**	**7**	**138**	**261**	**362**	**240**	**149**	**7**	**39**	**307**	**29**	**-**	**-**	**5,095**	**6,554**

Location: Km:19.300							Direction:Ramgarh to Jena More & Jena More to Ramgarh
Day	Date	Passenger Vehicles	Public Transport	Commercial Vehicles	Agri. Tractors	Slow Moving Veh.	Total

		Vehicles																	
		Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	2,590	590	2,878	122	24	136	388	879	667	280	25	107	427	122	-	-	9,235	12,678
Day 2: Thursday	12.04.2012	3,027	534	2,806	164	12	169	482	967	611	237	22	95	537	85	-	-	9,748	13,133
Day 3: Friday	13.04.2012	3,195	700	2,996	155	18	198	519	831	455	286	26	51	711	107	-	-	10,248	12,982
Day 4: Saturday	14.04.2012	3,630	409	3,003	186	17	196	650	689	457	227	16	146	339	22	-	-	9,987	12,777
Day 5: Sunday	15.04.2012	3,536	815	2,985	150	19	155	535	645	370	204	21	32	1,014	32	-	-	10,513	12,087
Day 6: Monday	16.04.2012	3,684	804	3,009	184	24	533	652	586	363	253	25	48	706	15	-	-	10,886	13,532
Day 7: Tuesday	17.04.2012	3,415	481	2,777	247	18	567	535	643	512	344	18	22	699	110	-	-	10,388	13,866
	ADT	**3,297**	**619**	**2,922**	**173**	**11**	**279**	**537**	**749**	**491**	**262**	**12**	**69**	**633**	**70**	**-**	-	**10,122**	**12,954**
	AADT	**3,462**	**650**	**3,068**	**181**	**11**	**293**	**564**	**786**	**515**	**275**	**13**	**72**	**633**	**70**	**-**	-	**10,593**	**7,131**
	SCF	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.00**	**1.00**	**1.00**	**1.00**		
	% of Modes	32.68	6.14	28.96	1.71	0.10	2.77	5.33	7.42	4.86	2.59	0.12	0.68	5.98	0.66	10,593			

GolaRamgarh

Location: Km:57.700													Direction: To Ramgarh to Gola						
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	1,180	295	2,574	78	3	108	182	176	161	76	3	10	113	23	-	-	4,982	4,979
Day 2: Thursday	12.04.2012	1,275	290	2,296	100	2	164	280	152	92	67	4	15	110	24	-	-	4,871	4,979
Day 3: Friday	13.04.2012	1,299	240	2,484	93	4	79	234	172	186	112	6	8	74	18	-	-	5,009	5,208
Day 4: Saturday	14.04.2012	1,183	228	2,615	78	7	92	189	193	162	74	3	10	54	17	-	-	4,905	4,916
Day 5: Sunday	15.04.2012	1,065	409	2,657	79	7	110	222	202	127	69	6	19	68	15	-	-	5,055	5,054
Day 6: Monday	16.04.2012	941	237	2,891	143	5	114	246	221	131	68	9	12	43	30	-	-	5,091	5,060
Day 7: Tuesday	17.04.2012	1,236	184	2,336	112	-	104	233	200	150	78	9	10	109	44	-	-	4,805	4,998
	ADT	**1,168**	**269**	**2,550**	**98**	**2**	**110**	**227**	**188**	**144**	**78**	**2**	**10**	**81**	**22**	**-**	**-**	**4,949**	**5,003**

Location: Km:57.700													Direction: To Gola To Ramgarh						
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	1,037	392	2,344	76	1	114	222	202	127	69	6	19	110	26	-	2	4,747	4,891
Day 2: Thursday	12.04.2012	1,376	314	2,412	89	2	135	201	173	162	63	2	8	112	5	-	-	5,054	5,133
Day 3: Friday	13.04.2012	1,108	244	2,550	120	4	114	251	215	155	68	8	12	73	30	-	-	4,952	5,101
Day 4: Saturday	14.04.2012	1,051	437	2,621	132	4	139	200	173	161	62	2	8	77	10	-	-	5,077	5,099
Day 5: Sunday	15.04.2012	880	233	2,887	138	3	114	264	215	155	68	8	12	49	29	-	-	5,055	5,061
Day 6: Monday	16.04.2012	1,279	420	2,296	82	3	94	162	169	165	86	5	16	40	19	-	-	4,836	5,021
Day 7: Tuesday	17.04.2012	1,058	187	2,561	112	-	104	221	200	150	78	9	10	113	37	-	-	4,840	4,909
	ADT	**1,113**	**279**	**2,524**	**106**	**1**	**111**	**217**	**192**	**154**	**71**	**1**	**9**	**79**	**11**	**-**	**-**	**4,867**	**4,926**

Location: Km:57.700													Direction:Ramgarh to Gola&Gola to Ramgarh						
Day	Date	Passenger Vehicles			Public Transport			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	

		Vehicles																	
		Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	2,217	687	4,918	154	4	222	404	378	288	145	9	29	223	49	-	2	9,729	9,870
Day 2: Thursday	12.04.2012	2,651	604	4,708	189	4	299	481	325	254	130	6	23	222	29	-	-	9,925	10,112
Day 3: Friday	13.04.2012	2,407	484	5,034	213	8	193	485	387	341	180	14	20	147	48	-	-	9,961	10,309
Day 4: Saturday	14.04.2012	2,234	665	5,236	210	11	231	389	366	323	136	5	18	131	27	-	-	9,982	10,015
Day 5: Sunday	15.04.2012	1,945	642	5,544	217	10	224	486	417	282	137	14	31	117	44	-	-	10,110	10,114
Day 6: Monday	16.04.2012	2,220	657	5,187	225	8	208	408	390	296	154	14	28	83	49	-	-	9,927	10,081
Day 7: Tuesday	17.04.2012	2,294	371	4,897	224	-	208	454	400	300	156	18	20	222	81	-	-	9,645	9,906
	ADT	**2,281**	**548**	**5,075**	**204**	**3**	**221**	**444**	**380**	**298**	**148**	**2**	**19**	**160**	**33**	**-**	-	**9,816**	**9,929**
	AADT	**2,395**	**576**	**5,329**	**214**	**3**	**232**	**466**	**399**	**313**	**156**	**2**	**20**	**160**	**33**	**-**	-	**10,297**	**7,902**
	SCF	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.00**	**1.00**	**1.00**	**1.00**		
	% of Modes	23.26	5.59	51.75	2.08	0.03	2.25	4.53	3.88	3.04	1.51	0.02	0.19	1.55	0.32	10,297			

ChitarpurRamgarh

Location: Km:65.125													Direction: To Ramgarh to Chitarpur						
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	778	231	1,533	28	26	164	244	45	37	38	30	26	514	106	4	2	3,806	3,773
Day 2: Thursday	12.04.2012	658	284	1,388	357	1	176	188	30	35	44	21	32	791	52	14	11	4,071	4,135
Day 3: Friday	13.04.2012	828	294	1,937	75	5	197	46	41	28	128	2	41	270	17	-	-	3,909	4,009
Day 4: Saturday	14.04.2012	836	939	1,816	37	13	51	89	69	61	107	30	65	366	46	-	-	4,525	4,525
Day 5: Sunday	15.04.2012	933	1,038	1,236	43	67	79	54	67	47	48	23	36	501	60	-	-	4,232	4,268
Day 6: Monday	16.04.2012	1,074	966	1,205	49	32	50	221	61	41	37	19	18	504	147	-	-	4,424	4,348
Day 7: Tuesday	17.04.2012	1,034	1,033	1,326	36	71	43	263	45	42	42	27	19	442	40	-	-	4,463	4,378
	ADT	**877**	**684**	**1,492**	**89**	**30**	**107**	**158**	**51**	**42**	**63**	**20**	**32**	**484**	**67**	**-**	**-**	**4,195**	**4,167**

Location: Km:65.125													Direction: To Chitarpur To Ramgarh						
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	861	214	1,783	364	2	163	319	29	54	50	34	30	369	147	12	2	4,433	4,599
Day 2: Thursday	12.04.2012	934	365	1,719	382	5	121	434	41	61	49	18	-	588	65	12	3	4,834	4,926
Day 3: Friday	13.04.2012	856	230	1,818	127	2	69	110	82	61	83	6	-	308	12	-	-	3,820	3,799
Day 4: Saturday	14.04.2012	1,014	1,080	1,385	35	45	40	280	59	60	67	26	-	406	56	-	-	4,589	4,661
Day 5: Sunday	15.04.2012	921	974	1,044	36	33	43	360	95	49	55	19	-	634	88	-	-	4,368	4,473
Day 6: Monday	16.04.2012	1,000	955	1,655	183	28	181	62	56	73	49	60	-	460	165	-	-	4,939	5,006
Day 7: Tuesday	17.04.2012	1,087	826	1,275	42	22	98	409	56	45	52	29	-	568	169	-	-	4,711	4,854
	ADT	**953**	**663**	**1,526**	**167**	**18**	**102**	**282**	**60**	**58**	**58**	**27**	-	**476**	**100**	**-**	**-**	**4,520**	**4,591**

Location: Km:65.125														Direction:Ramgarh to Chitarpur&Chitarpur to Ramgarh					
		Passenger Vehicles			Public Transport Vehicles			Commercial Vehicles				Agri. Tractors		Slow Moving Veh.				Total	
Day	Date	Car	Auto Rickshaw (Passenger)	Two Wheeler	Mini Bus	Govt. Bus	Pvt. Bus	LCV	2-Axle Truck	3-Axle Truck	MAV	Tractor	Tractor with trailer	Cycle	Cycle Rickshaw	Hand drawn	Animal Drawn	Vehicles	PCUs
Day 1: Wednesday	11.04.2012	1,639	445	3,316	392	28	327	563	74	91	88	64	56	883	253	16	4	8,239	8,372
Day 2: Thursday	12.04.2012	1,592	649	3,107	739	6	297	622	71	96	93	39	32	1,379	117	26	14	8,905	9,061
Day 3: Friday	13.04.2012	1,684	524	3,755	202	7	266	156	123	89	211	8	41	578	29	-	-	7,729	7,808
Day 4: Saturday	14.04.2012	1,850	2,019	3,201	72	58	91	369	128	121	174	56	65	772	102	-	-	9,114	9,186
Day 5: Sunday	15.04.2012	1,854	2,012	2,280	79	100	122	414	162	96	103	42	36	1,135	148	-	-	8,600	8,740
Day 6: Monday	16.04.2012	2,074	1,921	2,860	232	60	231	283	117	114	86	79	18	964	312	-	-	9,363	9,354
Day 7: Tuesday	17.04.2012	2,121	1,859	2,601	78	93	141	672	101	87	94	56	19	1,010	209	-	-	9,174	9,231
	ADT	**1,831**	**1,347**	**3,017**	**256**	**48**	**209**	**440**	**110**	**99**	**121**	**47**	**32**	**960**	**167**	**-**	-	**8,716**	**8,759**
	AADT	**1,922**	**1,414**	**3,168**	**269**	**51**	**219**	**462**	**116**	**104**	**127**	**49**	**34**	**960**	**167**	**-**	-	**9,063**	**7,141**
	SCF	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.05**	**1.00**	**1.00**	**1.00**			
	% of Modes	21.21	15.61	34.95	2.97	0.56	2.42	5.10	1.28	1.15	1.41	0.54	0.37	10.59	1.84	9,063			

5.0 DETAILED ENGINEERING DESIGNS

5.1 ROAD GEOMETRIC

5.1.1 Geometric of the Project Highway

There are many sharp horizontal curves and these are required to be improved as per NH standards. The formation width from km 58 to km 65 is generally found to be around 9.00m with carriageway width as 7.0m. While formation width in remaining sections is mostly about 5.75 m with carriageway width as 3.75 m with few exceptions. For geometric design of the road in open area in plain & rolling sections guidelines given in IRC: 73-1980 'Geometric Design Standards' for Rural (non-urban) Highways have been followed.

5.1.2 Alignment

The proposed up gradation and improvement in alignment design is based on a number of parameters of varying weight ages. The principles of alignment improvement have been evolved based on discussions with Highway Engineer, Bridge Engineer, Environmental Specialist, Social Expert & Transport Economist. The main criteria are:

- Technical soundness & economic viability.
- Maximum comfort to road users.
- Least social & environmental adverse impact
- Least displacement & loss of public property
- Restricting adverse impact on religious structures.
- Protection of protected tree species.
- Restricting tree felling.
- Safety to road users.
- Feasibility for widening existing cross drainage structures

5.1.3 Design Elements

The design of following elements has been considered:

i. Road Links - Cross-section, Horizontal Alignment, Vertical Alignment
ii. Road Junction - At-grade Intersections and Interchanges
iii. Road Bed - Flexible Pavement and Paved Shoulder
iv. Structures - Bridges & Culverts, ROBs etc.
v. Road Signs, Markings, Safety Features and Other Accessories

5.1.4 Guiding Standards for Highway Design

The design of various elements of highways for 2-lane shall be governed by the provisions of the following IRC Codes / Guidelines / Manuals:

i) IRC: 38-1998 – Guidelines for Design of Horizontal Curves for Highways and Design Tables
ii) IRC: 62-1976 – Guidelines for Control of Access in Highways
iii) IRC: 64-1990 – Guidelines for capacity of Roads in Rural Areas (1st Revision)

iv)	IRC: 65-1976 –	Recommended Practice for Traffic Rotaries
v)	IRC: 66-1976 –	Recommended Practice for Sight Distance in Rural Highways
vi)	IRC: 67-2001 –	Code of Practice for Road Signs (1st Revision)
vii)	IRC: 73-1980 –	Geometric Design Standards for Rural (Non-Urban) Highways.
viii)	IRC: 86-1983 –	Geometric Design Standards for Urban Roads in Plains.
ix)	IRC: SP: 23-1983 –	Vertical curves for Highways
x)	IRC: SP: 41-1994 –	Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas.
xi)	MORT & H –	Pocket book for Highway Engineers, 2002 (2nd Revision)
xii)	IRC: SP: 50-1988 –	Guidelines on Urban Drainage
xiii)	IRC: SP: 44-1994 –	Highways Safety Code
xiv)	IRC: SP: 19-2001–	Manual for Survey, Investigation and Preparation of Road Projects
xv)	IRC: 92-1985 –	Guidelines for the Design of Interchanges in Urban Areas
xvi)	IRC: 75-1979 –	Guidelines for Design of High Embankments
xvii)	IRC: 67-2001 –	Code of Practice for Road Signs (1st Revision)
xviii)	IRC: 54-1974 –	Lateral and Vertical clearances at Underpasses for Vehicular Traffic.

xix) MORT&H Type Designs for Intersections on National Highways, 1992.
xx) Manual for Safety in Road Design
xxi) IRC:SP:73-2007 – Manual of Standards & Specifications for Two Laning of Highways on BOT basis

5.1.5 Horizontal Alignment

The horizontal alignment shall be designed with curves supplemented with adequate transition curves at all the grade changes. The horizontal alignment and vertical alignment shall be coordinated to have a pleasant experience for the road users. The alignment shall be provided with very higher radius curves to avoid any super elevation.

The basic guidelines for the design of alignment will be IRC: 73, IRC: 52 and AASHTO green book. The alignment will be designed to confirm to the best possible geometric standards in order to ensure smooth and safe traffic flow. Design of road has been carried out with the aid of advanced techniques using suitable design software viz. MX / MOSS or equivalent with GENIO format/ MOSS with AutoCAD (Release 2006)/other equivalent package. The output of topographic survey, and digital terrain model covering the ROW, will be the base for geometric design

5.1.6 Horizontal Curves

The horizontal curves for the project road shall be designed in accordance with the requirements stipulated in IRC: 38 (Design Table for Horizontal curves for Highways). Horizontal curves consisting of a circular curve flanked by spiral transition curves shall be adopted. Horizontal curves with large radii shall be preferred.
The radii of the circular arcs shall be calculated from the following formula:

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

Where,
R= Radius (m)
V = design speed (km/hr)
e = super-elevation (m/m)
f = coefficient of side friction between vehicle tyres and the pavement (taken as 0.15)

For road in **plain/rolling terrain,** a minimum radius of **230m** corresponding to ruling design speed of **80km/hr**. shall be adopted. Radii less than 230 m based on minimum design speeds shall only be considered if economic considerations and / or the site conditions necessitate.
In the case of the existing road alignment, curves having radii corresponding to the ruling minimum standard of 230 m, or greater, shall not be improved unless it is necessary to re-align the road for some other reasons.

5.1.7 Transition Curves

The spiral transitions ensure that vehicles progress smoothly from the straight to the circular curve or between curves of different hands or radius. The transition curves also facilitate the gradual application of super-elevation and any widening of the carriageway that may be required for the horizontal curves.

The minimum length of the transition curve shall be determined from the following two considerations, the larger of the two values shall be adopted for design:

a) *Based on rate of change of centrifugal acceleration*

$$L_S = \frac{0.0215\ V^3}{CR}$$

Where,

Ls = length of transition in metres
V = design speed in km/hr
R = radius of circular curve in metres

$$C = \frac{80}{75 + V}$$ *(subject to a maximum of 0.8, minimum of 0.5)*

b) *Based on rate of change of the super-elevation or run-off, rate shall be 1 in 150 and the formula for the same is*

$$L_S = \frac{2.7V^2}{CR}$$

For the ruling design speed of 80 km/hr, no transitions shall be provided if the radius of the circular arc exceeds 1200 m.

5.1.8 Super-elevation

The super-elevation to be applied on the horizontal curves shall be calculated based on the following formula:

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

Where,
e = super-elevation (m/m)
V = speed (km/hr)
R = radius (m)

The super-elevation applied to the curves will however be limited to a maximum of 5%. The minimum value of super-elevation to be applied will not in any case be less than the standard cross-fall of 2.5%.

5.1.9 Widening of Carriageway on Curves

Vehicle safety and comfort is improved if carriageway widening is applied on sharp horizontal curves. This is not normally necessary for dual, multi-lane carriageways if the radius exceeds 200m and widening is therefore unlikely to be required for the project road. However, should smaller radii prove unavoidable; widening shall be provided in accordance with the criteria stipulated in IRC: 73-1980.

5.1.10 Set-back Distance at Horizontal Curves

Requisite sight distance should be available across the inside of horizontal curves. The set-back distance shall be calculated from the following equation:

$m = R- (R-n) \cos \theta$

Where

$\theta = S/2(R-n)$ radians

m = minimum set-back distance to sight obstruction in meters;
R = radius at centre line of road in meters
n = distance between the centre line of the road and the center line of the inside lane in meters
S = Sight distance in meters.

Where horizontal and summit vertical curves overlap, the design shall provide for required sight distance both in vertical direction along the road and in the horizontal direction on the inside of the curve.

5.1.11 Vertical Alignment

5.1.11.1 Gradient

The vertical alignment shall provide for a smooth longitudinal profile consistent with the terrain through which the road passes. Gradient up to the "ruling gradient" shall be adopted as far as possible in the design. Grade steeper than the "ruling gradient" shall be used for a length "as short as possible". "Limiting gradients" shall be used, where topography of the area dictates the same to be adopted or the adoption of gentler gradients would results in excessive cost.Gradients to be adopted for Roads in Plain Terrain (IRC: 73-1980)

Table 5.1: Gradients to be adopted for Roads in Plain Terrain

Sl. No.	Terrain	Ruling Gradient	Limiting Gradient	Exceptional Gradient
1	Plain or Rolling	3.3% (1 in 30)	5.0% (1 in 20)	6.7% (1 in 15)

"**Exceptional Gradients"** shall be adopted only in difficult situations and for short lengths not exceeding 100m at a stretch

5.1.11.2 Vertical Curves

Parabolic vertical curves shall be provided for smooth transition at grade changes. For satisfactory appearance, the minimum length of vertical curves shall be provided based on design speed as detailed below:

Table 5.2: Minimum Length of Vertical Curves (IRC: 73-1980)

Design Speed (km/hr)	Maximum grade change (per cent) NOT requiring a vertical curve	Minimum length of Vertical Curve (m)
Up to 35	1.5	15
40	1.2	20
50	1.0	30
65	0.8	40
80	0.6	50
100	0.5	60

In the approaches of the bridges, suitable vertical curves shall be provided as per provisions of relevant IRC Codes. Decks of small cross-drainage structures (i.e. culverts and minor bridges) shall be given the same profile as the flanking road section with no break in the grade line.

Summit curves:

The length of summit curve is governed by the choice of sight distance. The length of summit curve shall be calculated based on following formulae:

For safe stopping sight distance

Case **(i)** **L>S**

$$L = \frac{NS^2}{4.4}$$

Case **(ii)** **L<S**

$$L = 2S - \frac{4.4}{N}$$

Where,
L = length of the Summit curve (m)
S = required sight distance (m)
N = algebraic difference between the grades.

Valley Curves:

The length of valley curve shall be such that for night travel, the headlight beam distance is equal to the stopping sight distance. The length of valley curve shall be calculated based on following formulae:

The length of valley curves will be calculated as follows:

Case **(i)** **L>S**

$$L = \frac{NS^2}{1.50 + 0.35S}$$

Case **(ii)** **L<S**

$$L = 2S - \frac{1.50 + 0.035S}{N}$$

Where,
L = length of the Summit curve (m)
S = required sight distance (m)
N = algebraic difference between the grades

5.1.12 Sight Distance

On consideration of drivers' perception time & braking time required to control their vehicles to avoid unwarranted accidents before meeting a stationary object in their path, proper sight distance shall be required.

In carriageway configuration the various curves shall be designed corresponding to **minimum Safe Stopping Sight Distance** according to Design Speed as detailed below:

Table 5.3: Stopping Sight Distance (IRC: 73-1980)

Speed in Km/hr	Safe Stopping Sight Distance (m)
20	20
25	25
30	30
40	45
50	60
60	80
65	90
80	120
100	180

5.1.13 At-Grade Intersection

Most roads intersect at-grade. The intersectional area is one and integral part of each road. To minimize the resulting conflicts and to provide adequately designed road junction for anticipated crossing and turning movements, the geometric design of intersection at-grade shall be given careful consideration.

Objective of improving geometric at road intersection is to ensure speed, efficiency, safety, capacity-utilization and cost of operation. An intersection may be extremely simple or highly developed, depending on various factors.

5.1.14 Design Factors

The following factors shall be considered for design of at-grade intersections:

a) Human factors – such as driving habits, reaction time, decision-making ability, pedestrian habits etc.
b) Traffic factors – such as design and actual capacity, size and operating characteristics of vehicles, vehicle speeds, accident statistics etc.
c) Physical Element – includes vertical alignment, sight distance, angle of intersection, adjoining properties, traffic control system etc.
d) Economic factors – such as cost of improvements, effects of controlling ROW on abutting properties, energy consumption.

5.1.15 Geometrics

Following design standards have been adopted for the up-gradation and improvement of the road:

All other geometric standards shall conform to the IRC:73-1980

Cross Sectional Elements Carriageway Width: The carriageway capacity of the road has been worked out as per IRC: 64-1990 'Guidelines for Capacity of Roads in Rural Area' based on traffic data analysis report.

Roadway Width: The roadway width of 12.00m is proposed as per standards given in IRC:73-1980 for Plain and Rolling Areas.

Shoulders : The paved shoulder width of 1.5m and earthen shoulder of 1.0m is proposed as per guidelines given in IRC:73-1980 for Plain & Rolling Terrain.

Camber: The Camber for the pavement has been proposed as 2.5%, For the Paved shoulder has been proposed as also 2.5% and For earthen shoulders the camber has been proposed as 3.50%.

Extra Widening on Curves: Extra widening of pavement is proposed as per Clause 9.6 of IRC:73-1980. "Geometric Standards for Rural (Non Urban) Highways.

Table 5.4: Extra width of Pavement at Horizontal Curves

Radius of curve (m)	Upto 20	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Extra width (m)						
Two-lane	**1.5**	**1.5**	**1.2**	**0.9**	**0.6**	**Nil**
Single-lane	**0.9**	**0.6**	**0.6**	**Nil**	**Nil**	**Nil**

Roadway width will be increased suitably to accommodate the extra widening of pavements.

5.1.16 Slopes

The road is generally in embankment in plain and rolling sections. Side slopes for embankment have been proposed as 2 (H): 1(V)

5.1.17 Road Drainage

(i) Camber for bituminous surface will be provided as per IRC:73-1980.

(ii) Surface run off from road pavement in built up areas shall be collected through longitudinal covered / lined drains as per site requirement with a gradient not less than 1 in 100 for plain areas, which shall discharge into outfall at culverts provided for final disposal of runoff.

(iii) Longitudinal unlined drains, away from the toe of the embankment, near the ROW limit in open areas for intercepting surface run off from the road surface/ROW, which shall discharge into nearby culverts and/or outfall to a natural channel/ stream.

(iv) The drainage system for the subproject road has been designed following the provision of IRC: 42, "Guidelines on Road Drainage. All drains have been designed for an average velocity of flow and bed slope, which will be non-silting and non-scouring depending upon the type of strata.

Detailed designs of Road Elements are presented in ***Volume – II: Design Report – Part – I: Road.***

5.2 PAVEMENT DESIGN

5.2.1 General

The Project Highway has been sub divided into appropriate number of homogeneous sections. Homogeneous sections have been selected on the basis of uniform traffic volumes and road conditions. These have been verified on the basis of traffic studies.For design flexible pavement IRC: 37-2012 guidelines have been adopted for widening / new pavement and IRC: 81-1997 guidelines have been adopted for design of strengthening overlay over existing pavement.

The design process for new flexible pavement and Strengthening Overlay are explained in subsequent paragraphs.

5.2.2 Methodology for Pavement Design

The existing subproject road sections are with flexible pavement, accordingly it is proposed to adopt flexible pavement for the improvement of the road. While designing of the pavement following factors have been considered:

- New Flexible pavement using Granular Sub Base Course (GSBC), Base Course (Wet Mix Macadam (WMM)/ Bituminous Bases (DBM, BC).

- Reconstruction of Project Highway by laying of GSB, WMM, Dense Bituminous Macadam (DBM), Bituminous Concrete (BC) after Raising the entire stretch by 1.0m to 1.5m with respect to the existing Road;

5.2.3 Pavement Design

Following design parameters have been considered for the pavement design:

Base year traffic:

Base year traffic in terms of commercial vehicles for the year 2009 and the generated traffic during the year 2012 considered.

Lane Distribution factor:

Two lane single carriageway roads, Lane Distribution Factor is taken as 0.75 as per the IRC: 37-2012 guide lines. For an intermediate lane Carriageway configuration, Lane Distribution Factor is considered as 100 per cent of the number of commercial vehicles as per the IRC: 37-2012 guide lines.

5.2.4 Design Vehicle Damage Factor

Where sufficient information on axle loads is not available and the project size does not warrant conducting an axle load survey, the indicative values of Vehicle damage Factor (VDF) as mentioned in IRC: 37-2012.

Table 5.5: Vehicle Damage Factor (VDF)

Initial traffic volume in terms of number of commercial vehicles per day	Vehicle damage Factor	
	Rolling /Plain Terrain	Hilly Terrain
0-150	1.5	0.5
150-1500	3.5	1.5
More than 1500	4.5	2.5

5.2.5 Cumulative Million Standard Axles:

Cumulative Million Standard Axles are computed for the design Period of 15 years based on the above commercial traffic. Various parameters considered for the computations of CMSA are given below.

Procedure for calculation of CMSA (design period of 15 years)
Million Standard Axles are worked out based on the following equation:

$$N = \frac{365 \times \left[(1+r)^{n}-1\right]}{r} \times A \times D \times F$$

Where,

N: *The cumulative number of standard axles to be catered for in the design in terms of msa.*
A: *Initial traffic in the year of completion of construction in terms of the number of commercial vehicles per day*
D: *Lane Distribution Factor*
n: *Design Life in years (10 years for overlay and 15 years for New pavement design)*
r: *Annual Growth rate of commercial vehicles.*
F: *Vehicle Damage Factor*

Since existing pavement is flexible, it is proposed to adopt flexible pavement. Pavement design has been done as per IRC: 37-2012.

Table 5.6: Calculation Crust Thickness

Calculation of Crust Thickness (As per IRC:37-2012)				
Sl. No	**Symbol**	**Description**	**Value**	**Unit**
(i)	A	Initial Traffic in the year of completion of construction in terms of the number of commercial vehicles per day. - 2016	**2970**	CVPD
(ii)	D	Lane Distribution Factor	0.75	Per cent
(iii)	F	Vehicle Damage Factor	4.5	Plain
(iv)	n	Design Life (in years)	15	Years
(v)	r	Annual growth rate of commercial vehicles	7.5	Per cent
(vi)	P	Number of commercial vehicles as per last count - 2012	**2444**	Nos
(vii)	x	No of years between the last count and the year of completion of construction	4	Years

DESIGN CALCULATION			
A	$A=P(1+r)^x$		
A	Initial Traffic in the year of completion of construction in terms of the number of commercial vehicles per day.	**2970**	CVPD
N	$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$		
N (MSA)	Cumulative number of standard axles to be catered for in the design in terms of msa	**78.90**	**MSA**
PAVEMENT THICKNESS			
	Million Standard Axle	78.90	MSA
	Design CBR of Subgrade	10	Per cent
	As Per IRC:37-2001, Plate-1		
	BC	50	MM
	DBM	125	MM
	WMM	250	MM
	GSB	200	MM
	Total Pavement Thickness	**625**	**MM**

5.3 DESIGN PARAMETERS FOR BRIDGES

5.3.1 Geometric and Cross Sectional Features

Width of Structures: Overall width 12.0 m for new two lane bridges.

5.3.2 Hydraulic Parameters

Information with respect to the performance/overtopping of the existing structures has been collected from local enquiry during inventory and condition survey. The bridges have been proposed with the existing waterway and the depth of foundation as per Geotechnical Report.

5.3.3 Loads and Stresses

- **Dead Load**

  Dead Loads of various components shall be considered by adopting unit weight of material as below:

  Wearing Coat : 2.20 t/m^3
  RCC Structure : 2.50 t/m^3

PSC Structure	:	2.50 t/m^3
Selected Backfill	:	1.80 t/m^3
Structural Steel	:	7.80 t/m^3

- **Live Load**

The following live load has been considered for the design of each 2-lane bridge based on the recommendation of IRC code.

Single lane IRC Class 70R.

or,

Two lanes IRC Class A

- **Impact Load**

Impact load fraction has been calculated as per clause 211.0 of IRC: 6-2000.

- **Longitudinal Force**

Braking Force

Frictional Resistance offered to the movement of temperature or any other cause.

Above mentioned forces has been calculated as per clause 214 of IRC: 6-2000.

- **Centrifugal Force**

The centrifugal forces have been calculated as per clause 215 of IRC: 6-2000.

- Earth Pressure

For Box Culvert:	Box wall have been designed considering static earth pressure. Coefficient of static earth pressure (K_a) shall be considered as 0.6. However, standard drawings as per IRC: SP: 20-2002 have been followed.
For other Earth Retaining Structures:	Structures retaining earth fills have been designed to withstand active earth pressure in accordance with Coulomb's theory.

Following soil parameters have been considered for calculation of coefficient of earth pressure:

Value of internal friction for backfill earth (Ø) shall be limited to 30°

Value of angle of friction ( ) shall be taken as 2/3 ϕ subject to a maximum value of 20°

Point of application of earth load shall be as per clause 217 of IRC: 6 – 2000

- Seismic Load

Earthquake loads shall be calculated as per IS: 1893 and modified Clause for the interim measures for seismic provisions and clause 222 of IRC: 6 – 2000. Project is located inside the earthquake zone V.

- Force due to water current

Water current force has been calculated as per clause 213 of IRC:6-2000

- Temperature Stresses

i) Uniform rise/fall in temperature: +/- 17^{o} c

ii) Temperature Gradient: Temperature gradient shall be as shown below for the design of box type superstructure

In case of simply supported spans with open girders, temperature gradient has been ignored.
For the purpose of design only 50% of live load shall be considered for load combination with temperature gradient.

- Load Combination

Load combination as per clause 202.3 of IRC: 6 – 2000 shall be adopted.
Permissible increase in stresses

Permissible increase in stresses in the various members due to combination of loads shall be as per clause 203 of IRC: 6 – 2000.

5.3.4 Grade of Material

Grade of Concrete:

PCC

In pipe bedding	=	M 15
In floor protection and other fittings	=	M 15
In head and toe walls	=	M 20

RCC

In Piles	=	M 35
In RCC box	=	M 20
In Pile caps	=	M 35
In Pier, pier cap, abutment, abutment columns	=	M 30
In Pedestals	=	M 20
In Return wall, wing wall, dirt wall and curtain wall for bridges	=	M 20
In T-beam type superstructure	=	M 45
In Approach slab	=	M 30
In Safety kerb, parapet, median kerb	=	M 20

Grade of Reinforcement:Fe 415 as per IS: 1786

Grade of Structural Steel:Weldable Steel type Grade-B as per IS: 2062

Spherical Bearing: As per IRC: 83 –2000

5.3.5 Sub-Soil Parameters

Sub-soil exploration has been conducted at the bridge locations Foundations of the bridges have been designed based on the basis of the bearing capacity.Pile foundations have been provided.

- Depth of Foundation

  New bridges

  Founding levels have been fixed based on the sub soil investigation report.

5.3.6 Bearings

Elastomeric bearings have been proposed for the bridges.

5.3.7 Wearing Coat

Wearing coat 65mm thick consisting of 15mm Mastic asphalt topped with 50 mm Asphaltic Concrete has been proposed over all new structures.

5.3.8 Expansion Joints

In case of slab type bridges of individual span length of 8.00m or less and between box culvert & approach slab filler type joints have been proposed. In case of minor bridges strip-seal type joint has been proposed.

5.3.9 Road & Bridge Appurtenances

- **Railing**

  Bridges with Kerb are proposed with Concrete Railing towards the outer edge of the bridge.

- **Safety Kerb**

  Safety kerb of size 750 mm x 225mm has been proposed

- **Flooring & Protection**

  Flooring & protection has been proposed as per recommendation of IRC for existing structures needing such protection.

- **Service Duct**

  Water pipes of small diameter will be taken above the kerb.

Detailed designs of structures are presented in ***Volume – II: Design Report – Part – II: Structures***.

5.4 PROPOSALS FOR PROJECT HIGHWAY DEVELOPMENT

5.4.1 Width of Carriageway

The width of carriageway shall be 17.5 metres wide for 4 lane and 12 metres for 2 lane excludingthemedian.

5.4.2 Proposed bypass

The by-pass of 4 Laneshallbeconstructedon the Project Highway as per details given below:

Sl.NO:	Location	ExistingChainage (Km)		DesignChainage (Km)		Length (Km)	Sidew.r.t Existingroad
		From	To	From	To		
1	Chas By-Pass	NA	8+900	0+000	6+900	6+900	LHS
2	Jeanamore By-pass	18+805	24+070	16+900	21+800	4+900	RHS
Totallength(Km)						11+800	

5.4.3 Total number of structures

The total number of structures (135Nos) on the Site are noted below:

(i) No. of Major Bridges - 01
(j) No. of Minor Bridges - 11
(k) No. of Railway Over Bridge (ROB) - Nil
(l) No. of Railway Under Bridge (RUB) - 03
(m) No. of Grade Separators - Nil
(n) No. of Box Culverts - 34
(o) No. of Pipe Culverts - 21
(p) No. of Slab Culverts - 64
(q) No. of Arch Culverts - Nil
(r) Pedestrian Underpass(PUP) - 01

5.4.4 Major bridges to be retained with minor repairs

The site includes the following One Major Bridge on Bhera River:

Sr. No.	**Existing Km**	**Design Chainage Km**	**Type of structure**			**Span Details**		**Width of Carriageway between Kerbs (m)**	**Proposal**
			Foundation	**Sub Structure**	**Super Structure**	**No**	**Length of span (m)**		
1	64.230	61+500	Well	RCC	RCC	3	25.00	11.00	To be Retained

5.4.5 Widening/Reconstruction of existing major bridges

Nil

5.4.6 New Construction of major bridges

Nil

5.4.7 Minor bridges to be retained with minor repairs

S. No.	Existing Chainage(km)	Design Chainage(km)	Span Arrangement (m)	Overall Length (m)	Typeof Superstructure	Typeof Substructure
1	19+135	17+260	1 x 16.50	16.50	RCC	RCC
2	32+650	30+293	4 x 13.50	54.00	RCC	RCC
3	45+742	43+321	2 x 14.50	29.00	RCC	RCC
4	47+248	44+823	1 x 9.70	9.70	RCC	BW
5	48+835	46+336	1 x 16.00	16.00	RCC	RCC
6	56+976	54+141	1 x 6.50	6.50	RCC	RCC
7	76+015	72+976	1 x 10.00	10.00	RCC	BW
8	79+970	76+941	1 x 14.70	14.70	RCC	RCC

5.4.8 Widening/Reconstruction of existing minor bridges

Nil

5.4.9 New Construction of minor bridges

S.No.	Existing Chainage(km)	Design Chainage (km)	Span Arrangement (m)	Overall Length (m)	Formation Width
1	Chas By-Pass	4+190	3 x 16.00	48.00	4 Lane
2	72+484	69+526	1 x 14.00	14.00	2 Lane
3	78+300	75+596	2 x 10.00	20.00	2 Lane

5.4.10 Railway Over Bridge (ROB)

Nil

5.4.11 Railway under Bridge (RUB)

A. Details Of New proposed Rail under Bridge

S. No.	Existing Chainage(km)	Design Chainage(km)	Type Of Structure	Span	Lane Configuration
1	11+933	9+997	Push Box	1x12.6	Two lane
2	12+400	10+462	Push Box	1x12.6	Two lane

B. Details ofRailunderBridgetobeRepairedandRehabilitated

S. No.	Existing Chainage(km)	Design Chainage(km)	Lane Configuration
1	69+913	66+996	Two lane

5.4.12 Culverts to be retained with minor repairs

The following Culverts shall be retained with minor repairs:

S. No.	Existing Chainage(km)	Design Chainage (km)	Span Arrangement (m)	Overall Length (m)	Typeof Superstr	Typeof Substructure
1	23+850	21+935	1X1.70	1.70	Slab	Slab
2	24+225	21+975	1X1000mm	1.00	HP	HP
3	24+586	22+334	1X1000mm	1.00	HP	HP
4	25+172	22+913	1X1000mm	1.00	HP	HP
5	26+163	23+899	1X1.5	1.15	Slab	Slab
6	27+340	25+013	1X1000mm	1.00	HP	HP
7	28+135	25+773	1X1.60	1.60	Slab	Slab
8	29+980	27+648	1X1.70	1.70	Slab	Slab
9	30+570	28+219	1X1000mm	1.00	HP	HP
10	31+420	29+088	1X3	3.00	Slab	Slab
11	31+900	29+533	1X1.70	1.70	Slab	Slab
12	32+242	29+883	1X1.60	1.60	Slab	Slab
13	32+500	30+153	2X1000mm	2.00	HP	HP
14	34+020	31+637	1X1.30	1.30	Slab	Slab
15	34+475	32+388	1X1.80	1.80	Slab	Slab
16	36+450	34+026	2X1000mm	2.00	HP	HP
17	36+830	34+376	1X2.2	2.20	Slab	Slab
18	37+030	34+604	1X2.10	2.10	Slab	Slab
19	37+165	34+733	1X1.75	1.75	Slab	Slab
20	37+650	35+300	1X1	1.10	HP	HP
21	37+850	35+312	1X1.2	1.20	Slab	Slab
22	38+725	36+294	1X1000mm	1.00	HP	HP

23	39+350	36+907	1X1.25	1.25	Slab	Slab
24	47+026	44+602	1X1.05	1.05	Slab	Slab
25	47+125	44+702	1X1.15	1.15	Slab	Slab
26	47+250	45+172	1X1.16	1.16	Slab	Slab
27	47+800	45+333	5X1000mm	5.00	HP	HP
28	48+400	46+903	1X1000mm	1.00	HP	HP
29	48+600	46+092	1X1000mm	1.00	HP	HP
30	50+020	47+324	1X1	1.00	HP	HP
31	50+630	47+952	1X1.2	1.20	Slab	Slab
32	50+700	48+013	1X1.12	1.12	Slab	Slab
33	50+810	48+118	1X1.15	1.15	Slab	Slab
34	52+125	49+426	1X1.4	1.40	Slab	Slab
35	52+900	50+160	1X1.2	1.20	Slab	Slab
36	53+180	50+440	1X1.5	1.50	Slab	Slab
37	53+585	50+812	1X1.7	1.70	Slab	Slab
38	53+840	51+099	1X1.45	1.45	Slab	Slab
39	55+500	52+773	2X1000mm	2.00	HP	HP
40	56+425	53+609	2X1000mm	2.00	HP	HP
41	56+675	53+851	1X1.45	1.45	Slab	Slab
42	57+045	54+202	1X1.55	1.55	Slab	Slab
43	57+760	55+921	1X1.65	1.65	Slab	Slab
44	57+980	55+139	1X1.52	1.52	Slab	Slab
45	58+510	55+666	1X1.45	1.45	Slab	Slab
46	58+613	55+763	1X1.13	1.13	Slab	Slab
47	58+970	56+050	1X1.6	1.60	Slab	Slab
48	59+340	56+426	6X1200mm	72.00	HP	HP
49	60+948	58+076	3X1200mm	36.00	HP	HP
50	61+120	58+250	1X1000mm	1.00	HP	HP
51	61+420	58+562	1X1.85	1.85	Slab	Slab
52	61+710	58+839	1X1.9	1.90	Slab	Slab
53	63+240	60+348	1X1.45	1.45	Slab	Slab
54	65+702	62+764	1X1.5	1.50	Slab	Slab
55	66+238	63+294	1X1.5	1.50	Slab	Slab
56	66+468	63+524	1X1.2	1.20	Slab	Slab
57	67+520	64+541	1X1.15	1.15	Slab	Slab
58	70+028	67+112	1X1.92	1.92	Box	Box
59	70+152	67+231	2X2.2	4.40	Slab	Slab
60	73+134	70+266	1X2.3	2.30	Slab	Slab
61	74+250	71+281	4X1000mm	4.00	HP	HP
62	75+100	72+144	1x1.45	1.45	Slab	Slab
63	76+510	73+471	1 x 1.6	1.60	Slab	Slab
64	76+810	73+842	1 x 1.6	1.60	Slab	Slab
65	77+292	74+436	1x1.4	1.40	Slab	Slab
66	77+985	75+976	1x1.85	1.85	Slab	Slab
67	78+285	75+376	1x0.5	0.50	Slab	Slab
68	79+425	76+502	1X1.2	1.20	Slab	Slab
69	80+250	77+220	1X1.2	1.20	Slab	Slab
70	80+955	77+916	1X1.3	1.30	Slab	Slab

71	81+020	77+991	1X1.2	1.20	Slab	Slab
72	81+112	78+106	1X1.7	1.70	Slab	Slab

5.4.13 Widening of Existing Culverts

Following culverts are to be widened:

S. No.	Existing Chainage(km)	Design Chainage (km)	Span Arrangement (m)	Overall Length (m)	Typeof Structure	Widening Require
1	8+815	6+885	1x3.0x3.0	9.00	Box	All existing culvert having from formation less then 12m. to widened equal to the roadway width of approaches
2	10+287	8+395	1 x 2.5	2.5	Slab	
3	11+270	9+383	1x3.7	3.7	Slab	
4	11+505	9+615	1x2.6	2.6	Slab	
5	12+838	10+897	1x3.65	3.65	Slab	
6	17+435	15+493	1x1.2	1.2	Slab	
7	26+710	24+448	1 x 1.70	1.70	Slab	
8	33+330	30+948	1 x 1.60	1.60	Slab	
9	40+008	37+563	1 x 1.60	1.60	Slab	
10	50+175	47+500	1x1000mm	1.00	Hp	
11	51+050	48+339	1x1000mm	1.00	Hp	
12	52+305	49+611	1 x 1.50	1.50	Slab	
13	62+288	59+398	1 x 1.52	1.52	Slab	
14	73+725	70+759	1 x 1.17	1.17	Slab	
15	74+470	71+494	1 x 1.65	1.65	Slab	

5.4.14 Reconstruction/ New Construction of Culverts

The following Culverts shall be reconstructed new or re-constructed after dismantling of existing culverts:

S. No.	Existing Chainage(km)	Design Chainage(km)	Span Arrangement (m)	Overall Length (m)	Typeof Structure
1	Chas By-Pass	0+190	1 x 2.0 x 2.0	2.00	Box
2	Chas By-Pass	2+150	1 x 2.0 x 2.0	2.00	Box
3	Chas By-Pass	2+800	1 x 2.0 x 2.0	2.00	Box
4	Chas By-Pass	3+500	1 x 2.0 x 2.0	2.00	Box
5	Chas By-Pass	5+725	1 x 2.0 x 2.0	2.00	Box
6	17+050	15+073	1 x 2.0 x 2.0	2.00	Box
7	18+145	16+238	1 x 2.0 x 2.0	2.00	Box
8	18+800	16+833	1 x 2.0 x 2.0	2.00	Box
9	Jeanmore By-pass	17+205	1 x 2.0 x 2.0	2.00	Box
10	Jeanmore By-pass	17+650	3 x 3.0 x 3.0	9.00	Box
11	Jeanmore By-pass	18+100	1 x 2.0 x 2.0	2.00	Box
12	Jeanmore By-pass	18+630	1 x 2.0 x 2.0	2.00	Box
13	Jeanmore By-pass	18+895	1 x 2.0 x 2.0	2.00	Box

14	Jeanmore By-pass	19+210	1 x 2.0 x 2.0	2.00	Box
15	Jeanmore By-pass	19+980	1 x 2.0 x 2.0	2.00	Box
16	Jeanmore By-pass	20+700	1 x 2.0 x 2.0	2.00	Box
17	Jeanmore By-pass	21+200	1 x 2.0 x 2.0	2.00	Box
18	Jeanmore By-pass	21+370	1 x 2.0 x 2.0	2.00	Box
19	31+129	28+783	1 x 2.0 x 2.0	2.00	Box
20	35+100	33+013	1 x 2.0 x 2.0	2.00	Box
21	38+020	35+574	1 x 2.0 x 2.0	2.00	Box
22	46+650	44+202	1 x 2.0 x 2.0	2.00	Box
23	49+230	46+872	1 x 2.0 x 2.0	2.00	Box
24	49+425	47+113	1 x 2.0 x 2.0	2.00	Box
25	49+700	47+182	1 x 2.0 x 2.0	2.00	Box
26	54+260	51460	1 x 2.0 x 3.0	2.00	Box
27	62+008	59+146	1 x 2.0 x 2.0	2.00	Box
28	62+200	59+306	1 x 2.0 x 2.0	2.00	Box
29	67+700	65+616	1 x 2.0 x 2.0	2.00	Box
30	69+300	66+516	1 x 2.0 x 2.0	2.00	Box
31	71+522	67+916	1 x 2.0 x 2.0	2.00	Box
32	74+510	71+592	1 x 2.0 x 2.0	2.00	Box
33	74+886	74+866	1 x 2.0 x 2.0	2.00	Box

5.4.15 New ROBs

Nil

5.4.16 New Pedestrian under Pass (PUP)

S. No.	Existing Chainage(km)	Design Chainage(km)	Span Arrangement (m)	Overall Length (m)	Typeof Superstr	Typeof Substructure
1	Chas By-Pass	0+190	1 x 7.00 x 3.50	24.50	RCC	Box

5.4.17 List of Major Junctions

SI.No	DesignChainage(Km)	Side	Typeof Junction	Surface Type	Leadingto
1	NA	RHS	T	BT	Chas Bypass
2	NA	RHS	T	BT	Chas Bypass
3	8+725	RHS	Y	BT	NH-23
4	14+540	RHS	T	BT	Village
5	16+290	RHS	T	BT	Industrial Area
6	16+765	RHS	Y	BT	Industrial Area
7	18+863	LHS	Y	BT	Jenamore
8	24+025	LHS	Y	BT	Jenamore
9	68+214	RHS	Y	BT	chitarpur

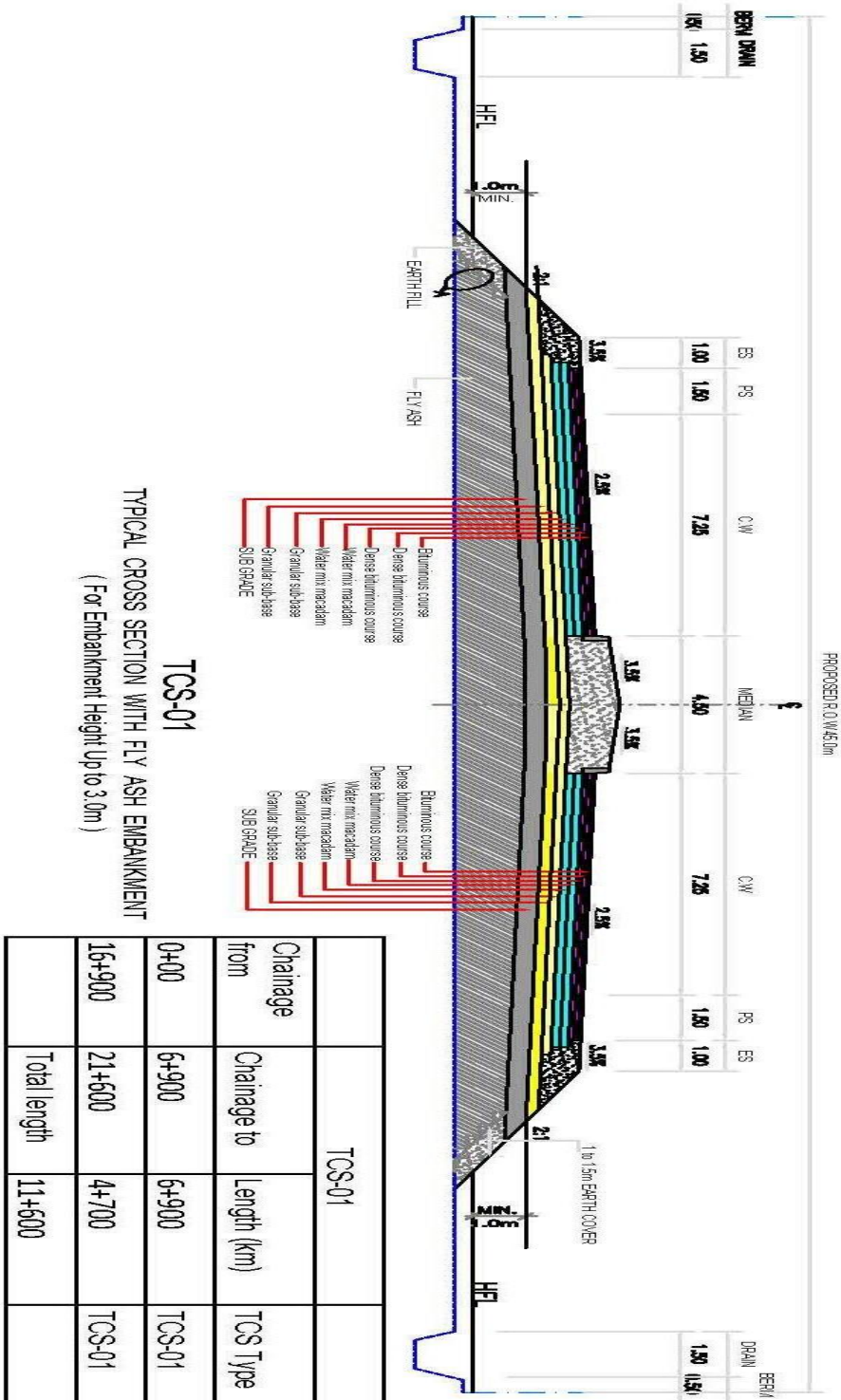
5.4.18 List of Minor Junctions

SI.No	DesignChainage(Km)	Side	Typeof Junction	Surface Type	Leadingto
1	2+880	Both	X	BT Road	Chas City
2	4+785	Both	X	BT Road	Chas City
3	6+125	RHS	Y	BT Road	Chas City
4	7+175	RHS	T	BT Road	Rajendernagar
5	7+315	LHS	T	BT Road	Colony
6	7+612	LHS	T	BT Road	River and colony
7	8+712	LHS	Y	BT Road	Nadiyakepaar
8	8+500	LHS	Y	BT Road	Baghgoda
9	8+675	LHS	T	BT Road	Baghgoda
10	8+773	LHS	T	BT Road	Baghgoda
11	9+122	LHS	Y	BT Road	Magdumpur
12	10+120	RHS	T	BT Road	Rly-Godwon
13	10+515	LHS	T	BT Road	Chainpur
14	10+580	RHS	Y	BT Road	BokaroRly.Station
15	11+350	LHS	T	BT Road	Shyampur
16	11+350	LHS	T	BT Road	Shyampur
17	11+775	RHS	T	BT Road	Canara bank
18	13+020	LHS	Y	BT Road	Brahampura
19	13+180	RHS	Y	BT Road	Bokaro Rly. Station
20	13+210	RHS	Y	BT Road	Industrial area (Bokaro)
21	14+046	RHS	T	BT Road	Vishanpur
22	15+823	Both	X	BT Road	Village
23	18+620	Both	X	BT Road	Village and Jenamore
24	19+620	RHS	T	BT Road	kalyanpur
25	26+700	RHS	Y	BT Road	Barubasti
26	27+290	RHS	Y	BT Road	Chado
27	27+575	LHS	Y	BT Road	Kashmar
28	28+080	LHS	Y	BT Road	Ramalapur
29	28+462	RHS	Y	BT Road	Sonpur
30	32+860	RHS	Y	BT Road	Mayapur
31	34+718	LHS	T	BT Road	Kojram
32	37+200	RHS	Y	BT Road	Sadama
33	38+390	LHS	Y	BT Road	Peterbar
34	39+557	LHS	Y	BT Road	Kashmar
35	40+270	RHS	Y	BT Road	Jenoghat
36	40+290	RHS	Y	BT Road	Lepo
37	41+680	RHS	Y	BT Road	Mangasarla
38	42+180	Both	X	BT Road	Chargi
39	43+890	LHS	T	BT Road	Chargi
40	44+760	RHS	Y	BT Road	Banda

41	45+664	Both	X	BT Road	Maganpur
42	50+345	LHS	T	BT Road	Khakhord
43	51+940	LHS	Y	BT Road	Sosokhurd
44	52+862	RHS	Y	BT Road	Sosokhurd
45	54+050	Both	X	BT Road	Sosokhurd
46	54+490	RHS	Y	BT Road	Hisimdog
47	54+938	LHS	T	BT Road	Village
48	55+405	RHS	T	BT Road	Tirla
49	56+605	LHS	Y	BT Road	Dodhatu
50	57+660	LHS	Y	BT Road	Bariyatu
51	57+660	LHS	Y	BT Road	Gola
52	58+360	RHS	Y	BT Road	Rajrappa
53	58+368	LHS	Y	BT Road	Kamta
54	59+317	RHS	Y	BT Road	Hupu
55	60+045	LHS	Y	BT Road	Sikin
56	62+640	RHS	Y	BT Road	Margamarcha
57	63+740	RHS	T	BT Road	Murubana
58	67+548	LHS	Y	BT Road	Chhotki
59	68+228	LHS	Y	BT Road	Murubana
60	68+945	LHS	Y	BT Road	Murubana
61	68+962	RHS	Y	BT Road	Murubana
62	69+798	Both	X	BT Road	Village
63	70+252	LHS	T	BT Road	Barki
64	70+582	Both	X	BT Road	Village
65	70+800	LHS	Y	BT Road	Murubana
66	71+757	RHS	T	BT Road	Hargaradih
67	73+673	RHS	T	BT Road	Chhatarmandu
68	74+392	LHS	T	BT Road	Chhatarmandu
69	77+832	LHS	Y	BT Road	Kothar

5.4.19 List of Typical Cross Sections

TCS Type	Description	Length (km)
TCS-01	TYPICAL CROSS SECTION WITH FLY ASH EMBANKMENT (For Embankment Height Up to 3.0m)	11.6
TCS-02	TYPICAL CROSS SECTION OF 2 LANE IN WIDENING & UPGRADATION WITH FOOTPATH CUM DRAIN (BUILT-UP AREA)	10.15
TCS-03	TYPICAL CROSS SECTION OF 2 LANE WITH PS IN WIDENING & UPGRADATION (OPEN AREA)	46.442
TCS-04	TYPICAL CROSS SECTION OF EXISTINIG 2 LANE TO 4 LANE WITH FOOTPATH CUM DRAIN (BUILT UP AREA)	5.3
TCS-05	TYPICAL CROSS SECTION OF EXISTINIG 2 LANE TO 4 LANE CONSTRUCTION (OPEN AREA)	4.7
	Total	78.192

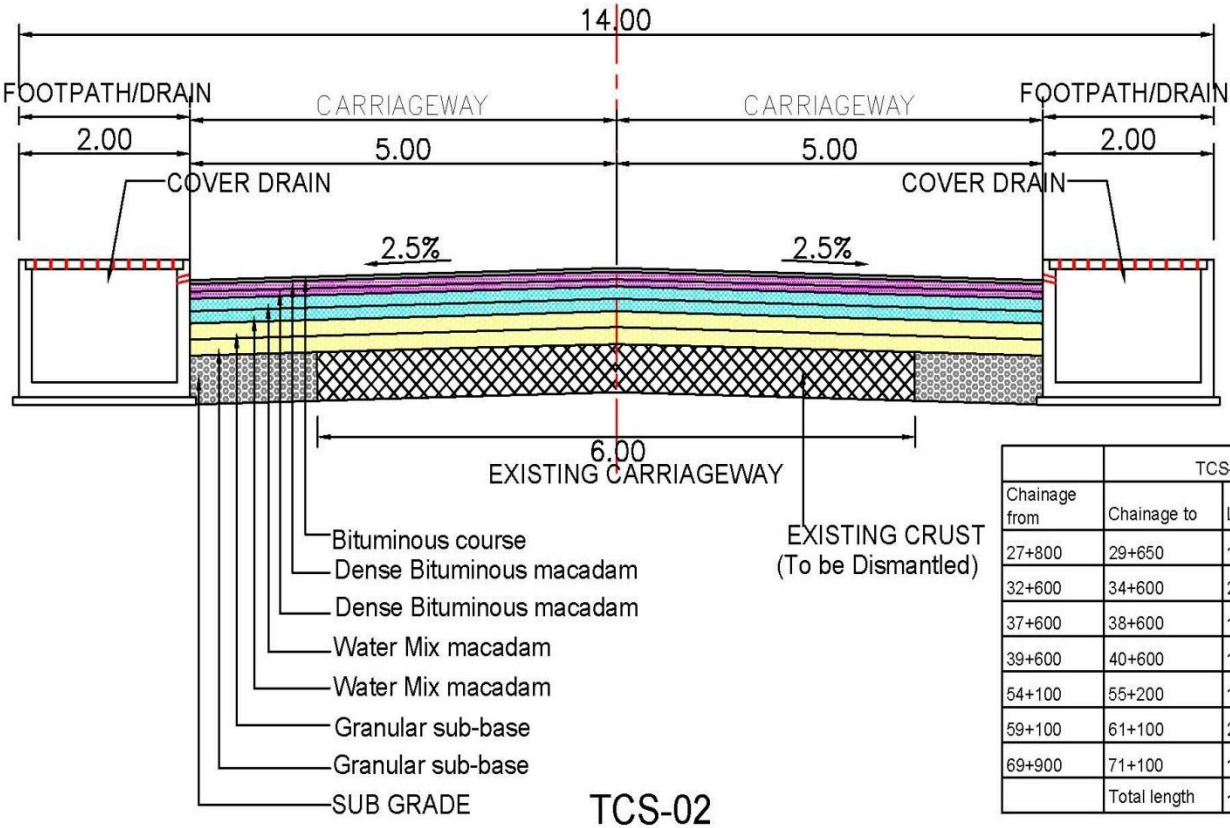


TCS-01

TYPICAL CROSS SECTION WITH FLY ASH EMBANKMENT

(For Embankment Height Up to 3.0m)

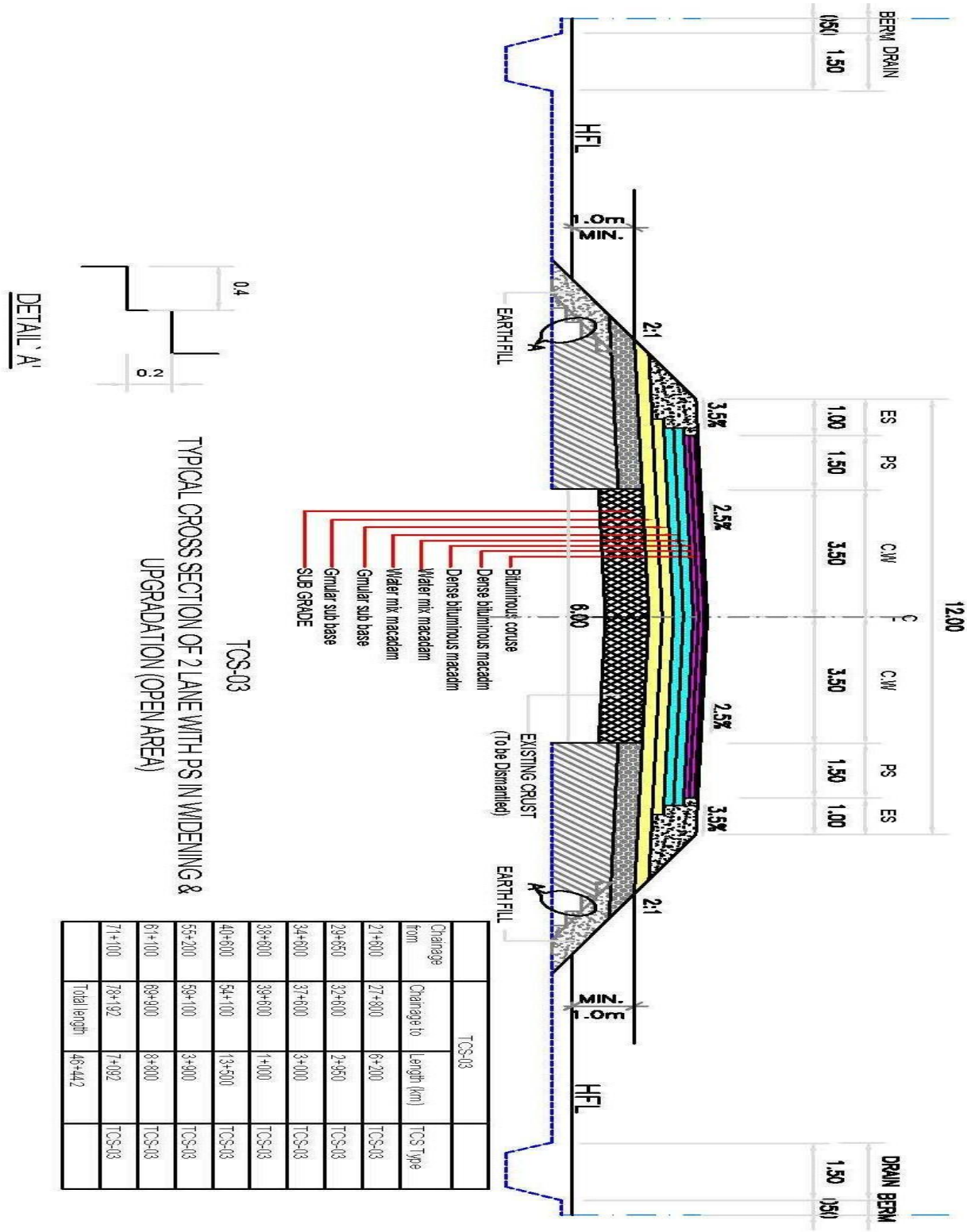
	TCS-01		
	Chainage from	Chainage to	Length (km)	TCS Type
	0+00	6+900	6+900	TCS-01
	16+900	21+600	4+700	TCS-01
		Total length	11+600	



	TCS-02		
Chainage from	Chainage to	Length (km)	TCS Type
27+800	29+650	1+85	TCS-02
32+600	34+600	2+00	TCS-02
37+600	38+600	1+00	TCS-02
39+600	40+600	1+00	TCS-02
54+100	55+200	1+10	TCS-02
59+100	61+100	2+00	TCS-02
69+900	71+100	1+20	TCS-02
	Total length	10+15	

TCS-02

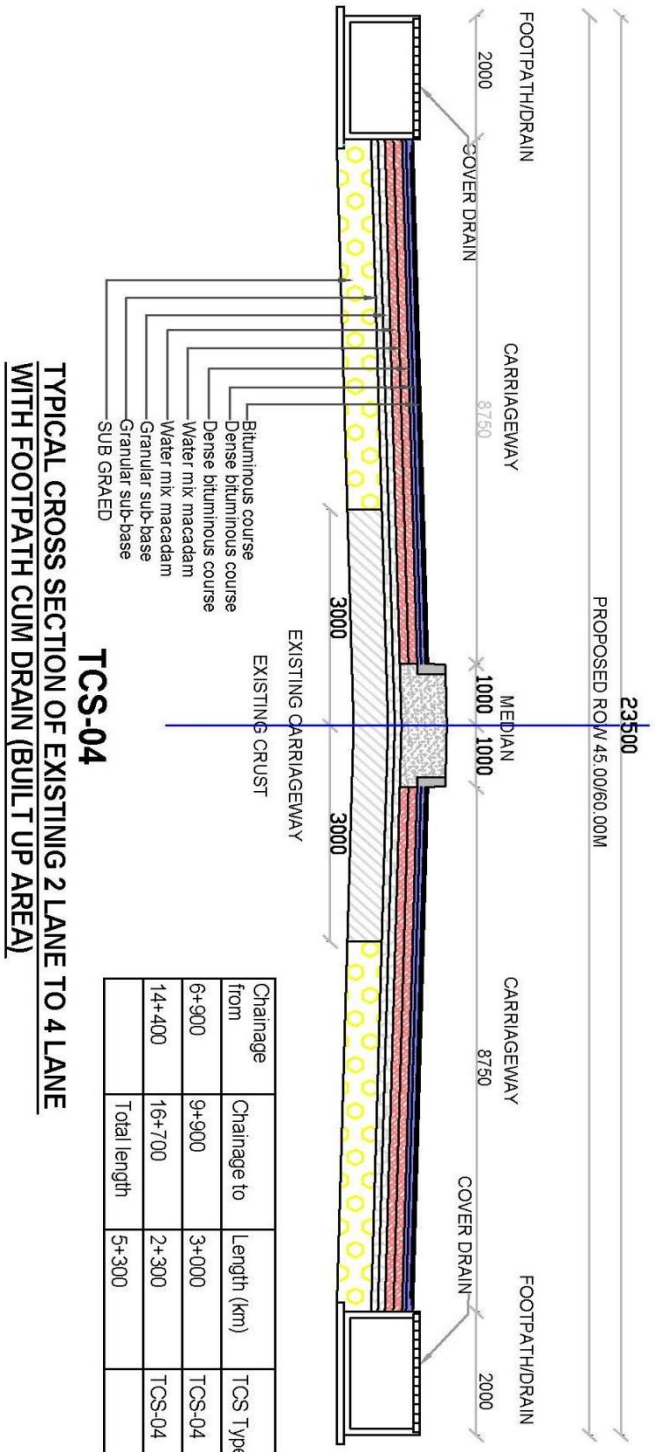
TYPICAL CROSS SECTION OF 2 LANE IN WIDENING & UPGRADATION WITH FOOTPATH CUM DRAIN (BUILT-UP AREA)



TYPICAL CROSS SECTION OF 2 LANE WITH PS IN WIDENING & UPGRADATION (OPEN AREA)

TCS-03

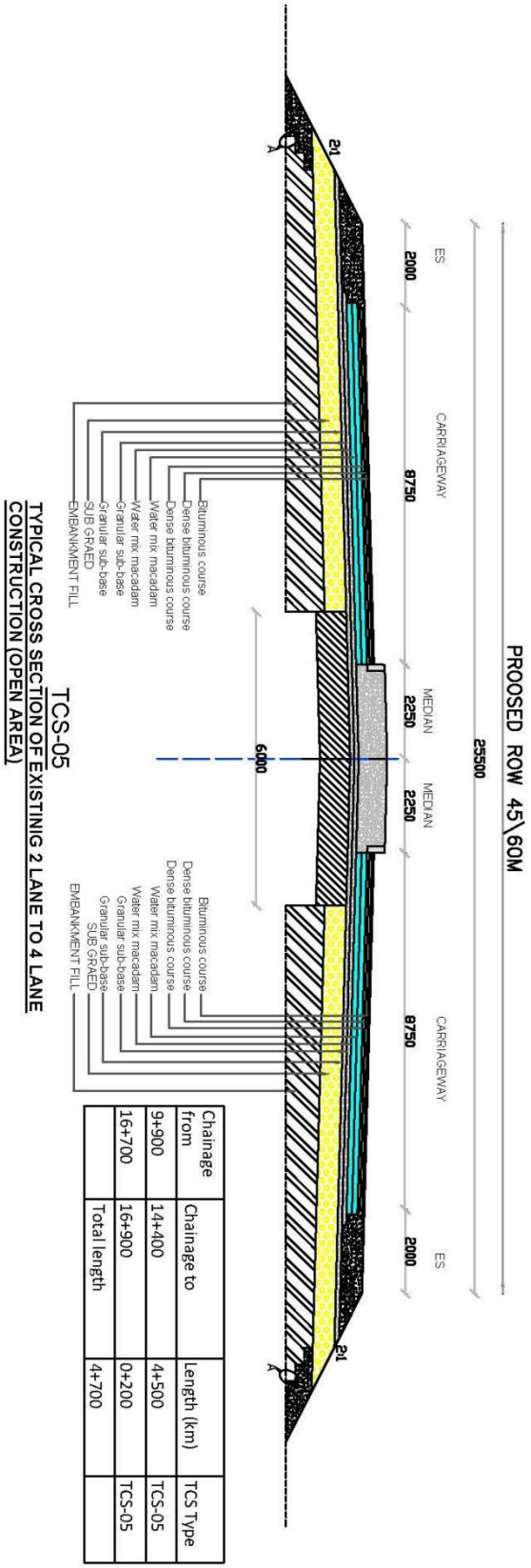
	TCS-03		
Chainage from	Chainage to	Length (km)	TCS Type
21+600	27+800	6+200	TCS-03
29+650	32+600	2+950	TCS-03
34+600	37+600	3+000	TCS-03
38+800	39+800	1+000	TCS-03
40+600	54+100	13+500	TCS-03
55+200	58+100	3+900	TCS-03
61+100	69+900	8+800	TCS-03
71+100	78+192	7+092	TCS-03
	Total length	46+442	



TCS-04

TYPICAL CROSS SECTION OF EXISTINIG 2 LANE TO 4 LANE WITH FOOTPATH CUM DRAIN (BUILT UP AREA)

Chainage from	Chainage to	Length (km)	TCS Type
6+900	9+900	3+000	TCS-04
14+400	16+700	2+300	TCS-04
	Total length	5+300	



TCS-05

TYPICAL CROSS SECTION OF EXISTING 2 LANE TO 4 LANE CONSTRUCTION (OPEN AREA)

Chainage from	Chainage to	Length (km)	TCS Type
9+900	14+400	4+500	TCS-05
16+700	16+900	0+200	TCS-05
	Total length	4+700	

6.0 ENVIRONMENTAL ASPECTS

6.1 INTRODUCTION

National Highway 23 starts at the junction of NH 32 at ITI More Chas, passes through Gola, Jenamore and Peterbar up to Ramgarh at the junction of NH 33.Its stretch is about 88km.This NH traverse the highly mineralized areas of Jharkhand.

A reconnaissance survey of project road from ITI More Chas to Ramgarh has been done by the Environmental team in June, 2010. Categorisation of the project road has been done on the basis of ADB Environmental Assessment Guidelines of 2003, ADB Environmental Policy 2002, ADB Safeguard Policy, June 2009, World Bank Guidelines and MoEF's Environmental Impact Assessment Notification dated 14th September 2006 and Amendment of 01 Dec, 2009.

- Project Road lies on the Chotanagpur Plateau of Jharkhand in the district of Bokaro and Rangarh.The terrain condition is rolling with intermittent populated towns and villages. It is highly eroded, has rolling topography, in situ soil, intermittent forest land, open forest land, fallowlands, low laying cultivable lands. The soil is sandy to gravelly. There are very few tributaries feeding the main river. Therefore, bridge and culverts are not much along the corridor.

- The carriageway of project road is of bituminous surface with configuration of two lane and the earthen shoulders varies from 1.0 m to 2.50 m along the project road. Width of existing carriageway is varying from 6.00m to 11.00m along the project road.

- A few protected forests come within the vicinity of 10 km from the project road. The area is generally dry with rainfall during monsoon months.

- As per initial site reconnaissance survey it has been observed that there is no ecologically sensitive area such as national park, wildlife sanctuary, reserved forest, or critically polluted area within corridor of impact (10 km on either side) of the project road, however the details of the above ecological sensitive area within 15 km will be collected from Forest Department during filling of FORM-1 for the project road. This project road passes through mainly agricultural land, built up areas and approximately 12.5 km of the project road from Km 48.00 to Km 83.00 has protected forest within a vicinity of 10km. Roadside plantation also exists at a number of places along the road. There will be negligible impact on forest land and existing plantation along the project road due to proposed paved shoulder (1.5 m width) and earthen shoulder (1.0 m width), as the project road is already having two lane with earthen shoulders all along the project corridor. The land requirement and number of tree to be cut due to proposed road design will be finalized during detailed project report (DPR) stage. The photographs of the Project Highway are given in Annexure 5**.**

6.2 MAIN FEATURES OF PROJECT ROAD

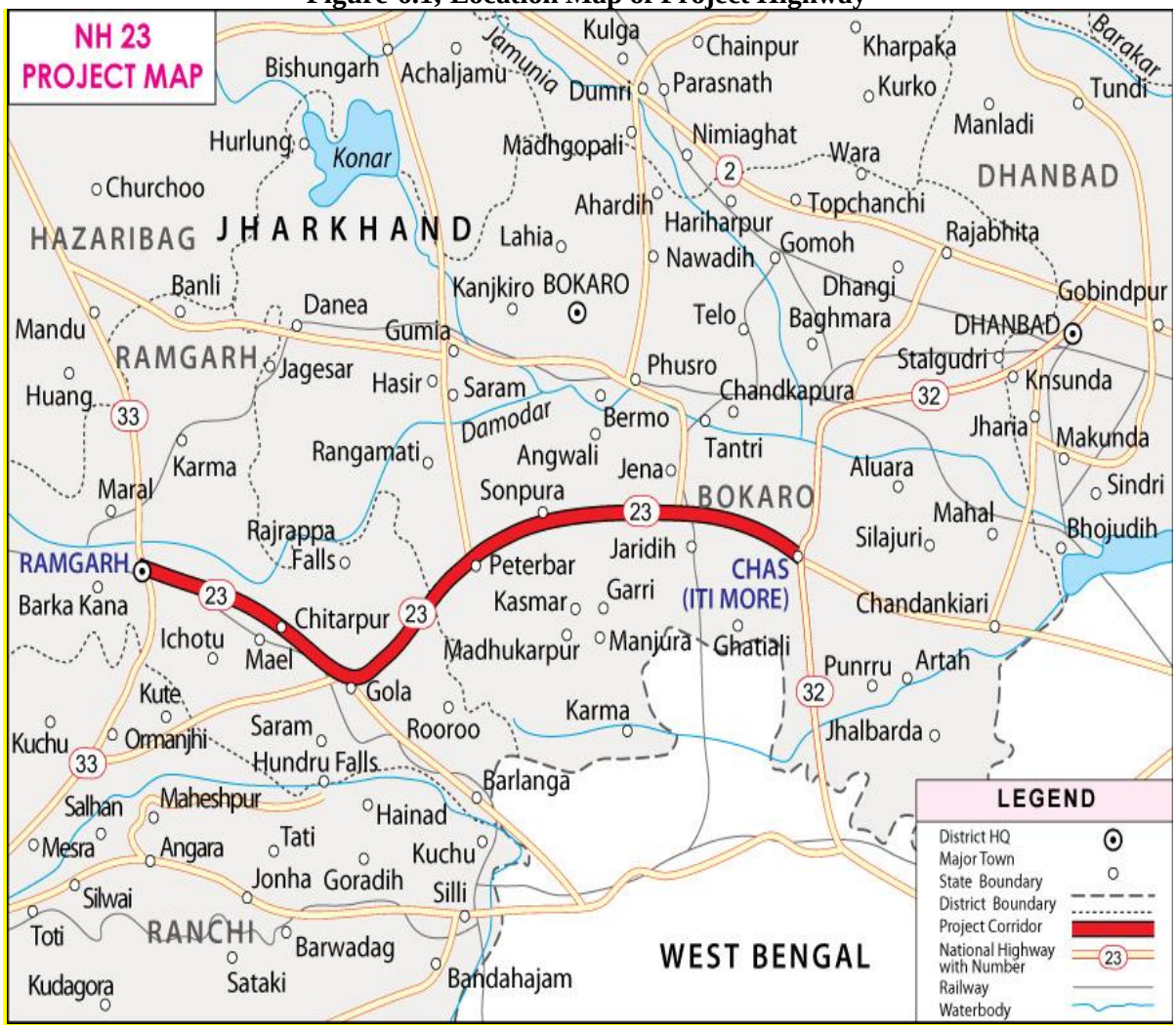
- Intermittent dense forest, open forest, fallow lands, cultivable lands and plantation is observed on both sides along the project stretch.
- The project road NH-23 startsat ITI More Chas at junction with NH 32 and ends at Ramgarh at junction with NH 33.
- The project road stretch has good land landscaping and generally road is following the rolling topography.
- There is protected forest along the project road at few stretches.
- About 38 settlements are located along Project Highway.

6.3 NEED FOR THE PROJECT

Jharkhand has not fully developed as per its immense potential. It is the richest state as far as mineral reserves and other resources are concerned. There are many reasons to this and one of them is the lack of proper infrastructure in the state. During the recent years there has been lots of focus on the economic development of the state. A large number of projects are coming up and are proposed for the state. To sustain the pace of economic development good road infrastructure is very important.

The current road project is located in the highly mineralised region of Jharkhand. This section of the road is going to witness very high flow of traffic in the coming years. So it is imperative to enhance the physical infrastructure and road access.It would result in iimprovement in social services by quicker and safe mode of transport. New employment potential for –skilled, semi-skilled and unskilled labour both during construction and operational phases of the project with specific attention to employment potential of local population as well as necessity for imparting any specialized skills to them to be eligible for such employment in the project. There will be reduction in traffic congestion through city/town/ and other locations. Tourism will get a boost as access to Rajrappa temple will become very easy, which is just 8 km from the project road. It would reduce pollution level and vehicle maintenance, fuel saving due to better quality of roads. Better road infrastructure would lead to the overall economic development and improved life style of the region and in turn would bring a social change.

Figure-6.1; Location Map of Project Highway



6.4 SALIENT FEATURES OF THE PROJECT

The Salient features of the project are provided in the box below:

Table-6.1: Salient features of Project Road

Available ROW: Varies from …9.. m to …25… m
Existing road width: Pavement width including shoulder varies from 7….. m to 11….. m.
Proposed road width (4Lane): 17.5…… m in rural area and …18… m in urban area.
Proposed road width (2Lane): 12…… m in rural area and …12… m in urban area.
Proposed pavement composition: BC-40…. mm, DBM-120….. mm, WMM-250….. mm, GSB-200….. mm and Sub grade-500….. mm.
Proposed borrow area: …45… Nos.
Proposed Stone Quarry: …3… Nos.
Proposed overlay composition: …NIL….
Proposed raising profile: …NIL
Proposed drain: 14km…… drain at urban areas.
Proposed widening: …1 to 6 m…..
Proposed Bus shelter: …14…. Nos.
Proposed truck lay-byes:…4…..Nos.
Identified accident prone locations: Chas, Bokaro, Gola and Ramgarh……. Locations
Proposed safety measures at sharp curve: …Chas and Gola …. Locations
Existing culverts: There are 21…… nos. of Pipe, 67…….Slab and 24…….Box culverts.
Proposed new culverts: …13….
Proposed culverts for reconstruction: …9….Nos.
Proposed culverts for rehabilitation/ widening: …32… Nos.
Existing minor and major bridges: …13… minor bridge and major bridge is …1..
Proposed minor bridge for rehabilitation/ widening: ….. Nil
Proposed major bridge for rehabilitation/ widening: Nil…….
Existing Traffic volume(Base year 2010…….): 12451. PCU
Proposed Traffic volume (Projected year …2025….): 25885. PCU

There is no ecologically sensitive area such as national park, wildlife sanctuary, reserved forest, or critically polluted area within 10km on either sides of the project road. But the project road is in the vicinity of 10km of protected forest in some stretches. The project road lies in the Chotanagpur Plateau, the terrain is highly eroded, has rolling topography, in situ soil, intermittent forest land, open forest and scrub, fallow lands, low laying cultivable lands. The soil is sandy to gravelly. There are bands of 8-15m wide roadside plantation along some stretches of the road.

6.5 ENVIRONMENTAL REGULATIONS AND POLICIES

6.5.1 Key Environmental Laws and Regulations

The key environmental laws and regulations and their applicability to the project has been explained below:

- Forest (Conservation) Act
- Wild Life Protection Act
- The Water (Prevention and Control of Pollution) Act, 1974
- The Air (Prevention and Control of Pollution) Act, 1981
- The Environment (Protection) Act, 1986

6.5.2 Forest (Conservation) Act

This Act is of particular significance in case the project corridors require acquisition of forestland outside the ROW of the road corridors as a result of the rehabilitation work proposed.

The Forest Conservation Act (1927) was amended in 1980 in an attempt to check the rapid deforestation occurring throughout India. At the state level, the government was empowered to declare reserves and protected forest and was also given the authority to acquire land for extension and preservation of the forests. An advisory Committee was formed to supervise compliance, within other government departments. In December 1996, a Supreme Court Judgment further defined the types of forests to be protected. Depending on the size of the tract to be cleared, clearances are applied at the following levels in government:

- If the forest land exceeds 20 hectare then prior permission of Central Government is required;
- If the forest land is between 5 to 20 hectare, then permission from the Regional Office of Chief Conservator is required;
- If the forest land is below or equal to 5 hectare the State Government can give permission; and,
- If the construction area is more than 40% forest, permission to undertake any work is needed from the Central Government, irrespective of the size of the area.

In the present project the project road passes through, intermittent protected forest, open forest and scrub, fallow lands, low laying cultivable lands. The terrain of Chotanagpur Plateau is highly eroded, has rolling topography. There are bands of 8-15m wide roadside plantation along some stretches of the project road hence, this act will be applicable in the project road. However, the detailed information will be provided at the DPR stage.

6.5.3 Wild Life Protection Act

The Wildlife Protection Act,1972has allowed the government to establish a number of National Parks and Sanctuaries over the past 25 years, to protect and conserve the flora and fauna of the state.

The project road does not pass through any notified National Park or Wild life Sanctuary; hence this act is not applicable.

6.5.4 The Water (Prevention and Control of Pollution) Act, 1974

Resulted in the establishment of the Central and State level Pollution Control Boards, whose responsibly includes managing of water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of any facility. This will include generation of liquid effluent during construction of road from civil engineering activities or from domestic activities in workers colony. There are specific penalties for violation, which

includes imprisonment for responsible officials. **This act will be applicable during implementation of project road for establishments of hot mix plant, batching plant and DG set.**

6.5.5 The Air (Prevention and Control of Pollution) Act, 1981

Empowers Central and State Pollution Control Boards for managing air quality and emission standards, as well as monitoring air quality, prosecuting offenders and issuing licenses for construction and operation of any facility. There are specific penalties for violation, which include imprisonment for responsible officials. This act has notified National Ambient Air Quality Standard for different regions e.g. Industrial, Residential and Sensitive. Air quality during construction and operation phases will be guided by this specific Act. **This act will also be applicable to the project road during construction for obtaining NOC for establishment of hot mix plant, crushers, etc.**

6.5.6 The Environment (Protection) Act, 1986

This act was passed as an overall comprehensive act "for protection and improvement of environment". Under this act rules have been specified for discharge/emission of effluents and different standards for environmental quality. These include Ambient Noise Standard, Emission from Motor Vehicles, Mass Emission standard for Petrol Driven Vehicles, General Effluent Standards etc. especially important for road project. **This act will be applicable during all three phases of project namely pre construction, construction phase and operation phases.**

6.6 PROJECT CATEGORIZATION/ SCREENING

6.6.1 ADB Project Categorization

Site reconnaissance survey undertaken for screening and scoping of this Sub-project road on environmental considerations followed by environmental field survey and investigation resulted in following key findings:

- This project road passes through mainly agricultural land, built up areas and approximately 12.5 km of the project road from Km 48.00 to Km 84.00 falls under protected forest within 1 km.
- Roadside plantation also exists at a number of places along the project road. There will be negligible impact on forest land and existing plantation along the project road due to proposed paved shoulder (1.5 m width) and earthen shoulder (1.0 m width), as the project road is already having two lane with earthen shoulders all along the project corridor.
- The land requirement and number of tree to be cut due to proposed road design will be finalized during detailed project report (DPR) stage.
- The project does not entail the encroachment of precious ecology and historical or cultural areas;
- The project does not involve alteration of surface water hydrology but little bit of siltation and erosion is anticipated during construction;
- There would be some dislocation and resettlement of people along the project road mainly in the congested areas. Sometemporary commercial structure located within formation width will be shifted. This has been addressed as per the principles of the Resettlement Framework in social report; and
- Most of the anticipated potential adverse impacts are limited in spatial and temporal extent i.e. short-term (during construction) and are mitigable.

As per ADB Environmental Assessment Guidelines 2003 and ADB Safeguard Policy, June, 2009; the project road falls under "**Category A"** project. Land acquisition may be required at the realigned sections. All the development works will be carried out within the existing ROW. **No Diversion of Forest Lands** is involved for the project road, however, the exact land requirement will be updated after design finalization of the project road during DPR stage. This minimizes the impact of road development on natural vegetation to a negligible extent. Considering the above, the project road has been re-classified as **"Category B"** project, as per ADB guidelines. The details are given in Rapid Environmental Assessment (REA) checklist is enclosed as Annexure 1.

6.6.2 Project Categorization as per Government of India Requirements

The project is Up-gradation, Rehabilitation and Strengthening of existing Project Road which is part of National Highway No. 23. As per EIA Notification, 14th September 2006 and its Amendment 01st Dec, 2009, the project road is broadly categorized in to "**Category A"** project due to following information as per EIA Notification:

(i) New National High ways; and

(ii) Expansion of National Highway greater than 30 KM, involving additional right of way greater than 20m involving land acquisition and passing through more than one State.

The Environmental clearance will have to be taken by the Client, NHAI, with the help of Design Consultant in two different stages i.e. Prior Environmental Clearance and the Final Environmental Clearance:

- The prior environmental clearance shall be taken by filling FORM-1 and proposed TOR for EIA study of the project road and the same shall be submitted to Ministry of Environment and Forests (MoEF) and
- The final environmental clearance shall be taken upon submission of EIA & EMP report as per approved TOR of EIA study by Expert Appraisal Committee (EAC), MoEF.

6.6.3 Scope and Purpose of Environmental Screening and Prioritization

The environmental screening and prioritization is taken up to make a preliminary assessment / review of environmental issues that are relevant to JH/DPR/NHDP-IV/ 05 from Environmental consideration. The purpose is to prioritize the project road on environmental considerations along with technical, economical and social aspects. The other purposes are to recommend suitable measures which could be considered during preliminary design. As the project road falls under category A project as per EIA Notification, hence, Environmental Impact Assessment (EIA) study will be done for the project road and clearance will be obtained from MoEF.

6.6.4 Environmental Screening and Prioritization Methodology

The environmental screening and prioritization process adopted in this project is shown in ***Figure-6.2***.

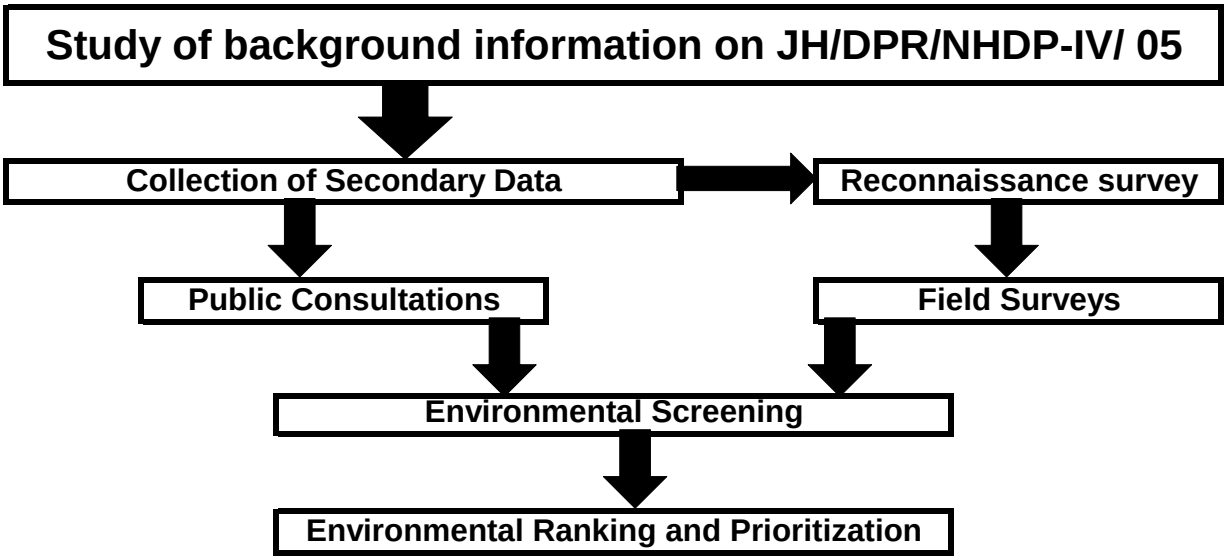


Figure-6.2: Methodology of Environmental Screening and Prioritization

The above steps have been completed through identification of relevant sub parameters in physical, ecological and socio-economic environments. These identified sub parameters have been assigned scores and the project corridor has been assessed based on evaluation criteria evolved on the basis of available baseline data. The sub parameters identified and total score assigned have been given below in Table – 9.2.

Physical environmental and ecological environment has been given equal significance while socioeconomic environment has been given comparatively less weightage as these have been separately considered in social and economic raking.

6.7 PROJECT INFLUENCE AREA

The project influence area (PIA) is defined as follows:

- Direct Corridor of Impact (COI) within toe lines
- General Corridor of Impact up to 10 km on either sides of the Project Road
- Ancillary sites such as borrow area, quarry site, waste disposal sites and construction camp sites.

Table 6.2: Environmental Parameters Weightage Assigned

S. No.	Parameters	Weightage Assigned
1	**Physical Environment**	***40***
	(i) Land use	6
	(ii) Availability of construction material	6
	(iii) Soil erosion and sedimentation	5
	(iv) Drainage and water logging	5
	(v) Water resources	7
	(vi) Air quality	6
	(vii) Noise environment	5
2	**Ecological Environment**	***40***
	(i) Ecologically sensitive area	25

S. No.	Parameters	Weightage Assigned
	(ii) Road side plantation	10
	(iii) Flora and Fauna	5
3	**Socio-economic Environment**	***20***
	(i) Cultural properties including heritage sites	5
	(ii) Common property resources (CPRs)	5
	(iii) Residential properties	6
	(iv) Commercial properties	4

The score for each environmental parameter for a particular sub-project has been calculated based on the analysis of that parameter and the assigned evaluation criteria. Accordingly, total score for each sub-project has been obtained for ranking them on environmental consideration.

6.8 VALUED ENVIRONMENTAL COMPONENTS (VECS)

The valued environmental component is defined as physical, ecological or socioeconomic component of an environment, which is of value (for any reason) in a project influence area (PIA). Based on analysis of screening data and reconnaissance survey following VECs have been identified for the project road:

a) Physical Environment

(i) Land use
(ii) Sources of construction material
(iii) Water resources
(iv) Air quality
(v) Noise environment

b) Ecological Environment

(i) Ecologically sensitive area
(ii) Road side plantation
(iii) Flora and Fauna

c) Socio-economic Environment

(i) Cultural properties including heritage sites
(ii) Common property resources (CPRs)
(iii) Residential properties
(iv) Commercial properties

6.9 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

6.9.1 Statutory Requirements

The applicability of environmental and other relevant rules and acts has been assessed. ***Table-6.3***shows required during different stages of road works.

Table – 6.3: Clearance Requirements

S. No.	Type of Clearance	Project Stage	Responsible Agency for Obtaining Clearance	Time Required

S. No.	Type of Clearance	Project Stage	Responsible Agency for Obtaining Clearance	Time Required
1	Prior Environmental Clerance after submission of FORM-1 and proposed TOR for EIA study.	Design Stage	Design Consultant and NHAI	1-2 Months
2	Compilation of EIA & EMP report based on approved TOR of MoEF	Design Stage	Design Consultant and NHAI	8-9 months
3	Kilometer-wise account in regard to felling of trees of different type and girth and value estimate of such trees based on realistic rates obtainable from concerned District forest office	Design Stage	Design Consultant	1 month
4	Clearance for tree cutting from Forest Dept.	Pre-construction	Design Consultant and NHAI	2-3 months
5	Forest clerance, if any for the project road	Pre-construction	Design Consultant and NHAI	5-6 months
6	Consents under Air and Water Acts for instalation and operation of stone crusher, hot mix plant and concrete batching plant	Pre Construction	Contractor	2-3 Months
7	Explosive License from Chief Controller of Explosives for transportation, use and storage of explosive for quarry blasting work, as per India Explosive Act 1984.	Pre Construction	Contractor	2-3 Months
8	Permit for storage of fuel oil, lubricants, diesel, etc. at construction camp as per rules of handling under the Manufacture, Storage and Import of Hazardous Chemical Rules 1989 from CGSPCB.	Pre Construction	Contractor	2-3 Months
9	Permit for Operation of Quarries from Dept. of Mines and Geology	Pre Construction	Contractor	2-3 Months
10	Permit for Extraction of ground water from State Ground water Board	Pre Construction	Contractor	2-3 Months
11	Labour license for engaging labour from Labour Commissioner	Pre Construction	Contractor	2-3 Months

6.10 BASELINE ENVIRONMENTAL SCENARIO

The consultants have collected baseline data during reconnaissance visit, survey for strip maps, discussion with PWD and locals. This data along with likely impacts has been presented in **Tables – 6.4.**

Table –6.4: Route Specific Environmental Impacts

Physical Environment				
Land Use	**Drainage and water logging**	**Water bodies near or along the project**	**Air Quality**	**Noise**
Agriculture : 14.68%	No project road	Yes. 3 minor rivers	Yes. Existing air	Yes. About 67.13%

Commercial : 20.14% Residential : 46.99% Barren: 16.90% Forest 1.28% **(Refer Annexure-6.2)**	stretch is effected by water logging raising	(GargaNadi, KhanjoNadi and BheraNadi) and nallah crossings. Plus 14 ponds located close to NH 23. Potential impact on these water bodies anticipated, especially during construction stage	quality seems to be much within permissible limits however, the baseline monitoring will be done during EIA study. About 67.13% of this road passes through habitat (human) area. Potential impacts on these receptors anticipated due to increased dust pollution during construction.	of this road passes through habitat (human) area. There are 8 schools, 33 temples and 2 hospitals within 100m as per feasibility survey (but only some will be directly affected). Adjacent number of sensitive location will be updated in EIA study. Potential impacts on these receptors anticipated due to increased noise level.

Ecological Environment

Ecologically Sensitive Area	Road side plantation	Flora and Fauna
There is no National park, Wild life Sanctuary and reserved forest within 10km of the project corridor However approximately 12.5km from chainage 48.000 to chainage 84.000 has protected forest within vicinity of 10 km.	The tree counting has been done within 15 meter of existing road centre line of NH-23 The counting of tree has been done with respect to different Girth size such as 30-60 cm, 60-90 cm, 90-120 cm, 120-150,150-180 cm,180-210 cm and more than 210 cm throughout the stretch. The total number of trees within 7 meter of existing road centre line is 2441 Nos.(Refer Annexure 3). It is as per the formation width of the project road. The major species of trees along the project road are mentioned in Annexure 4**.**	No endangered / rare species will be affected. Only loss of some common flora and fauna from COI and other ancillary sites anticipated.

Socio-economic Environment

Cultural properties	Common Resources Properties	Residential properties	Commercial properties	Lively hoods
As per feasibility survey there are some	As per feasibility	Some residential properties will be	Some residential properties will be	No potential adverse impact on

temples and a mosque along the project corridor but only a few will be affected. The adjact number to be affected will be given during EIA study	survey 34 water hand pump and 5 wells will be affected. No other CPR (such as community water tank, play ground, common grassing ground or pasture, market area, community building etc.) will be affected.	affected; however, the detailed information about cultural properties has been given in social report.	affected; however, the detailed information about cultural properties has been given in social report.	livelihoods anticipated, however, the detailed information about cultural properties has been given in social report

6.11 METHODOLOGY OF ENVIRONMENT SCREENING

As visualized in the project objectives, environment and social assessment are being carried out in close co-ordination with the design of the project. The object of screening exercise of the proposed project is the early determination of the potential magnitude of environmental and social impact of the project. Scope and screening study has been defined in many ways in various guidelines. For the present study, the scope of work defined in the document prepared by Ministry of Road transport and Highway, Govt. of India has been considered.

The major issues identified in the scope are:

I) Baseline scenario
II) Assessment of potential impacts
III) co-ordination of environmental screening with the preliminary study
IV) legal and policy framework and
V) Important environmental features along the alignment.

The present screening study includes these activities:

Study of Project Documents: The project documents have been studied to understand the project objectives, its main components, its boundary etc.

Study of Laws and Regulations: Laws and regulations enacted by Government of India and State of Jharkhand relevant to road construction and environment have been studied. The applicability of various acts and laws has been specified earlier.

Study of Guidelines, Standards etc.: Ministry of Environment and Forest (MoEF), Indian Road Congress, Bureau of Indian Standards, Asian Development Bank, World Bank etc. have published different useful documents, which are also studied for screening exercise.

6.12 RECONNAISSANCE SURVEY OF THE PROJECT IMPACT ZONE

To study critically all the feasible alternatives for proposed project road, a team of environmental experts in coordination with design & social team carried out reconnaissance survey of the project stretch in the month of May and June 2010. Important environmental components along the corridor of impact zone have been identified. These are trees, forests, public utilities, community resources, cultural sites etc. On the basis of background information, legal and policy positions etc. a checklist has been prepared to conduct screening exercise. Discussions with local people were also conducted to obtain their opinion about the project.

6.13 ANALYSIS OF DATA AND SCREENING EXERCISE

The collected data have been compiled to develop the environmental scenario of the project area and the sensitive components within the project area. The entire three alternatives have been considered under screening to identify the valued environmental components (VEC). The identification of valued environmental components in project area will help in further detailed study and preparation of Environmental Assessment report and Environmental Management Plan for the project at later phase.

6.14 PUBLIC CONSULTATION

The initial public consultations including consultations with communities located along the project road, NGO working in the area have been done, however, the detailed public consultation will be done during EIA study.

6.15 ENVIRONMENTAL EVALUATION OF PROJECT CORRIDOR

Based on baseline data collected, evaluation criteria established and environmental attributes selected a comparative evaluation has been done for project corridor. The scores obtained by the project road are given in **Annexure-6** which is summarized in **Table – 6.5**

Table – 6.5: Environmental Score of Project road

	Environmental Attribute	Total Score	Score Allocated to Project Highway
1	**Physical Environment**		
	i. Land use	**6**	**2.99**
	ii. Construction material	**6**	**5.00**
	iii. Soil erosion and sedimentation	**5**	**2.00**
	iv. Drainage and water logging	**5**	**0.00**
	v. Water resources	**7**	**1.00**
	vi. Air quality	**6**	**6.00**
	vii. Noise environment	**5**	**3.00**
	Sub Total	40	19.99
2	**Ecological Environment**		
	i. Ecologically sensitive area	**25**	**8.00**
	ii. Roadside plantation	**10**	**5.00**
	iii. Flora and fauna	**5**	**3.00**
	Sub Total	40	16.00
3	**Socioeconomic Environment**		
	i. Cultural properties	**5**	**2.00**
	ii. Common property resources	**5**	**2.00**
	iii. Residential properties	**6**	**1.00**

	Environmental Attribute	Total Score	Score Allocated to Project Highway
	iv. Commercial properties	**4**	**1.00**
	Sub Total (%)	20	6.00
	Overall Score	**100**	**41.99**

6.16 ENVIRONMENTAL IMPACTS

Most of the adverse impacts will be limited during construction stage. The potential key impacts identified are as follows:

- Impact on air quality due to increased dust level and vehicular emission mainly during construction stage;
- Impact on nearby human habitations due to increased noise level;
- Exploitation of forest resources and disturbance to forest area during construction and indirect impact during operation stage;
- Impact on receiving water bodies due to increased soil erosion and sedimentation.

The criteria of environmental categorization are given in **Table 6.6.** Based on score obtained**(47.05%) by** various environmental attributes, the project road is having medium impact (Rank 2).

Table-6.6:Ranking of project Routes and Scores limits criteria of Environmental categorization

S. No.	Impact Category	Score Limit
1.	**Low**	**<30%**
2.	Medium	30-50%
3.	High	50-80%
4.	Very High	>80%

6.17 ESTIMATES OF TREE FELLING

Estimates of Tree felling within 7 meter of existing road of centre line of NH-23 from Km 0.00 ITI More Chas to 84.00 Km Ramgarh is presented in ***Table-6.7***.

The rates of the trees with respect to different types/species, girth size and height have been collected from Forest Department (Division 4), Ranchi. As for the feasibility stage an estimate derived from various ranges of girth size have been considered for value estimation of the existing trees within 7 meter on either side of centre line of road NH-23 from Km 0.00 (ITI More Chas) to 84.00 Km (Ramgarh). Actual cost estimates of individual tree to be cut of different type/species, girth size and length will be worked out at the EIA study.The Table-6.7 gives the approximate estimates of the tree to be cut within 7 m on either side of existing road of the centre line.

Table 6.7: Estimates of Tree felling within 7 meter on either side of existing road with respect to centre line of NH-23 from Km 0.00 (ITI More Chas) to 84.00 Km (Ramgarh)

Details	NH-23		
	From Km 0.000 To Km 80.275	**Rate (Rupees)**	**Total Cost (Rupees)**

No. of Tree of **Girth Size 30 cm to 60 cm**	729	1,500	10,93,500
No. of Tree of **Girth Size 60 cm to 90 cm**	480	5,000	24,00,000
No. of Tree of **Girth Size 90 cm to 120 cm**	300	7,000	21,00,000
No. of Tree of **Girth Size 120 cm to 150 cm**	285	9,000	25,65,000
No. of Tree of **Girth Size more than 150 cm**	647	11,000	71,17,000
Total	**2441**		**1,52,75,500**

6.18 FINDINGS AND CONCLUSIONS

6.18.1 Findings

- As per ADB Environmental Assessment Guidelines of 2003, ADB Environmental Policy 2002, ADB Safeguard Policy, June 2009, World Bank Guidelines, NH-23 (ITI More Chas to Ramgarh) of the project road has been done categorised as **Category B** project.
- As per MoEF's Environmental Impact Assessment Notification dated 14th September 2006 & Amendment of 01st Dec, 2009, the project highway falls under **"Category A"** project, due to expansion of National Highways greater than 30 KM, involving additional right of way greater than 20m involving land acquisition at few places.
- There is no ecologically sensitive area such as national park, wildlife sanctuary, reserved forest, or critically polluted area within corridor of impact (10 km on either side) along the project road; however the details of the above ecological sensitive area within 15 km will be collected from Forest Department during filling of FORM-1 for the project road.
- This project road passes through mainly agricultural land, built up areas and approximately 12.5 km of the project road from Km 48 to Km 84 is in the vicinity of protected forest. Roadside plantation also exists at a number of places along the road. There will be negligible impact on forest land and existing plantation along the project road due to proposed paved shoulder (1.5 m width) and earthen shoulder (1.0 m width), on either side as the project road is already two lane with earthen shoulders all along the project corridor.
- The project does not entail the encroachment of precious ecology and historical or cultural areas. The project does not require dislocation or involuntary resettlement of people. Few residential, and commercial structure located within formation width will be shifted. This has been addressed as per the principles of the Resettlement Framework in social report.
- The valued environmental component is defined as physical, ecological or socioeconomic component of an environment, which is of value (for any reason) in a project influence area (PIA). Based on baseline data collected, evaluation criteria established and environmental attributes selected, a comparative evaluation has been done for project corridor. The scores obtained by the project road are 41.99 % having Medium impact.
- The total number of trees within 7 meter of existing road from the centre line is 2441. The rate of the trees with respect to different types & girth size has been collected from Forest Department. The rate of higher side with respect to girth size of different types has been considered for value of the existing tree within 7 meter from existing road centre line of NH-23 from Km 0.00 (ITI More Chas) to 84.00 Km (Ramharh).
- As for feasibility stage; cost estimate for various ranges of girth size have been considered for value estimation of the existing trees within 7 meter of centre line of road NH-23 from Km 0.00 (ITI More Chas) to 84 Km (Ramgarh). The total estimates (Rupees) of tree felling within 7 meter of existing road from centre line comes nearly Rs1,52,75,500, however, during DPR stage (EIA study), the actual estimates of individual tree to be cut of different type, girth size and length will be estimated.

6.18.2 Conclusions

- As per **"Category A"** project, the environmental clearance will have to be taken by the Client, NHAI, with the help of Design Consultant in two different stages i.e. Prior Environmental Clearance and the Final Environmental Clearance.

  - The prior environmental clearance will be taken after submission of FORM-1 with proposed TOR of EIA study and Feasibility Report of the project road to Ministry of Environment and Forests (MoEF), Delhi; and
  - The final Environmental clearance will be taken after EIA study as per approved TOR of EIA study by Expert Appraisal Committee (EAC), MoEF.

- The felling of tree will be restricted up to formation width of the project road. Alignment of project road will be changed to avoid cutting of trees where ever possible. Focus will be to avoid tree cutting by all means. Also, the actual estimates of individual tree to be cut of different type & girth size will be estimated during DPR stage (EIA study).The final cost estimate with respect to different species and their respective girth size will be calculated at the DPR stage (EIA study).

ANNEXURE-6.1

RAPID ENVIRONMENTAL ASSESSMENT (REA) CHECKLIST

Country/Project Title : **India/ Preparation of Detailed Project Report for Widening, Rehabilitation and Strengthening of NH-23 in the State of Jharkhand Under NHDP IVB**

Sector Division : **GOI, Ministry of Shipping, Road Transport & HIGHWAY (Department of Road Transport & Highways)**

Road Section : **From Km0+000 to Km 78+192 of NH-23**

Screening questions	Yes	No	Remarks
A. Project siting Is the project area adjacent to or within any of the following environmentally sensitive areas?		√	
▪ Cultural heritage site		√	
Protected area		√	Approximately 12.5 km of the project road from Km 0.00 to Km 84 stretch falls under protected forest. There will be negligible impact on forest land due to proposed paved shoulder (1.5 m width) and earthen shoulder (1.0 m width) on either side; however, the land requirement and number of tree to be cut due to proposed road design will be finalized during detailed project report (DPR) stage. All the up-gradation/rehabilitation works would be carried out within the existing ROW. Land acquisition will be done at some sections. No **Diversion of Forest Lands** is involved for the project road, however, the exact land requirement will be updated after design finalization of the project road during DPR stage. This minimizes the impact of road development on natural vegetation to a negligible extent.
Wetland		√	
Mangrove		√	
Estuarine		√	
Buffer zone of protected area		√	
Special area for protecting biodiversity		√	
B. Potential environmental impacts Will the project cause…			
Encroachment on historical/cultural areas; disfiguration of landscape by road		√	No encroachment on historical/cultural areas. Existing / licensed quarries will be used with necessary redevelopment to avoid any

Screening questions	Yes	No	Remarks
embankments, cuts, fills, and quarries?			disfiguration of landscape.
Encroachment on precious ecology (e.g. Sensitive or protected areas)?		√	Approximately 12.5 km of the project road from Km 48.00 to Km 84.00 stretch has protected forest in the vicinity of 10 km, however, there shall not be any encroachment on the same and the requirement of land and number of tree to be cut due to proposed road design will be finalized during detailed project report (DPR) stage
Alteration of surface water hydrology of waterways crossed by roads, resulting in increased sediment in streams affected by increased soil erosion at construction site?		√	The project road cross GargaNadi at 4.1 km, KhanjoNadi at 33.5 km, BheraNadi at 66.6 km on NH 23. Project involves rehabilitation / widening of some existing CD structures which will not alter hydrology. Mitigation measures will be adopted for avoiding soil erosion /sedimentation during construction.
Deterioration of surface water quality due to silt runoff and sanitary wastes from worker-based camps and chemicals used in construction?	√		Locating camps away from water bodies and providing septic tanks & soak pits as sewage disposal facilities
Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing?	√		Dust collection and suppression system for crushers and hot mix plants, water sprinkling on earthen surface used by construction vehicles
Noise and vibration due to blasting and other civil works?	√		Locating quarries at least 1km form settlement and public properties, adopting controlled blasting, providing PPEs to workers etc.
Dislocation or involuntary resettlement of people			Has been updated in social report
The other social concerns relating to inconveniences in living conditions in the project areas that may trigger cases of upper respiratory problems and stress?		√	As a result of the widening and strengthening of this road section, the communication and accessibility will increase which will lead to develop the socio-economic and living condition of the area. It would not trigger any respiratory problem or stress in the long run as the bottle necks on the road will be removed. Traffic flow will be smooth and air pollution will decrease.
Hazardous driving conditions where construction interferes with pre-existing roads?	√		Suitable traffic management plan will be followed as per IRC 55 and MoRTH Specification for Road and Bridge Works along with planned construction to minimize impact on road users.
Poor sanitation and solid waste disposal in construction camps and work sites, and possible transmission of communicable diseases from workers to local populations?	√		Construction camps will be provided with necessary water supply, sanitation, storm water drainage, solid waste management and first aid facilities.

Screening questions	Yes	No	Remarks
Creation of temporary breeding habitats for mosquito vectors of disease?	√		Sound borrow area and quarry management, proper disposal of liquid effluent at camps to avoid water stagnation and creation of breeding grounds.
Dislocation and compulsory resettlement of people living in right-of-way?	√		Has been updated in social report
Accident risks associated with increased vehicular traffic, leading to accidental spills of toxic materials and loss of life?	√		Suitable road safety measures to be incorporated in design and creating awareness amongst road users on safe driving.
Increased noise and air pollution resulting from traffic volume?	√		Ambient air quality will improve. Slight increase in noise level is envisaged but no considerable impact is anticipated in the long run.
Increased risk of water pollution from oil, grease and fuel spills, and other materials from vehicles using the road?		√	3 minor seasonal rivers crosses the project road. Risk of water pollution is negligible. For most of the time in the year there is very little water in these rivers.

	should be categorized as an A project.
X	**should be categorized as a B project**
	should be categorized as a B project in an environmentally sensitive area[1].
	should be categorized as a C project.

ANNEXURE-6.2

LAND USE PATTERN ALONG NH23 PROJECT ROAD

Sl.No	ExistingChainage (Km)		DesignChainage (Km)		Length (Km)	Existing ROW (m)	Proposed ROW(m)
	From	To	From	To			
1	NA	8+900	0+000	6+900	6+900	Bypass	60
2	8+900	12+140	6+900	10+200	3+300	28.8	45
3	12+140	15+150	10+200	13+130	2+930	22.5	60
4	15+150	18+405	13+130	16+500	3+370	21.5	45
5	18+305	18+292	16+400	16+900	0+500	21.0	120
6	18+292	NA	16+900	19+300	2+300	NA	60
7	NA	NA	19+300	19+800	0+500	NA	45
8	NA	NA	19+800	21+600	1+800	NA	60
9	NA	25+810	21+600	23+550	1+950	NA	45
10	25+810	26+513	23+550	24+250	0+700	22.8	30
11	26+513	28+960	24+250	26+600	2+350	22.8	45
12	28+960	30+940	26+600	28+600	2+000	22.3	30
13	30+940	31+685	28+600	29+350	0+750	23.0	45
14	31+685	32+465	29+350	30+100	0+750	22.7	30
15	32+465	33+630	30+100	31+250	1+150	21.8	45
16	33+630	35+605	31+250	33+200	1+950	22.0	30
17	35+605	36+455	33+200	34+050	0+850	22.1	45
18	36+455	38+583	34+050	35+150	1+100	21.9	30
19	38+583	38+187	35+150	35+750	0+600	21.8	45
20	38+187	43+092	35+750	40+650	4+900	22.2	30
21	43+092	51+658	40+650	48+950	8+300	22.3	45
22	51+658	53+977	48+950	51+100	2+150	22.5	30
23	53+977	54+571	51+100	51+750	0+650	22.6	45
24	54+571	59+000	51+750	56+080	4+330	22.8	30
25	59+000	59+744	56+080	56+880	0+800	22.1	45
26	59+744	61+858	56+880	59+000	2+120	22.8	30
27	61+858	62+688	59+000	59+800	0+800	21.7	45
28	62+688	64+000	59+800	61+100	1+300	21.3	30
29	64+000	65+320	61+100	62+380	1+280	21.4	45
30	65+320	71+408	62+380	68+450	6+070	21.9	30
31	71+408	71+922	68+450	68+950	0+500	22.7	80
32	71+922	73+015	68+950	70+050	1+100	22.8	30
33	73+015	73+305	70+050	70+400	0+350	22.5	45
34	73+305	81+200	70+400	78+192	7+792	22.5	30

LAND USE IN KM	**Km**
Land Use (Agricultural Land)	12.600
Land Use (Built-up Area)	57.586
Land use (Forest)	1.100
Land Use (Barren Area)	14.500
Land use (Environmental sensitive area)	0.000
LAND USE IN %	**%**
Land Use (Agricultural Land)	14.68
Land Use (Built-up Area)	67.13
Land use (Forest)	1.28
Land Use (Barren Land)	16.90
Land use (Environmental sensitive area)	0

ANNEXURE -6.3

TREE CUTTING DETAILS ALONG THE FORMATION WIDTH OF THE PROJECT ROAD

Sl. No	TREES	G1	G2	G3	G4	G5	G6	G7	Total
1	Ashok	5	2						7
2	Amrud		1						1
3	Babool	1						1	2
4	Baken	11	2	8	2	2		2	27
5	Shisham	154	77	78	76	40	7	6	438
6	Bargad	4	3	3	7	8	9	22	56
7	Chhatni	2	1	1					4
8	Eucalyptus		10	10					20
9	Gamhar	89	13	4			1	1	108
10	Gulmohar	10	17	9	2	4	2	2	46
11	Imli	4	1	4		2	1	4	16
12	Jalebi	4	6	2	3	3	1	1	20
13	Jamun	8	14	9	2	6	8	16	63
14	Kadam	9	14	11	3	1		3	41
15	Kahua	12	6	6	15	23	21	41	124
16	Kanail	3	2						5
17	Karanj	139	45		1		13	1	199
18	Karuaini				4				4
19	Katahal	19	10	1	2			2	34
20	Khajur		6	3					9
21	Kusum			2			4	3	9
22	Mahua		1	9	16	5	7	9	47
23	Mango	23	6	6	11	31	17	50	144
24	Neem	20	6	8	9	7	2	14	66
25	Palas	34	55	7	5	29	1	8	139

Sl. No	**TREES**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**Total**
26	Peepal	2	2	2	8	13	11	48	86
27	Putus	3		1					4
28	Sagwan	2							2
29	Sahjan		2						2
30	Sakhua	10	52	64	93	79	28	13	339
31	Semal	15	41	21	9	2			88
32	Siris	96	57	28	14	4	1	6	206
33	Teak	26	10	3	3			1	43
34	Urhul		4						4
35	Sindwa		3						3
36	Ber	15	10						25
37	Bel	9	1						10
	Total	**729**	**480**	**300**	**285**	**259**	**134**	**254**	**2441**

Sl. No	**Girth**		**Size(Circumference 1.5 m above the ground level)**
1	G1		30-60cm
2	G2		60-90cm
3	G3		90-120cm
4	G4		120-150cm
5	G5		150-180cm
6	G6		180-210cm
7	G7		210 and more

ANNEXURE –6.4

Species of Trees along the project road	
1	Ashok
2	Amrud
3	Babool
4	Baken
5	Shisham
6	Bargad
7	Chhatni
8	Eucalyptus
9	Gamhar
10	Gulmohar
11	Imli
12	Jalebi
13	Jamun
14	Kadam
15	Kahua
16	Kanail
17	Karanj
18	Karuaini
19	Katahal
20	Khajur
21	Kusum
22	Mahua
23	Mango
24	Neem
25	Palas
26	Peepal
27	Putus
28	Sagwan
29	Sahjan
30	Sakhua
31	Semal
32	Siris
33	Teak
34	Urhul
35	Sindwa
36	Ber
37	Bel

7.0 COST ESTIMATION

7.1 GENERAL

The Estimates have prepared by taking quantities from the drawings. The quantities have been grouped under different subheads. The subheads adopted for preparation of estimate are based on MORT&H Specifications for roads and bridge works (Fourth Revision, Reprint of August 2008) issued by Ministry of Road Transport & Highways. However where drawings are silent, the quantities have been worked out from the other data as available.

7.2 SUBHEADS

The Estimate has been prepared under the following subheads for computing the quantities:

1. Site Clearance
2. Earthworks
3. Sub-base and base course
4. Bituminous Course
5. Cross Drainage Works (Culverts)
6. New Bridges/Underpasses/Grade Separators/ROBs
7. Traffic Signs, Markings and Road Appurtenances
8. Repair and Rehabilitation
9. Maintenance or Roads and Bridge Structures

The item of work has been provided only in summarized form without detailed description of work and materials. All individual items however have/Reference to the relevant Sections/Clauses of MORT &H Specification as applicable. The MORT&H Sections/Clauses cover input details, method of construction, mode of measurement etc. The quantities grouped under 'Miscellaneous' subheads include cost logistic items like transport for movement of supervisory staff and maintenance of photographic records for the work. The 'Maintenance' subhead however, includes the items required for maintaining existing carriageway and structures and providing periodical renewal coat etc.

7.3 CENTAGES

The centages have been included @25% over amount of BOQ for Physical & price contingencies, interest during construction and other financing costs, pre - construction expenses as per provisions of MORT&H.

7.4 COST

SUMMARY OF COST

Item No.	Description	Total Amount (Rs. In Crores)
BILL NO. 1	SITE CLEARANCE	2.48
BILL NO. 2	EARTH WORKS	49.93
BILL NO. 3	SUB-BASES AND BASES COURSES	69.95
BILL NO. 4	BITUMINOUS COURSES	160.31
BILL NO. 5	CROSS DRAINAGE WORKS(CULVERTS)	7.28
BILL NO. 6	BRIDGES/ROBs	33.08
BILL NO. 7	TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES	17.91
BILL NO. 8	REPAIR AND REHABILITATION	0.10
BILL NO. 9	MAINTENANCE OF ROADS	0.57
TOTAL CIVIL CONSTRUCTION COST AS PER JHARKHAND STATE SOR 2013-14		**341.61**
Contingency@2.8%		9.57
Construction Supervision Charge @ 2%		6.83
Administrative Charge @ 1%		3.42
Quality Control Charge @ 1%		3.42
Road Safety Cell Audit Charge @ 0.5%		1.71
Maintenance during DLP payable to Concessionaire @ 3.5%		11.96
Escalation @ 5% per annum for 2 years i.e. 10% during construction payable to contractor		34.16
	TOTAL	**412.67**
Environmental Impact Assessment, Land Acquisition, Resettlement and Shifting of Utilities		60.00
Total Capital Cost		**472.67**
Cost per Km (Construction Cost for 78.192km)		4.37
Cost per Km (including centages for 78.192km)		6.04
Construction Period		**730 days**
Date of start of the Project		

8.0 ECONOMIC AND COMMERCIAL ANALYIS

8.1 GENERAL

The construction of roads plays a significant role in a developing country like India in the overall development activities as a whole. In fact, the construction of roads brings a variety of benefits to the different development sectors such as agriculture, industry, hydro-power, mineral resources, education, health, tourism, and other service sectors as well. Road is one of the key element to provide an easy access to the people as the primary means of transport to the people of rural as well as urban areas. Planning and development of such a vital infrastructure like road transport has to be made in the constraints of the scare resources under the increasing road demand of the people concerned. Thus the governments both at the state level as well as at central level have given a high priority in the overall development of road sector throughout the country in general.

The project road under study is National Highway no 23. It starts from Chas a junction of National Highway 23 and 32.It further moves towards south East direction to reach Gola and further down it reaches Ramgarh and Bokaro. Chas a municipality in Bokaro district in the state of Jharkhand, India. Chas is also included in the urban area of Bokaro Steel City having Population of More than 250000. Chas market is one of the biggest wholesale markets in the region. It is situated on the junction of National Highway 23 and National Highway 32. Chas comes under the agglomeration of Bokaro Steel City..

When the road is constructed, the socio-economic impacts can be seen in all development sectors. These benefits can also be measured on the basis of using a large-scale time-series data in establishing an empirical relationship between the road density and different development parameters. In addition, the road demand estimation models could have also been developed in relation with multiple parameters, but development of such models is not feasible due to lack of specific data needed. Some of the indirect benefits could have been determined by using such empirical relations on the basis of correlating similar socio-economic, cultural and geographical locations. However, in absence of these representative empirical models, the common logic has been applied on the existing statistical data to estimate the distinct benefits with a view to use these values in the economic model considered in the course of this study.

The economic analysis involves comparison of project costs and benefits under the "with" and “without" project conditions and determining the Economic Internal Rate of Return (EIRR) of the project using discounted cash flow technique. This shows the return, which the society could expect from the proposed investment during the project life, i.e. analysis period.

8.2 APPROACH

The approach used to evaluate the proposed road under this DPR study follows standard practice of comparing life cycle road agency and user costs with and without project to determine Economic Internal Rate of Return (EIRR) based on a 12 percent discount rate. The Highway Development and Management Model, HDM-4 has been used as a basis for determining the Vehicle Operating Costs (VOC) in the specific context of these states. Vehicle Operating Costs, Travel Time with and without project have also been used to determine the net benefits gained in considering the road parameters and surface conditions before and after the implementation of the project. The analysis focuses on savings in transport costs. But value added from better transport links resulting in new industries and employment other than increased literacy rate in rural areas are not quantified in this analysis as they are captured through benefits to the generated traffic. The main assumptions about

maintenance and improvement strategies "with" and "without" the project are discussed below.

Initially the VOC costs and travel time costs have been determined by HDM-4 under the existing conditions of road parameters, road roughness, rise/fall, road width, and curvature, etc. Initial tests showed that the benefits obtained due to the difference between the VOCs and the travel time under "with" and "without" the project is found sufficient to have EIRR more than 12 %. In the course of the economic analysis, a matrix of the costs and benefits for various combinations of risks in considering the worst scenarios between the costs and benefits has also been used in determining the EIRR and NPV of economic analysis.

The project analysis period is considered for a period of 20 years and the construction period is only for 2 years. Considering that the project implementation shall start in 2011 and it will be completed during 2012. Traffic data have also been analyzed to estimate the recent traffic growth rate. Thus the project period will start in 2013 and will end in 2032 year. Both the periodic and routine maintenance works are considered. The periodic maintenance, every five years is proposed with thin overlay of 40 mm BC. The analysis year cost for 40 mm thin BC is 2.827million / km and it is proposed in every 5 years. Based on the detailed designs, financial costs has been estimated and it has been converted into economic costs by multiplying with Standard Conversion Factor (SDF) of 0.85 as suggested by World Bank for highways in India. Social impact assessments on the project road have been carried-out and these aspects are included separately. The main quantifiable benefits of the investment are (i) savings in vehicle operating costs (VOC) for existing traffic; and (ii) VOC savings for generated traffic. Due to the low economic activities and prevailing unemployment and underemployment in the region, a low value of time has been assumed in the analysis. However this situation is expected to change as economic activity in the state and adjoining area improves. The statistical data on literacy, agriculture, industry and the employment clearly indicate that there could be a substantial economic impact to these sectors and even a partial improvement on these development sectors can generate large benefits. However, these benefits are not considered in the costs benefits analysis model used to determine both the EIRR and Net Present Value (NPV) in this DPR study.

Physical road characteristics such as formation and pavement width and type have been used in HDM model together with other parameters such as terrain, high of cut, height of fill, natural surface slope, rise /fall and the road curvature. Road condition parameters such as cracking, rutting, area of failed areas, and potholes, travel speed possible due to roughness, etc. are considered while considering with and without project in determining the VOC and travel time. For roads to be reconstructed under the Project, design standards consistent with the Indian Roads Congress (IRC) stipulations, specifications and guidelines have been adopted. Based on the traffic surveys carried out, traffic data analyzed in order to use it through HDM to determine the VOC costs. Under both the normal as well as generated traffic data, Vehicle Operating Costs have been determined to examine the different cases of risks of economic analysis to assess the minimum threshold of EIRR as per the ADB framework on such road projects. The project road section is a new construction with 2- lane with hard shoulder as well as earthen shoulder.

8.3 OBJECTIVE

The main objective of Economic Analysis is to provide a wide range of options to carry the tasks of determining the various components of vehicle operating costs (VOC) and the economic analysis of determining Net Present Value (NPV) and Internal Rate of Return (IRR) under various alternative options of sensitivity analyses.

Generally speaking, any investment on a road project needs to be evaluated by determining the user's costs with economic analysis of Net Present Value (NPV) and Internal Rate of Return (IRR). The net benefits determined by the difference in vehicle operating costs, and the costs of time saving under the "with" and "without" project conditions may not alone reflect all types of economic and social benefits of the society in the economic analysis of a road project. The road project can also be of different project cycles such as planning stage, procurement stage, construction stage, and post-construction stage.

The economic analysis of the road project has been carried-out by determining the various components of the user's costs, which are dependent upon the traffic volume, rise and fall, curvature, road condition, altitude, and the costs of the items such as vehicles, tyres, labour charges, and the fuel charges, etc. In addition, the empirical relations on the user's costs are based on various parameters like the horizontal curvature, rise and fall of the longitudinal profile on the road section-wise basis in general. The user's cost of the existing road also depends upon the road surface condition of roughness to the great extent in the context of the road project considered under this study.

Economic analysis should rely on discounting methods and incorporate sensitivity analyses. Thus the project is evaluated based on the direct and indirect effects on the economy of the zones influenced by the construction of the roads in the States of Orissa, India. Thus VOC costs include different parameters which are as below:

- Vehicle Speed,
- Fuel Consumption,
- Tyre Wear,
- Maintenance Parts,
- Maintenance Labour,
- Lubricant Consumption,
- Crew Requirements,
- Depreciation Costs,
- Interest Charges,
- Overhead Costs, and
- Passenger Delays Value

The project is further subjected to sensitivity analysis by assessing the effects of adverse changes in the key variables on the base EIRR. In this, project costs are increased by 15 percent and benefits are reduced by 15 percent.. This helps to gauge the economic strength of the project to withstand future risks and uncertainties.

8.4 DETAILS OF INPUTS IN ECONOMIC ANALYSIS

8.4.1 Costs

The costs considered comprise agency costs and costs to road users as follows.

- Society Costs
  - Road Agency Costs
  - Road Users Costs
- Agency costs
  - Construction and maintenance
  - Road user costs

- Vehicle Operating Costs
  - Travel Time Costs
  - Congestion Costs

The agency costs comprise the costs of road construction and maintenance. Road user's costs comprise vehicle operating costs grouped into time and distance dependent costs. Road congestion costs imply increased vehicle operating costs as a result of increased travel time and consumption of fuel and lubricants, etc.

Road users experience different costs in the "With Project" and "Without Project" conditions. The benefits to road users are contributed by the savings in costs. Increasing traffic volumes as a result of the project implies more vehicle kilometre and hence more vehicle operating costs and, possibly showing more saving in "with project conditions" viz. benefits as a result of the project.

All costs for the economic analysis are given in economic terms thus ignoring transfers in the form of taxes and duties.

8.5 OTHER INPUTS

Analysis period	20 years
Discount rate	12 %
Construction Period	2 years
Improved Road to be opened to traffic in	2014 (Open to Traffic)
Standard Conversion factor	0.85
Salvage value	15 %

8.6 ROAD DETERIORATION FACTORS

The deterioration factors used in the study have to be derived from the MORTH study on Vehicle Fleet Modernization and Road Use Charges, Final Report, April 1989. This report gives a range appropriate for Indian conditions, for each of the users defined deterioration factors. Recommended deterioration factors for the project and adopted for this project are given below in **Table-8.1.**

Table-8.1: Standard Deterioration Factors

Sl. No.	Distress Mode	Recommended Range of Deterioration Factors	Adopted Deterioration Factors
1	*Cracking*		
	(a) Cracking Initiation	1.00 – 1.50	1.00
	(b) Cracking Progression	1.25 – 2.00	1.00
2	Raveling		
	(a) Reveling Initiation	0.40 – 0.50	1.00

Sl. No.	Distress Mode	Recommended Range of Deterioration Factors	Adopted Deterioration Factors
3	Potholing		
	(a) Potholing Progression	1.00 – 1.50	1.00
4	Rut Depth		
	(a) Rut Depth Progression	1.25 – 1.75	1.00
5	Roughness		
	(a) Roughness Progression	1.00 – 2.00	1.00

The adopted values are taken for the study keeping in consideration the environmental conditions pertaining to the road packages in the study corridors. It should be noted, however, the term deterioration factor differs from their default value – which is 1.0 for all factors. All changes in values relative to the default value tend to increase the deterioration predicted by the model, resulting in a more rapid increase in the roughness predictor, especially, for the existing pavements.

8.7 TRAFFIC COMPOSITIONS

Fast moving vehicles are considered from the traffic study conducted in the year 2010. Slow moving vehicles are not considered in the analysis.

8.8 PROJECT COST

The construction cost includes cost of strengthening and widening of the existing facility to the required lane configuration. Economic cost has been worked out by converting the financial cost using standard conversion factor of 0.85 as suggested by World Bank for highway projects in India. Computed capital construction cost per kilometre for the project road sections with the improvements considered are given in Table-8.2.

Table-8.2: Capital Construction Costs (Financial cost / Economic cost)

Financial Cost Rs. in million.	EconomicCost Rs. in million.	Improvements Considered
2218.82	1774.54	Widening of existing 2 lane NH 23 to 2 Lane with paved shoulder

8.9 ROUTINE AND PERIODIC MAINTENANCE

Routine maintenance and periodic maintenance costs have been considered from the rate analysis. It is considered to escalate the maintenance cost by 15% every year for the scenario 'Without Project Concept' and 'With Project Concept' the escalation is considered 5% per annum

8.10 VEHICLE OPERATING COSTS (VOC)

Vehicle operating costs depend upon road conditions on the one hand and vehicle characteristics, utilization and prices on the other. Vehicle characteristics; prices of new vehicles and other inputs; vehicle utilization and values of time have been applied through HDM to determine VOC.

8.11 DETERMINATION OF NET PRESENT VALUE (NPV)

The net present value (NPV) of a project is defined as the value obtained by discounting, separately for each year, the difference of all the cash outflows and inflows accruing throughout the life of a project at a fixed, pre-determined interest rate. This difference is discounted to the point at which the implementation of the project is supposed to start. A separate computer-based model has been used to determine the NPV and the other parameters for financial analysis. The Consultant has used an Economic Analysis Model (EAM) linked with VOC model for determining the VOC components of roads to determine the significant parameters for the financial analysis. The Net Present Value (NPV) of the investment option, m, relative to the base option, n, is the sum of the discounted annual net benefits or costs, which can be determined by the following relation:

$$NPV_{(m-n)} = \sum_{y-1}^{y} \frac{NB_{y(m-n)}}{[1+0.01*r]^{(y-1)}}$$

Where, $NB_{y(m-n)}$ = Net economic benefit of investment option m relative to base option n in year y.

r = Discount rate (%)

y = Analysis year (y=1,2,……,y)

8.11.1 Internal Rate of Return (IRR)

The internal rate of return (IRR) is the discount rate at which the present value of the cash inflows is equal to the present value of cash outflows. In other words, it is the rate at which the present value of the receipts from the project is equal to the present value of the investment, and the net present value is zero. The computer-based model permits to search the discount rate at which the NPV value that will be zero. The Internal Rate of Return (IRR) can be determined by solving the equation of Net Present Value on the basis of making NPV equal to zero. The below given equation will permit to determine the value of Internal Rate of Return. Thus IRR of the total investment outlay is also used to determine the conditions of loan financing since it indicates the maximum interest rate that could be paid without creating any losses for the project proposal. The EIRR have been calculated by considering the opportunity cost of capital in India to be 12%.

$$\sum_{y-1}^{y} \frac{NB_{y(m-n)}}{[1+0.01*r]^{(y-1)}} = 0$$

By iteration process, the solution is searched at 5 percent interval of discount rates between -95 to 500 percent.

8.11.2 Discount Value

For all practical purposes of financial analysis, the discount value is used and the relation gives it:

$$K = \left[1 + \frac{I}{100}\right]^{y-1}$$

Where,

Travel Time = Road Length/Speed of Vehicle

I = the annual discount rate in percent.

y = the user-specified year.

8.11.3 Benefit Cost Ratio

The Benefit Cost Ratio of investment option m relative to the base option n is the ratio, which can be determined by the relation, which is as below:

$$BCR_{(m-n)} = \frac{NPV_{(m-n)}}{C_m} + 1$$

where,

$BCR_{(m-n)}$ = Benefit cost ratio of investment option m relative to base option n.

$NPV_{(m-n)}$ = Discounted total net benefit of investment option m relative to base option n.

This is the Net Present Value at discount rate r.

C_m = Discounted total agency costs of implementing investment option m.

$$FYB_{(m-n)} = \frac{100\, x\, NB_{y^0(m-n)}}{\Delta TCC_{(m-n)}}$$

8.11.4 Benefit Components

$$DTCNmny = \sum_{e=1}^{n} TNiy\left[UTniy - UTmiy\right]$$

The benefit components of a road project can be determined by considering the benefits generated by the difference of the vehicle operating costs between the two options considered. The actual calculation can be presented as follows:

Where, TNiy = Numbers of vehicle trip per year of group i normal traffic in the baseline route (any option of the compared alternatives) in the year Y. UCiiy = the average operating cost per vehicle trip in the year Y, at the route j [j = m or n].

The operating benefits due to traffic generated can be also determined by the similar relation as presented above.

(2) The travel time benefit due to the normal traffic be determined by the relation:

For each group of vehicle, one has to determine the travel time and then the cost per vehicle. Finally, the average travel time cost per vehicle is determined and so the benefit due to the difference in the travel time can be given by:

Where, UTjiy = the average travel time cost per vehicle per trip of vehicle group i on the option j in the year y. [J = m or n]. UTjib

= the average travel time cost per vehicle per trip of vehicle group i on the option j in the base year y. [J = m or n].

The average travel time benefit per trip of each type of vehicle could be decided by determining the time of travel depending upon the distance & speed of the vehicle.

(3) The vehicle travel time benefit due to the generated traffic can be determined by the similar relation.

Savings in vehicle operating costs and travel time could be considered as endogenous benefits. Other type of savings such as reduction in accidents, saving in the environmental impacts due to noise, and air pollution could be considered as exogenous variables.

8.12 STEP-WISE PROCEDURE

General

Economic Internal Rate of Return (EIRR) is carried-out by determining costs and benefits of each road project considered. The project costs is directly determined on the basis of using the total costs (multiplied by Standard Conversion Factor SCF) assumed as 0.85) considered as economic costs. Major benefits are determined by difference of Vehicle Operating Costs (VOC) and the Travel Time difference between the two options considered "with" and "without" project conditions. In addition to these project costs, other costs such as a) routine maintenance, b) periodic maintenance are also considered for the entire project period. Other benefits such as increase in employments, increase in agriculture production, increase in tourist number and improvement in accessibility to hydropower and mineral resources are not considered. Although the projections of the benefits on these aspects have been made by using the growth trend in the similar socio-economic and geographical locations in other parts of the country, these benefits are not included. While determining the Economic Internal Rate of Return (EIRR), different technical steps and procedures are adopted. These quantitative procedures are described as below:

Beginning Step (0)

The financial costs of both the construction costs and maintenance costs are converted into economic costs. Different parameters such as construction period, discount rate, analysis period are considered. Prepare the normal traffic as well as the generated traffic with consideration of traffic growth rates. Return to the Step-1 below.

$$DVCNmny = \sum_{N-1}^{N} TNiy\,(UCniy - UCmiy)$$

Step-1

Use HDM to determine the total VOC costs on the basis of using different parameters essential to determine the VOC costs under the present or existing conditions of road project. In addition, determine the travel time under the existing situation. Once these parameters are determined, return to Step-2 as below.

Step-2

Use HDM to determine the total VOC costs on the basis of using different parameters essential to determine the VOC costs under the future/proposed road conditions. In addition, determine the travel time under proposed improvements of the road project. Once these parameters are determined, return to Step-2 as below.

Step-3

Prepare a matrix of costs and benefits in Excel format for the entire construction and analysis periods on the basis of projecting growth rates of costs, and benefits. Costs components include construction costs, routine maintenance costs and periodic maintenance costs. But the benefits include benefits due to difference of VOC costs, benefits due to saving in travel time (not considered) and other benefits (not considered) determined on the basis of using separate estimations based on available statistical data. Growth projections of both the costs and benefits streams are also estimated in Excel data sheet with a view to use this table for further economic analysis. Return to the Step-4 below.

Step-4

A separate computer based model called as Economic Analysis Model (EAM) is used for utilizing the cost-benefit matrix as input data prepared under different cases of sensitivity to generate a general report on the economic analysis of EIRR and NPV. In order to conduct or repeat the Economic Analysis procedure under various risks, return to Step-5, Step-6, Step-7, Step-8, Step-9, Step-10, and Step-11 respectively depending upon different risks considered. Otherwise return to Step-12 to terminate the process.

Step-5

Increase the construction costs by 15% in the Excel sheet called as the cost benefit matrix. Repeat the same procedure through Step-3 above.

Step-6

Reduce the benefits by 15% in the Excel sheet called as the cost benefit matrix. Repeat the same

Step-7

Increase the construction costs by 15 % by reducing the benefit by 15 % to examine the worst case in the cost-benefit matrix. Repeat the procedure of Economic Analysis through the Step-3 above.

Step-8

Terminate the entire process of Economic Analysis by deriving the findings.

8.13 SENSITIVITY ANALYSIS

Economic analysis has been carried-out under the assumptions of different risks. The economic analysis includes four sensitivity tests or analysis to address various risks which are presented as below:

- Case-I. Normal-estimation of costs (Base Cost and Base Benefit).
- Case-II. Over-estimation of Costs (Base Cost +15 % and Base Benefits).
- Case-III. Under-estimation of Benefits (Base costs and Base Benefits- 15 %)
- Case-IV. Over-estimation of costs and under-estimation of benefits (Base costs +15% and Base benefits- 15%).

The costs and benefits have been prepared for all the options considered under sensitivity analysis to derive different values of EIRR. Four different matrixes of costs and benefits have been prepared in Excel format by considering all the combinations defined in sensitivity options.

Summary Results of Sensitivity Analysis (EIRR)

Case-I (%)	Case-II (%)	Case-III (%)	Case-IV (%)
18.59	16.10	13.77	12.04

8.14 FINANCIAL ANALYSIS AND COMMERCIAL VIABILITY

Various outputs of Financial Analysis are presented in the tabular form below:

Financial Analysis of NH-23 (IRR)

No of Years	Year	Initial Construction Cost after 25% VGF (A)	Routine Maintenance @ Rs. 150,000/Km/year (B)	Periodic Maintenance @ Rs. 11,55,000/Km (C)	Operation &Maintenance Cost @ Rs200000/Toll/Month (D)	Total Cost E= A+B+C+D	Total toll Revenues (F)	Net returns (G)
	2011							
	2012	975.73				975.73	0.00	975.73
	2013	975.73				975.73	0.00	975.73
1	2015		11.73		4.80	16.53	241.46	224.93
2	2016		11.73		4.80	16.53	261.14	244.61
3	2017		11.73		4.80	16.53	282.42	265.90
4	2018		11.73		4.80	16.53	305.44	288.91
5	2019		11.73	90.31	4.80	106.84	330.34	223.50
6	2020		11.73		4.80	16.53	357.26	340.73
7	2021		11.73		4.80	16.53	386.37	369.85
8	2022		11.73		4.80	16.53	417.86	401.34
9	2023		11.73		4.80	16.53	451.92	435.39
10	2024		11.73	90.31	4.80	106.84	488.75	381.91
11	2025		11.73		4.80	16.53	528.59	512.06
12	2026		11.73		4.80	16.53	571.66	555.14
13	2027		11.73		4.80	16.53	618.26	601.73
14	2028		11.73		4.80	16.53	668.64	652.11
15	2029		11.73	90.31	4.80	106.84	723.14	616.30
							IRR	**13.86%**
Note: All Figures in Millions							**NPV**	**225.28**

Financial Analysis of NH-23 (Equity IRR) (25%VGF)

No of Years	Year	25% VGF	Inflow from Loan	Initial Construction Cost	Principal Repayment	Interest on Loan @12% p.a.	Routine Maintenance @ Rs. 1,22,000/Km/year	Periodic Maintenance @ Rs. 11,55,000/Km	Operation & Maintenance Cost @ Rs. 1,50,000/ Toll/Month	Total toll Revenues	Net returns
	2011										
	2012	325.24	683.01	(1300.97)						0.00	(292.72)
	2013	325.24	683.01	(1300.97)	(136.60)	(81.96)				0.00	(511.28)
1	2014				(273.20)	(147.53)	(9.54)		(3.60)	241.46	(192.41)
2	2015				(273.20)	(114.75)	(9.54)		(3.60)	261.14	(139.95)
3	2016				(273.20)	(81.96)	(9.54)		(3.60)	282.42	(85.88)
4	2017				(273.20)	(49.18)	(9.54)		(3.60)	305.44	(30.08)
5	2018				(136.60)	(16.39)	(9.54)	(90.31)	(3.60)	330.34	73.89
6	2019						(9.54)		(3.60)	357.26	344.12
7	2020						(9.54)		(3.60)	386.37	373.24
8	2021						(9.54)		(3.60)	417.86	404.73
9	2022						(9.54)		(3.60)	451.92	438.78
10	2023						(9.54)	(90.31)	(3.60)	488.75	385.30
11	2024						(9.54)		(3.60)	528.59	515.45
12	2025						(9.54)		(3.60)	571.66	558.53
13	2026						(9.54)		(3.60)	618.26	605.12
14	2027						(9.54)		(3.60)	668.64	655.50
15	2028						(9.54)	(90.31)	(3.60)	723.14	619.69
										EQUITY IRR	**14.65%**
Note: All Figures in Millions										**NPV**	**243.69**