# ANALYSIS OF FLEXIBLE PAVEMENT

A PROJECT REPORT

*Submitted by*


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*in partial fulfillment for the award of the degree of*

BACHELOR OF TECHNOLOGY

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Bistumpur, Jhinkpani, West Singbhum, Jharkhand 833215

2022

# DECLERATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

.....

Signature of the Students

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CERTIFICATE

Certified that this project report titled "**ANALYSIS OF FLEXIBLE PAVEMENT"** is the bonafide work of **"**SAGEN TUDU [18011435006] MANISH BHAGAT [18011430011]MADHUSHUDAN HEMBROM [18011435003] MARSEL KISKU [18011435004] FIRDOUS HUSSAIN [18011435015]**"** who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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# ABSTRACT

The highway plays an important role in development of a country and also improves the living standard of people. The road development programs envisaged for the country involve large amount of money, man power, materials, and machinery not only for the construction of new roads, but also for the improvement of existing road network. The objective of this project is to provide a pavement design with sufficient information so that the necessary input data can be developed and proper engineering principles applied to design a new flexible pavement. The design is based on Indian Road Congress “guidelines for flexible pavement”. These are based on CBR method: in this approach, the pavement thickness is related to the cumulative number of axles to be carried out for different sub grade strengths. There are so many methods for pavement design but that methods are theoretical. The IRC design criteria are based on CBR method and traffic.

# ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my guide, **Mr. SANTOSH KUMAR** his valuable guidance, consistent encouragement, personal caring, timely help and providing me with an excellent atmosphere for doing the project. All through the work, in spite of his busy schedule, he has extended cheerful and cordial support to me for completing this project work.

…….

**Signature of the Student**

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7.11 Transit Mixture

7.12 Sensor Pavers

| | |
|---|---|
| 12) TOTAL NO. OF BRIDGE TO BE REPLACED/C0NSTRUCTED | : 5 |
| 13) TOTAL ROAD OF PUCCA DRAINS IN M<br>L: left R: RIGHT B: BOTH SIDE MASONARY DRAIN | : 4619.0M |
| 14) STATUS OF LAND AVAILABILY IN M | : 6.0M av |
| 15) STRECTCHED PASSING THROUGH FOREST AREA (ROAD LENGHTH INCLUDING NO. OF STRECHES IN m ) | : NIL |
| 16) CUTTING NO. OF TREES-SPECIFIED NOS. | : 1151 |
| 17) THICKNESS OF EXISTING CRUST (in mm) | : WBM- 100MM, BT 20MM |
| 18) UTILITY SHIFTING | |
| I. Electric pole to be shifted (nos) | : 58 |
| II. Transformation to be shifted (nos) | : 0 |
| III. TELEPHONE POLES TO BESHIFTED (nos) | : 0 |
| IV. HAND PUMPS TO BE SHIFTED (NOS) | : 9 |
| V. P. O BOX TO BE SHIFTED (NOS) | : NIL |
| 19) STRUCTURE TO BE REMOVED | : 110 |
| AI. EXISTING CULVERT TO BE REMOVED | : 7 |
| BI. EXISTING PUCCA STRUCTURE TO BE REMOVED | : NIL |
| C. AFFECTED KUCHA STRUCTURE | : NIL |
| 20) LAND ACQUISITION REQUIRED (m2) | : NIL |
| 21) THICKNESS OF CRUST PROVIDED AS PER DESIGN | : 585mm |
| 22) THICNESS OF PQC PROVIDED | : 250mm |

| | |
|---|---|
| 1) NAME OF WORK | : RECONSTRUCTION OF JAGANNATHPUR (MONGRA) TO BERKELA VIA SWAMBA, MAILPI ROAD |
| 2) EXISTING CARRIAGE WIDTH | : 3.0m TO 3.75m |
| 3) PROPOSED CARRIAGE WIDTH | : 5.50m |
| 4) ACTUAL LENGTH OF JOB AS PER DETAILS SURVEY (KM) | : 44.42KM |
| 5) STARTING POINT F ROAD | : NEAR MONGRA VILLAGE IN 39TH KM OF SINGHPOKHARI JHINKPANI-JAGANATHPUR-JAINGARH ROAD (MDR) |
| 6) TERMINATION POINT OF THE ROAD | : NEAR BERKELA IN 13TH KM OF CHAIBASA- SAITWA GOELKERAPOAD (MDR-186) |
| 7) ROAD VIA (IMPORTANT MILE STONE) | : SWAMBA, MAILPI |
| 8) TOTAL NOS. OF EXISTING CULVERTS | : 117 |
| 19) STRUCTURE TO BE REMOVED | : NIL |
| AI. EXISTING CULVERT TO BE REMOVED | : 110 |
| BI. EXISTING PUCCA STRUCTURE TO BE REPAIR/ WINDEND | : NIL |
| C. AFFECTED KUCHA STRUCTURE | : 7 |
| 9) NEW CULVERT PROPOSED (NOS) | : NIL |
| 10) TOTAL NO. OF EXISTING BRIDGE | : 34 |
| 11) TOTAL NO. OF BRIDGE TO BE REPAIR/NREHABILITATED | : 5 |

Existing To Be Replaced

# 1. INTRODUCTION

## 1.1 A PROJECT HIGHLIGHT (ROAD WORK)

| | |
|---|---|
| 23) DESIGNED LIFE FOR STAGE CONSTRUCTION (YEARS) | : NA |
| 24) PRESENT TRAFFIC STATUS<br>25) (B) SUMMERY OF PROJECT COST | 47CVPD |
| I. COST OF WIDENIG AND STRETCHINING/ RECONSTRUCTION INCLUDING CD WORK (LACS)<br>II. SCHEDULE OF RATE EFFECTIVE FROM<br>III. COST OF LAND ACQUISITION (LACS)<br>IV. COST OF CONSTRUCTION OF BRIDGE(LACS)<br>V. COST PER KILOMETER (LACS) | : 11929.55<br>: RCD S.O.R EFFECTIVE FROM 01.07.2016<br>4180.00<br>715.14<br>Rs. 251.110 LACS PER KM |

**1.2 REPORT**

Road construction department, Jharkhand intended to developed a good network of road in the state. Highway consultants have been empanelled to serve the purpose. Many roads have been identified in the state for this purpose one such road is Jagannathpur (Mongra) to berkela via samba, mailpi. It connects Hatgamharia osmunda beriberi road (Jagannathpur) with Chaibasa sagitta goal kera road berkela. Archie consultant harm hosing colony Ranchi has been assigning to prepare a detail project report for development to this road topographical survey, traffic data collection soil data collection, etc. Has been conducted for design of crust of the

| | |
|---|---|
| 1. Name of the Road | Reconstruction Of Jagannathpur (Mongra) To Berkela Via swamba |
| 2. Authority and plan provisions | Departmental letter No. |
| 3. State | Jharkhand |
| 4. department | R.C. D |
| 5. Circle | Road Circle, Chaibasa. |
| 6. division | Road Division, Chaibasa. |

road based upon CBR value of the under has been prepared. Which may be summarized as followed:-

| | |
|---|---|
| 7. starting chainage at | Near Mongra Village in 39th Km. of Singhpokharia – Jhinkpani -Jaganathpur-Jaingarh Road (MDR-181) |
| 8. present carriage width | 3.0 m to 3.75 m |
| 9. Proposed carriage way width | 5.50m |
| 10. (a) camber of flexible | 9.0 m |
| 11. (b) camber of rigid pavement | 2.50% |
| 12. (c) camber of the earthen shoulder | 2.0% |
| 13. super elevation and bends | As per requirements of the horizontal curves |
| 14. Actual length of the road section: - | 44.420 Km. |
| 15. Embankment slope: -<br>In filling: -<br>In cutting: - | <br>2:1<br>1:1 |
| 16. Termination point of the road section: - | Near Berkela in 13th Km. of Chaibasa - SaitwaGoelkera Road (MDR-186). |
| 17. Total No. of existing Bridges | 5 |
| 18. Total No. of existing Bridges to be retained | Nil |
| 19. Total No. of existing Bridges to be replaced | 5 |
| 20. Total No. of proposed new Bridges | 1 |
| 21. Total No. of Existing culverts<br>(a) Existing to be retained<br>(b) Existing to be removed<br>(c) Existing to be replaced | 117<br>NIL<br>7<br>110 |
| 22. Proposed New Culverts | 24 |
| 23. (a) Total length of R.C.C drains<br>(b) Total length of Masonry drains | Nil m<br>4619.0 m |
| 24. Total length of retaining wall | 14752.0 m |
| 25. Existing Right of Way | 6.0 m Av. |
| 26. No. of Electric /Telephone | 58 |

| | |
|---|---|
| poles/Transformers to be shifted | |
| 27. Stretch passing through forest area | Nil Km. |
| 28. Thickness of the Existing crust (excluding - premix carpet) | WBM -100mm (Av.) |
| 29. (a) Proposed Length of Flexible pavement<br>(b) Proposed Length of Rigid pavement | 39.973 Km.<br>4.447 Km |
| 30. Design Thickness of the crust (Rigid) | 250 mm |
| 31. Design thickness of the crust (flexible) | 30 mm BC over 55 mm DBM over 250 mm WMM over 250 mm GSM Gr.-I |
| 32. Design life; Flexible Pavement<br>; Rigid Pavement | 15 years<br>30 years |
| 33. 4 days soaked CBR adopted for Design | 4.0% |
| 34. Design Traffic intensity | 47 CVPD |

## 1.3 PROJECT COST

The estimated project cost is Rs 16109.546 lakh (Rupess one hundred sixty one crore nine lakhs fifty four thousand and six hundred) only. The estimate has been framed on the basis of current schrdule of rate of road construction department, GOJ, effevtive from 10.07.2016. the cost per km. work out to be Rs. 251.110 lacs

## 1.4 PROJECT STANDARD SPECIFICATION ANDGUIDELINES

### 1.4.1 ROAD STANDARD AND SPECIFICATIONS

The road proposed to be constructed as per the standards of state highways laid down by the I.R.C. and specifications for road works as per MORTH & Government of India.

### 1.4.2 DESIGN AND DRAWINGS

Rigid pavement has been designed as per guidelines contained in IRC 58-2002" & Flexible pavement as per IRC- 37:2012 whereas the design of drains and cross drainage works is based on IRC SP-13:2004

### 1.4.3 TRAFFIC SURVEY

The Traffic Survey has been Conducted at two locations near Mongra Village at ch.0+100 Km of road, and near Berkela Village at ch 44+400 Km of the Road A seven day twenty four hour traffic census was conducted to access the flow of traffic on the road. The CVPD near these Count Station comes to be 46 and 47 respectively The PCU at these Count Stations are 344 and 347 respectively. Accordingly CVPD for design purposes has been taken as 47

## 1.5 DESIGN AND DRAWINGS

### 1.5.1 DESIGN OF PAVEMENT FOR RECONSTRUCTION

The flexible pavement has been designed in accordance with IRC 37 2012 In CBR Method of Design Traffic defined in terms of cumulative no. of standard axles(8160Kg) to be carried during design life of the road It is well known that the structural damage caused by a vehicle depends on the axle load it imposes on the road and equivalent axle load concept is the best method available for design purposes to handle the large spectrum of axle load actually applied to a pavement. The pavement thickness is calculated with the help of design curves/tables/blocks, relating pavement thickness to the cumulative no. of standard axle to be carried for different sub grade strength values in terms of the CBR values of the sub grade. The thickness thus deduced are total thickness of pavement consisting of various combination of bituminous surfacing, granular base and sub base thickness,

### 1.5.1 DRAWINGS

Drawing such as Plan Longitudinal section, Typical cross section detailed cross section, section of drains guard walls and cross drainage works have been prepared in accordance with IRC SP-19-2001.

## 1.6 DESCRIPTION OF THE PROJECT & PROPOSED CONSTRUCTION

**Introduction:-** This road starts from Monera Village in 39th Km of MDR-181( Chainsaw Akita through Jhinkpani – Jaganathpur – Jaingarh Road) and after passing Lisimoti, Palisal, Swamba. Mailpi, Singhiajori, Jojohatu, Hensabandh and Pasbera villages terminates at Berkela village in 13th Km. of MDR-186 (Chaibasa-Saitwa-Goelkera Road) Presently this road is under the ownership RWD Chaibasa. This Road runs parallel to NH-75 and will serve the purpose of by pass of many congested Towns such as Hatgamharia, Jhinkpani, Chaibasa etc.

This road will provide connectivity to as many as 40 villages to the main highway and will activate healthy Socioeconomic activity in the region. The Road passes through Rolling and Hilly terrain. Major stretch of the road passes through Forest area.

**(ii) Existing Road:-** Existing Road is a combination of BT pavement, PCC Road and Earthen road with carriageway varying from 3.0m (av.) to 3.75m. Pots as deep as 200mm were visualize at many locations. In fact, major stretch of road needs reconstruction from GSB level. The Horizontal alignment and Vertical profile of the road has not been found as per IRC norms and proper correction in horizontal alignment and vertical profile has been done as and where required.

CBR test of Underlying soil strata has been conducted

after collecting the soil samples at regular intervals. It works out to be average 5.0%. Based upon the CBR value of Subgrade soil and traffic count in terms of msa ,the pavement was designed Accordingly provision of 30mm BC over 55mm DBM over 250mm WMM over 250mm GSB Gr-1 has been made in the crust of road. Bottom 100mm of GSB Gr-l is to be extended in full formation width to serve the purpose of Drainage Layer. These layers are to be laid after scarifying the existing Bituminous layer. Some stretches of PCC road have been dismantlement in stretches as mention in the schedule and rest part has been strengthened with 250mm PQC. Widening of PCC pavement has been done with 250mm PQC over 150mm DLC over 200mm GSB Gr-1.

**(iii) Culverts: -**There are 117 nos. of existing culverts in this part of the Road. All culvert is in poor condition with inadequate waterway, Provision for replacement of these culvert has been made in the DPR. The linear waterway of culvert at ch.26.590 is very less Provision for replacement of this culvert with bridge has been made in the DPR.T enhance the cross drainage, provision for construction of 24 new culverts has been made in the DPR.

**(iv) Bridges: -** There are 5 nos. of existing bridges in the Road and there is one unbridged

gap at ch.42.431 Km. over Roro (Kechabaipi) River. One bridge at ch.14.200 Km. Ove Denali is under construction by RWD, Special Division, Chaibasa. Two Bridges ch.38.240 Km. and 39.565 Km. have been replaced by Box Culvert. Provision replacement of rest bridges by H.L. bridge has been made in the DPR.

**(v) Drains: -**The Road passes through thickly inhibited area with poor drainage facility. Provision for construction of 450mm wide and 600mm deep masonry drain has been made in built area and in Toe of Hills in Hilly area. Provision for construction of Drain cover length has made in the DPR.

**(vi) Protection work: -** Near High embankment provision for construction of Retaining wall as mentioned in calculation of Retaining wall has been made in the DPR.

**(vi) Plantation**: - Provision for Plantation of trees as many as twice the number of trees to cut widening has been made in the DPR. Climatic:

Climatic and Geographical condition of the region is almost similar to other regions of Jharkhand. The road region falls in semi-arid zone. 7.0 Economic profile of region and road influence area.

Road passes through many thickly inhibited villages who earn their likelihood by Cultivation. The Construction of road will mobilize the agro based business in the villages lying the area of Road.

**Route and Alignment:-** The captioned road is a defined road with fixed alignment.

**Land Acquisition:**

Since exact ROW of the existing Road has not been made available to this Division, Toe to Toe width 6.0m has been taken as ROW of the Road. The area of Land acquisition has worked on the basis of 25.0m land Width required and 6.0m Land width available. area of land to be acquired works out to be 44420 x (25.0-6.0) 2.47/100=20900.0 decimal.

10.0

| SL NO. | MATERIALS | PLACE | AV. LEAD in KM | |
|---|---|---|---|---|
| 1 | SAND | KUJU RIVER | | 46 |
| 2 | CHIPS | NOAMUNDI | | 51 |
| 3 | METALS | NOAMUNDI | | 51 |
| 4 | BOLDERS | NOAMUNDI | | 51 |
| 5 | MOORUM | LOCAL | | 5 |
| 6 | BUTIMUN | HALDIA | | 357 |
| 7 | CEMENT | CHAIBASA | | 38 |
| 8 | STEEL | CHAIBASA | | 38 |

Skilled, Semi-skilled labors are available abundance the region.

## 1.7 LABOUR

### 1.7.1 QUALITY ASSURANCE QUALITY CONTROL

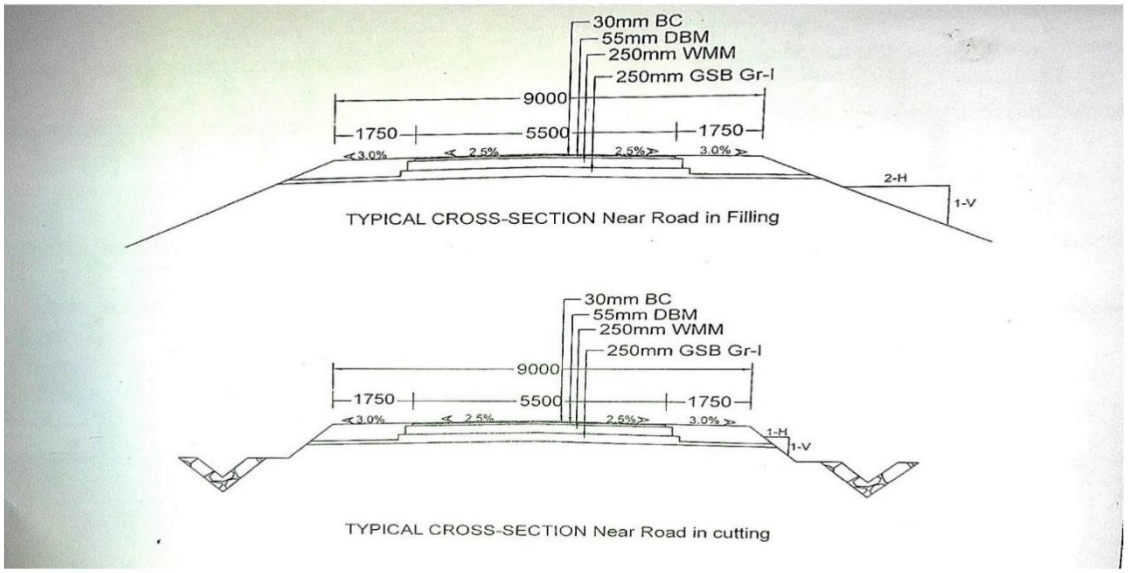
To achieve high quality construction the of the project should be assigned efficient reputed contractors and effective monitoring should done official Road Department. officials whether from side or Government side should be sufficient training know quality construction. responsibility construction should be assigned to these officials.

Site laboratory fully equipped and functional MOSRT&H (5th graduate material engineer and adequate of experienced technical staffs carry tests is must to achieve quality Q-3 level of quality is proposed for the above work. Rough meter/ Bump indicator used check quality after construction road before taking it over. The mix should be prepared transit or in batching and mixing plant. The should with electronic paver with sensor.

### 1.7.2 Design of flexible Pavement

Name of Work:- Reconstruction of Design by Standard Axle Method Jaganathpur (Mongra) to Barkela via Swamba, Mallpi Road.

## 1.8 TYPICAL CROSS-SECTION OF ROAD



# 2. PAVEMENT DESIGN

## 2.1 INTRODUCTION

Pavement is the durable surface material laid down on an area intended to sustain vehicular or foot traffic, such as a road or walkway.

In the past cobblestones and granite sets were extensively used, but these surfaces have mostly been replaced by asphalt or concrete

There are two types of pavements:

Flexible pavement

Rigid pavement

## 2.2 Flexible pavement:

Flexible pavements are those, which on the whole have low flexural strength and are rather flexible in their structural action under the loads.

The flexible pavement layers reflect the deformation of the lower layers on to the surface of the layer.A typical Flexible pavement consists of four components:

- Surface course
- Base course
- Subbase course
- Soilsub grade

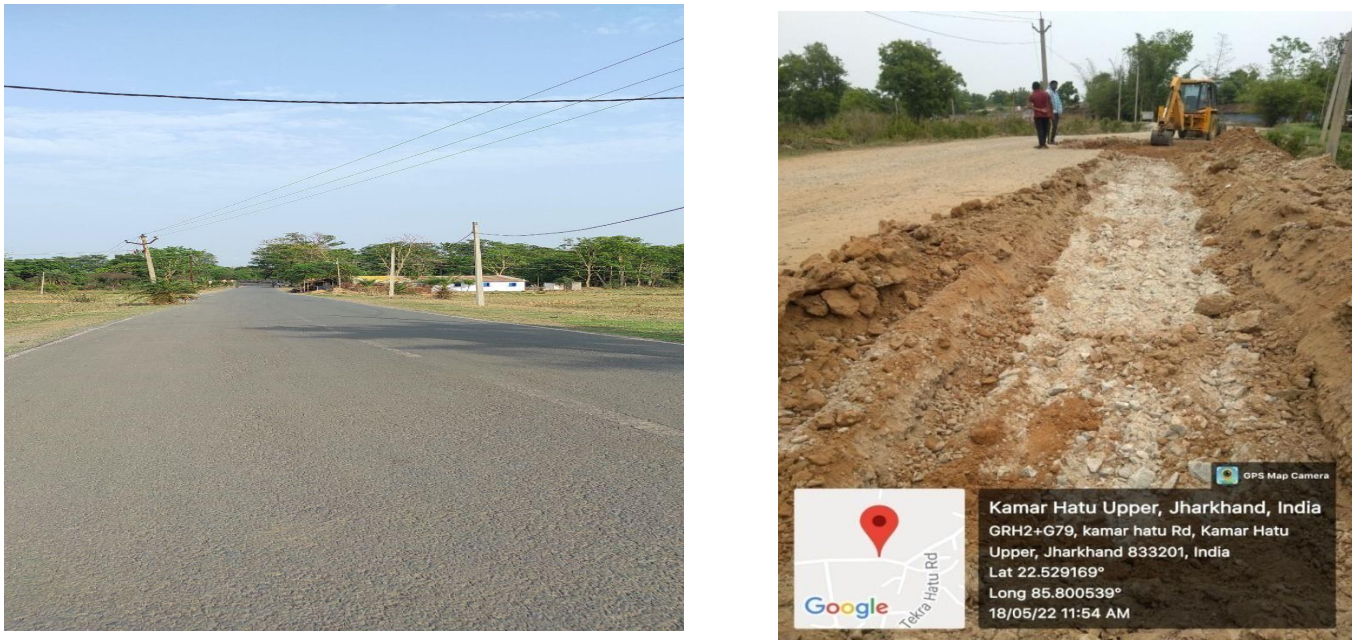



Fig 1: A view of Flexible pavement components

## 2.3 Rigid Pavement:

Rigid pavements are those possess noteworthy flexural strength. The stresses are not transferred from grain to the lower layers as in case of flexible pavement layers. The rigid pavements are made of Portland cement concrete-either plain, reinforced or prestressed concrete. The plain cement concrete slabs are expected to take up to about 40 kg/cm$^2$ flexural stress. The rigid pavement has the slab action and is capable of transmitting the wheel load stresses through a wide area below

Fig 2:- A  view of Rigid pavement

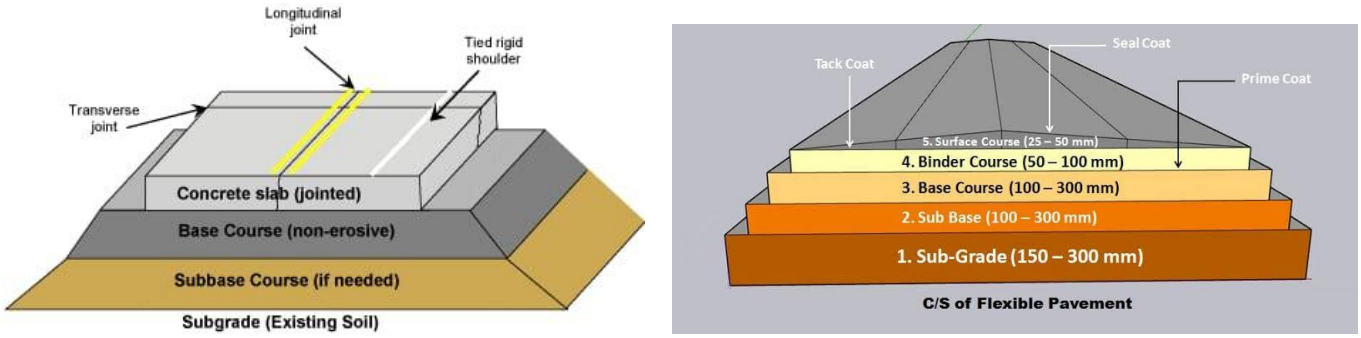



Fig 3: The difference between flexible and rigid pavement

## 2.4 Functions of Pavement Components:

- Soil Sub grade
- Sub-base and Base Course
- Wearing Course

Fig 4: A view of Sub grade

### 2.4.1 Soil Sub grade:

The soil sub grade is a layer of natural soil prepared to receive the layers of pavement materials placed over it. The load on the pavement is ultimately received by the soil sub grade for dispersion to the earth mass. It is essential that at no time, the soil sub grade is overstressed. It means that the pressure transmitted on the top of the sub grade is within the allowable limit, not to cause excessive stress condition or to deform the same beyond the elastic limit. It is necessary to evaluate the strength properties of a soil sub grade. This helps to designer to adopt the suitable values of the strength parameters for design purpose and in case this supporting layer does not cum up to the expectations, the same is treated or stabilized to suit the requirements.

### 2.4.2 Sub-base and Base Course:

These layers are made of broken stones, bound or unbound aggregate. Some times in sub- base course a layer of stabilized soil or selected granular soil is also used. In some places boulders stones or bricks are also used as sun-base or soling course. When the sub grade consists of the grained soils and when the pavement carries heavy wheel loads, there is a tendency for these boulders stones or bricks to penetrate into the wet soil, resulting in the formation of undulation and uneven pavement surface in flexible pavement.

Base course and Sub-base course are used under flexible pavement primarily to improve the load supporting capacity by distributing the load through a finite thickness. Base course are used in rigid pavement for:

Preventing pumping

Protecting the sub grade against frost action

### 2.4.3 Wearing course:

The purpose of wearing course is to give a smooth riding surface that is dense. It resists pressure exerted by tires and takes up wear and tear due to the traffic. Wearing course also offers a water tight layer against the surface water infiltration.

## 2.5 Design Factors

Factors to be considered in Design of Pavements Pavement Design consist of two parts:

- Mix design of materials to be used in each pavement components layer.
- Thickness design of the pavement and the component layers.
- The various factors to be considers for the design of pavements are given below:
- Design wheel load
- Subgrade soil
- Climatic factors
- Pavement component materials
- Environmental factors
- Special factors in the design of different types of pavement.

# 3. Design Standards

## 3.1 INTRODUCTION

Expressway, a controlled access facility is intended to provide most efficient speedy movement of relatively high volumes of motorized traffic with higher degree of safety, comfort and economy. Alignment characteristics and parameters of physical dimensions should be such that the resulting road has inbuilt flexibility of adjustment for additional carriageways in foreseeable future without any extravagant or wasteful expenditure, because in a rapidly developing economy it may not always be possible to forecast the traffic growth accurately.

Geometric and other elements should be preferably matched to the individual and collective requirement of traffic using the facility. Predominant vehicles trucks and passenger vehicles were considered in finalizing the basis for the design parameters like carriageway widths, Capacities, Design Speeds and other geometric elements.

## 3.2 ROAD DESIGN

### 3.2.1 Terrain Classification:

The general slope of the country classifies the terrain across the area. The terrain is an important parameter governing the geometric standards and the criteria given in the table 1 as shown below, are used in classifying terrain under these categories. While classifying a terrain, short isolated stretches of varying terrain were not taken into consideration.

| **Terrain Classification** | **Cross slope of the country** | |
|---|---|---|
| Plain | 0 – 10 | More than 1 in 10 |
| Rolling | 10 –25 | 1 in 10 to 1 in 4 |
| Mountainous | 25 –60 | 1 in 4 to 1 in 1.67 |
| Steep | >60 | Less than 1 in 1.67 |

Table 1: Terrain Classification Recommended by IRC

### 3.2.2 Design Speed:

Design speed is the basic criterion for determining all geometric features of horizontal and vertical alignments. The design speeds for various terrain conditions are given in the table 2 as shown below. Design speed is mainly be used to determine the following parameters:

- Horizontal alignment radii
- Length of Vertical Curves / Factors
- Geometric layout of the interchanges (specifically layout of the accesses, including length of taper and merging areas, and of weaving zones)
- Layout and characteristics of signs

| Sly No | Road Classification | Design Speed (Km/h) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Plain Terrain | | Rolling Terrain | | Mountainous Terrain | |
| | | Ruling | Minimum | Ruling | Minimum | Ruling | Minimum |
| 1 | Expressway | 120 | 100 | 100 | 85 | 80 | 60 |
| 2 | Link Road | 100 | 80 | 80 | 65 | 50 | 40 |

Table 2: Design Speeds to be adopted for Different Terrain

In fact, in urban areas, even in plain terrain, there could be geometric constraints and controls similar in their effects to mountainous terrain. Thus, design speed should be adapted in areas with densely built environment having important facilities and other environmental constraints.

Also, considering the above, in areas with close accesses to the project corridors exists, the design speed should be adapted to suit the site conditions. This can be achieved by either decreasing design speed on the main carriageway, or by providing an auxiliary lane physically separated from main carriageway, with a different design speed from main carriageway.Design speed should also include provision for the approaches of adjacent road sections (State Highways, National Highways, and Local Roads). This will require speed to be reduced when approaching these sections. Normally, ruling design speed was taken as the guiding criterion for the purpose of the geometric design. Minimum design speedways however adopted where site condition and cost does not permit a design based on "Ruling Design Speed". In the link road section, the design speed was taken as 100 Kamp and for the rest of the ORR the design speed is taken as 120 Kamp.

### 3.2.3 Basic Principles of GeometricDesign:

The guidelines are intended for uniform practices to achieve optimum design standards for Expressway. As a general rule, geometric features of a road do not allow for stage construction. Improvement of features like grade, curvature and widening of cross drainage structures at a later date can be very expensive and sometimes impossible.

Geometric design standards and specifications given in IRC: 73-1980 / AASHTO were followed for the designing of Outer Ring Road. However, the minimum values have been applied only where serious restrictions are implied from technical or economical considerations. In General, the design standards adopted were more than the minimum values suggested.

## 3.3 CROSS SECTIONALELEMENTS:

### 3.3.1 Road Land width:

Road land width also termed as right-of-way is the width of land acquired for road purposes. The desirable land width for the Outer Ring Road is given in the following Table 3.

| Sl No | Road classification | Right of way (m) |
|---|---|---|
| 1 | JAGANNATHPURTO BERKELA VIA SWAMBA | 6m |

Table 3: Right of Way

### 3.3.2 Lane width:

As per the specifications in the IRC: 73-1980, the recommended lane widths are 3.50m. California State Highway standards allow for 3.6m wide lanes. As per the AASHTO design standards, the recommended lane width for expressways is 3.75m. Since the Outer Ring Road is going to be a high speed facility, it was felt necessary to keep the lane widths as per the design standards given in AASHTO, and are given in the following table 4.

| Lane | Lane width (m) |
|---|---|
| Left lane (slower moving vehicles) | 3.75 |
| Right lane (fast lane) | 3.50 |

Table 4: Recommended Lane width on main carriageway

### 3.3.3Width of the Shoulder:

Width of the shoulder plays an important role in the capacity of the carriageway. The shoulders, so provided will not only cater as an emergency lane but also act as parking lanes and cater to the break down vehicles. Since, these vehicles will be parked on the shoulders; they will not hinder the free movement of traffic on the main carriageway. The width of the shoulders adopted (both Paved and earthen shoulders) for the Outer Ring Road is given in the table 5 as shown below.

| Type of Shoulder | Shoulder width (m) |
|---|---|
| Paved Shoulder (including edge strip)<br><br>Will serve as emergency lane | 3.0m |
| Earthen Shoulder | 3.0m |

Table 5: Recommended Shoulder width

When the truck traffic increase over 2000 vehicles/day (both directions), it is necessary to increase the width of paved shoulder / emergency lane in excess of 3m. In the present case, earthen shoulders of 3.0m are provided, which can be easily converted to paved shoulders when the situation warrants.

### 3.3.4 Side Slopes:

Side slopes for the Outer Ring Road for different embankment heights or in cutting are given in the table 6 as shown below.

| Height of Embankment (m) | Slope (H:V) |
|---|---|
| Up to 4m | 2.0 : 1 |
| 4 to 7m | 2.0 : 1, with toe walls |
| >7m | Reinforced Soil Structures |
| **For Cutting Sections** | |
| **Depth of Cutting (m)** | **Slope (H:V)** |
| In Soil | 1.5 : 1 |
| In Soft and medium rock | 0.50 : 1 |
| Cutting in hard rock | 0.25 : 1 to Near Vertical |

Table 6: Side Slope for Different Embankment heights/Cutting Sections

### 3.3.5 Width of Median and Edge Strip:

The width of the median island proposed for Outer Ring Road is 5.0m (Outer to Outer). Keeping in view the human psychology, to accommodate the high speeds of the vehicles, and to provide additional capacity and margin for later operation, an edge strip of 0.70m is provided on the median side. On the shoulder side, the paved shoulder will be used as an emergency lane and also provides sufficient space; hence, it was felt that the edge strip on the shoulder side is not necessary (it is in fact included in paved shoulder).

### 3.3.6 Reduction of cross-section:

During the Work shop, the panel of experts has recommended the reduction of lane widths from 3.75m to 3.5m to reduce the land acquisition, if the availability of land is a constraint. However, it should be possible, if space constraints require so, to implement a narrower cross section at specific locations. However, such narrower cross sections were not designed in this phase Considering heavy truck traffic, sufficient width should be provided to avoid dangerous conflicts, which is why 3.75m has been considered. Moreover, the provision of 8- lane divided carriageway may not be warranted considering the present traffic levels. However, considering the likely increase in the traffic levels and the capacity that may be requiredatalaterdate,itwasfeltthatan8-lanedividedcarriagewaywithlanewidthsof3.5m (Inner two lanes) and 3.75m (outer two lanes) will be provided. Regarding the safety aspect, the surplus of capacity provided at this stage might have a negative impact with increase in vehicular speeds and road accidents.

### 3.3.7 Camber:

The camber on straight section of road should be recommended in the table 7 as shown below:

| Type | Camber (%) |
|---|---|
| Carriageway (Flexible Pavement) | 2.5% |
| Paved Shoulder | 2.5% |
| Earthen Shoulder | 3.5% |
| Carriageway (Rigid Pavement) | 2.0% |

Table 7: Camber for different surface types

At super-elevated road sections, the shoulder should normally have the slope of same magnitude and direction as the pavement slopes subject to the minimum cross-fall allowable for shoulder. The camber for earth shoulder should be at least 0.5% more than that for the pavement subject to the minimum of 4%. However, 1.0% more slope than the camber for the pavement is desirable; hence 3.5% camber is adopted for earthen shoulders.

## 3.4 HORIZONTAL ALIGNMENT

### 3.4.1 Horizontal Curve:

Horizontal curve consists of circular portion flanked by spiral transition at both ends. Design speed, super elevation and coefficient of side friction affect the design of circular curves. The provision of transition curves enhances the safety of the road users, as it will allow a smooth change in the rate of change of super elevation, and also reduces the centrifugal forces on the vehicle. Length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of super elevation. The rate of change of super elevation is considered to be 1:200, as prescribed in AASHTO, and the same rate has been adopted in this project.

### 3.4.2 Super elevation:

Super elevation is generally considered to counteract only a fixed percentage of the centrifugal force developed, so that the slow moving traffic will be aided. The radii beyond which super elevation is not required is shown in table 8 below. The value of super elevation, which should not be less than the camber, is restricted to 7%. It is calculated by the following formula.

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

Where

‘e’ is Super elevation

‘V’ is the design speed in Km/h

‘R’ is the radius in meters

| Design Speed (Km/h) | Radius of Curve (m) |
|---|---|
| 100 | 1800 |
| 120 | 2600 |

Table 8: Radii beyond which super elevation not required

### 3.4.3 Gradients:

The gradients adopted in the design are as per guidelines given in the IRC manual. The allowable difference in grade where no vertical curve is required is 0.4. The minimum length of vertical summit curve is 140m and minimum length of valley curve is 60m. In general the maximum gradient adopted in the design is 2%. Gradient values for roads in different terrains are as shown in table 10.

| Sl. No | Terrain | Ruling gradient | Limited gradient |
|---|---|---|---|
| 1 | Plain or Rolling | 2.0 % (1 in 50) | 2.5 % (1 in 40) |
| 2 | Mountainous | 2.5 % (1 in 40) | 3.0 % (1 in 33.33) |

Table 9: Gradients for Roads in Different Terrain

### 3.4.4 Access design speed:

Care should be taken that signs and geometry match, and that sufficient information is given to the user. This would be of great importance due to the presence of complex interchanges. Conventional design speed values for accesses at entrance and exit are shown in table 11 below.

| Sl No | Convention design speed (km/h) | Main Carriageway (120 km/h) | Collector / Distributor (80 km/h) |
|---|---|---|---|
| 1 | Exit speed | 70 | 55 |
| 2 | Entrance speed | 55 | 50 |

Table 9:Convention design speed

# 4. DESIGN OFPAVEMENTS

## 4.1 Soil and Material Properties:

From the soil and material investigations, the CBR values are found to be more than 10%. From the quarry and borrow area investigations, the good quality material required for the construction is available in abundance. The summary of test results are presented in Chapter II – Material & Sub grade investigations of Main Volume.

## 4.2 Traffic Surveys:

### 4.2.1 Introduction:

An accurate estimate of the traffic that is likely to use the project road is very important as it forms the basic input in planning, design, operation and financing. A thorough knowledge of the travel characteristics of the traffic likely to use the project road as well as other major roads in the influence area of the study corridor is, therefore, essential for future traffic estimation. Hence, detailed traffic surveys were carried out to assess the present day traffic and its characteristics.

### 4.2.2DesignTraffic:

Traffic for the estimation of the Msa was extracted from the Traffic Report. Present and estimated traffic for future along the project road is presented in table 2 furnished below.

IRC: 37-2001

Flexible pavement design has been carried out using the IRC: 37-2001 and AASHTO design methods. IRC: 37-2001, a modification to IRC: 37-1984 has been revised to incorporate the mechanistic design approach. In the new code pavement designs have been extended to cover up to traffic loading of 150 Msa. Design was also carried out using the AASHTO pavement design guidelines.

The scope of pavement design in this project can be divided into the following sections.

- **Design of Flexible Pavement for the Maincarriageway**
- **Design of Flexible Pavement for Serviceroads**

In the design of flexible pavements, a sub grade CBR of 10% has been considered. Wherever the CBR of existing soils was found to be less than 10%, select sub grade material, with a thickness of 500mm, having a CBR of 10% or more has been considered in the design. If the CBR of the existing sub grade is more than 10% it will be loosened and re-compacted and then the new pavement layers will be laid on it. The availability of the soils with CBR more than 10% has been thoroughly investigated and is found to be in sufficient quantity.

## 4.3 Design Period:

A 15-year design period (2016 - 2031) is assumed for the design of flexible pavement.

## 4.4 Vehicle Damage Factor:

Vehicle damage factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, terrain, type of road and from region to region. Axle load surveys were conducted on NH 7 and NH 9 at the proposed junction with ORR. Vehicle damage factors are tabulated in table 3 as shown below.

The above values are slightly lower than the values suggested in IRC: 37 – 2001 for trucks. In any case, MSA has been calculated with both the VDFs for comparison and presented in table 4 as shown below.

## 4.5 Sub grade Strength:

The new pavement will be constructed on a sub grade with minimum soaked CBR 4%.

## 4.6 Design Composition:

Based on the guidelines given in IRC: 37-2001, for a sub grade CBR of 10% and a design lane Mesa of 100, the following composition has been worked out.

- BC 50mm
- DBM 130mm
- WMM 250mm

- GSB 200mm
- SelectedSubgrade 500mm

## 4.7 Adopted Pavement Design:

The pavement composition suggested by IRC: 37-2001 has been considered for the project road. Since, the bituminous layer thickness is coming very high in the case of AASHTO pavement design, and moreover, also keeping in view the susceptibility of the bitumen to the rise in temperatures, the pavement composition suggested by IRC: 37-2001 has beenadopted.

The adopted pavement composition for the main carriageway is given below:

- BC 30mm
- DBM 50mm
- WMM 225mm
- GSB 175mm
- Select Subgrade500mm

## 4.8 DESIGN OF SERVICE ROADS:

Service roads will carry a lower MSA than the main carriageway. Local traffic viz., 2/3 wheelers, cars/ jeeps/ vans along with the commercial vehicles which would like to approach the nearest interchange will use the service roads. Hence, the pavement is designed for 20 Msa, and for a sub grade CBR of 10%. The recommended pavement design is given below:

BC 30mm

DBM 55mm

WMM 250mm

GSB 250mm

Select Subgrade500mm

# 5. LABORATORY TESTS

## Test:

5.1 Grain Size Analysis (GSA)

5.4 Free Swell Index (FSI)

5.5 Field Density Test by Sand Replacement Method

5.6 Modified Proctor Compaction Test

5.7 Bitumen Extraction Test

5.8 California Bearing Ratio Test (CBR test)

## 5.1 Grain Size Analysis (GSA)

### Purpose:

This test is performed to determine the percentage of different grain sizes contained within a soil. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles.

### Significance:

The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

### Equipment:

Balance, Set of sieves, Cleaning brush, Sieve shaker, Mixer (blender), 152H

Hydrometer, Sedimentation cylinder, Control cylinder, Thermometer, Beaker, Timing device.

Test Procedure:

1.Write down the weight of each sieve as well as the bottom pan to be used in the analysis.

2.Record the weight of the given dry soil sample.

3.Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom). Place the pan below #200 sieve. Carefully pour the soil sample into the top sieve and place the cap over it.

4.Place the sieve stack in the mechanical shaker and shake for 10minutes.

5.Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.


## 5.2 Flakiness and Elongation

### STANDARD

IS: 2386 (Part 1)1963.

### DEFINITION

- The Flakiness Index of aggregates is the percentage by weight of particles whose least dimension (thickness) is less than 0.6 times their mean dimension.
- The Elongation Index of aggregates is the percentage by weight of particles whose greatest dimension (length) is greater than 1.8 times their mean dimension.

### APPARTUS

- Standard thickness gauge.
- Standard length gauge.
- IS sieves 63mm, 50mm, 40mm, 25mm, 20mm, 16mm, 12.50mm 10mm and 6.30mm.
- Balance of capacity 15kg and sensitivity 1gram.
- Thermostatically controlled oven with capacity up to *250* °C.


### PROCEDURE

- Take representative sample of aggregates from the stockpile.
- Dry the whole sample in the oven to a constant weight at a temperature of 105° C to 110°C and cool at room temperature.
- Sieve the whole sample through the sieves mentioned in the columns (1) and (2) of the Table: 1

## FLAKINESS INDEX

- Take minimum of 200 pieces from each fraction and weigh (A).
- Separate flaky material from each fraction by gauging through the standard thickness gauge.
  Weigh the flaky material passing though the specified gauge from each fraction C1+C2+C3+C4+C5+ …….= C.

## CALCULATIONS

- Flakiness index, % = ( C/A ) X 100

## ELONGATION INDEX

- Take minimum of 200 pieces from each fraction and weigh (F).
- Separate the elongated material from each fraction by gauging through the standard length gauge.
- Weigh the elongated material passing through the specified gauge from each fraction E1+E2+E3+E4+E5+…….= E.

## CALCULATIONS

- Elongation Index, **(%) =** (E / F) x 100.

| Passing through | Retained on IS sieve, mm | Thickness gauge (0.6 times mean sieve) | Length gauge (1.8 times mean sieve) |
|---|---|---|---|

| IS sieve ,mm | | mm | mm |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 63.00<br>50.00<br>40.00<br>25.00<br>20:00<br>16.00<br>12.50<br>10.00 | 50.00<br>40.00<br>25.00<br>20.00<br>16.00<br>12.50<br>10.00<br>6.30 | 33.90<br>27.00<br>*19.50*<br>13.50<br>10.80<br>8.55<br>6.75<br>4.89 | –<br>81.50<br>*58.50*<br>40.50<br>32.40<br>25.60<br>20.20<br>14.70 |

## REPORT

- Report the result obtained to the nearest second decimal

## COMBINED FLAKINESS AND ELONGATION INDEX

Take minimum of 200 pieces from each fraction and weigh **(A).**

Separate flaky material from each fraction by gauging through the standard thickness gauge.

- Weigh the material retained and passed through the specified gauge from each fraction b1+b2+b3+b4+b5……..= B and c1+c2+c3+c4+c5+ = C respectively.
- Take the material retained on the thickness gauge (Non flaky material) and separate the elongated material from each fraction by gauging through the standard length gauge.
- Weigh the material retained on the length gauge from each fraction d1+d2+d3÷d4+d5+…..= D.

**CALCULATIONS**

- Flakiness index (Fl), % =(C / A) x 100
- Elongation index (El), % (D / B) x 100
- Combined flakiness and Elongation Index = FI + El.

## 5.3 IMPACT VALUE OF AGGREGATE

### Objective

The aggregate impact value gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load.

Apparatus Required.


### 3. Reference

IS 2386(Part 4):1963 Methods of Test for Aggregates for Concrete- Mechanical Properties. Reaffirmed- Dec 2016

### 4. Procedure

- The test sample shall consist of aggregate the whole of which passes a 12.5 mm IS Sieve and is retained on a 10 mm IS Sieve. The aggregate comprising the test sample shall be dried in an oven for a period of four hours at a temperature of 100 to 110°C and cooled.

- The measure shall be filled about one-third full with the aggregate and tamped with 25 strokes of the rounded end of the tamping rod. Further similar quantity of aggregate shall be added and a further tamping of 25 strokes given. The measure shall finally be filled to overflowing, tamped 25 times and the surplus aggregate struck off, using the tamping rod as a straight edge. The net weight of aggregate in the measure shall be determined to the nearest gram (Weight A).

- The impact machine shall rest without wedging or packing upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.

- The cup shall be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by a single tamping of 25 strokes of the tamping rod.

- The hammer shall be raised until its lower face is 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on to the aggregate. The test sample shall be subjected to a total of 15 such blows each being delivered at an interval of not less than one second.

- The crushed aggregate shall then be removed from the cup and the whole of it sieved on the 2.36 mm IS Sieve until no further significant amount passes in one minute. The fraction passing the sieve shall be weighed to an accuracy of 0.1 g (Weight. B).

- The fraction retained on the sieve shall also be weighed (Weight C) and, if the total weight (C+B) is less than the initial weight (Weight A) by more than one gram, the result shall be discarded and a fresh test made. Two tests shall be made.

## 5. Calculation

The ratio of the weight of fines formed to the total sample weight in each test shall he expressed as a percentage, the result being recorded to the first decimal place:

Aggregate Impact Value = (B/A) X 100

where

A = weight in ‘g’ of saturated surface - dry sample,

B = weight in g of fraction passing through 2.36 mm IS Sieve

Free Swell Index (FSI)

Object: To determine the free swell index of soils

## Apparatus:

1. 4425 micron IS sieve
2. Glass graduated cylinders – 2 nos 100ml capacity
3. Distilled water and kerosene.

## Procedure:

1. Take two 10 grams soil specimens of oven dry soil passing through 425-micron IS sieve. Each soil specimen shall be poured in each of the two glass graduated cylinders of 100ml capacity.
2. One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100ml mark.
3. After removal of entrapped air the soils in both the cylinders shall be allowed to settle. Sufficient time (not less than 24 hours) shall be allowed for the soil sample to attain

equilibrium state of volume without any further change in the volume of the soils.

4. The final volume of soils in each of the cylinders shall be readout

## 5.5 Field Density Test by Sand Replacement Method

OBJECTIVE: Determine the in situ density of natural or compacted soils using sand pouring cylinders

### NEED AND SCOPE:

The in situ density of natural soil is needed for the determination of bearing capacity of soils, for the purpose of stability analysis of slopes, for the determination of pressures on underlying strata for the calculation of settlement and the design of underground structures. It is very quality control test, where compaction is required, in the cases like embankment and pavement construction.

### APPARATUS REQUIRED:

1. Sand pouring cylinder of 3 litre/16.5 litre capacity, mounted above a pouring come and separated by a shutter cover plate.
2. Tools for excavating holes; suitable tools such as scraper tool to make a levelsurface.
3. Cylindrical calibrating container with an internal diameter of 100 mm/200 mm and an internal depth of 150 mm/250 mm fitted with a flange 50 mm/75 mm wide and about 5 mm surrounding the opened.
4. Balance to weigh unto an accuracy of 1g.
5. Metal containers to collect excavated soil.
6. Metal tray with 300 mm/450 mm square and 40 mm/50 mm deep with a 100 mm/200 mm diameter hole in the Centre.
7. Glass plate about 450 mm/600 mm square and 10mmthick.
8. Clean, uniformly graded natural sand passing through 1.00 mm I.S. sieve and retained on the 600micron I.S. sieve. It shall be free from organic matter and shall have been oven dried and exposed to atmospheric humidity.
9. Suitable non-corrodible airtight containers.
10. Thermostatically controlled oven with interior on non-corroding material to maintain the temperature between $105^0$C to$110^0$C.
11. Sand pouring cylinder of 3 litre / 16.5 litre capacity, mounted above a pouring come and separated by a shutter cover plate.

12. Tools for excavating holes; suitable tools such as scraper tool to make a levelsurface.
13. A desiccator with any desiccating agent other than sulphuric acid.

PROCEDURE:

Calibration of the Cylinder

1. Fill the sand pouring cylinder with clean sand so that the level of the sand in the cylinder is within about 10 mm from the top. Find out the initial weight of the cylinder plus sand ($W_1$) and this weight should be maintained constant throughout the test for which the calibration is used.
2. Allow the sand of volume equal to that of the calibrating container to run out of the cylinder by opening the shutter, close the shutter and place the cylinder on the glass sand takes place in the cylinder close the shutter and remove the cylinder carefully. Weigh the sand collected on the glass plate. Its weight($W_2$) gives the weight of sand filling the cone portion of the sand pouring cylinder. Repeat this step at least three times and take the mean weight ($W_2$) Put the sand back into the sand pouring cylinder to have the same initial constant weight ($W_1$) Determination of Bulk Density of Soil.
3. Determine the volume (V) of the container be filling it with water to the brim. Check this volume by calculating from the measured internal dimensions of the container.
4. Place the sand poring cylinder centrally on the calibrating container making sure that constant weight ($W_1$) is maintained. Open the shutter and permit the sand to run into the container. When no further movement of sand is seen close the shutter, remove the pouring cylinder and find its weight ($W_3$). Determination of Dry Density of Soil in place.

5. Approximately 60 sq cm of area of soil to be tested should be trimmed down to a level surface, approximately of the size of the container. Keep the metal tray on the level surface and excavate a circular hole of volume equal to that of the calibrating container. Collect all the excavated soil in the tray and find out the weight of the excavated soil ($W_w$). Remove the tray, and place the sand pouring cylinder filled to constant weight so that the base of the cylinder covers the hole concentrically. Open the shutter and permit the sand to run into the hole. Close the shutter when no further movement of the sand is seen. Remove the cylinder and determine its weight($W_3$).

6. Keep a representative sample of the excavated sample of the soil for water content determination.

## 5.6 Modified Proctor Compaction Test

### Equipment:

1. Proctor mould with a detachable collar assembly and base plate.
2. Manual rammer weighing 2.5 kg and equipped to provide a height of drop to a free fall of 30cm.
3. Sample Extruder.
4. A sensitive balance.
5. Straightedge.
6. Squeeze bottle
7. Mixing tools such as mixing pan, spoon, trowel, spatulate.
8. Moisture cans.
9. Drying Oven.


## Test procedure:

1. After 24 hrs recover the sample in the oven and determine the weight W5,(g).
2. Fill out the following table completely; Calculate rows 9 and 10, these two will give one point of the plot.

## 5.7 Bitumen Extraction Test

Aim of the test: The method described is a procedure used to determine the bitumen content of bitumen aggregate mixtures.

Units of Measure:

The bitumen content is expressed as a percent by dry weight of extracted aggregate.

## Apparatus And Materials:

## Equipment:

1. Centrifuge extractor with a bowl. The extractor must be capable of rotating the bowl at controlled variable speeds up to 3600 rpm.
2. Paper or felt filter rings to be placed on the rim of the bowl and beneath the bowl lid. Scale capable of weighing to 2500 g at a 0.1 g accuracy.

3. Heating equipment such as electric stove. 500 ml cup or beaker.
4. Hand Tools - spatula, small brush, scoop, large pan for collection of a representative bitumen mix sample, pan for test sample.
5. Container for collection of bitumen laden solvent thrown from the bowl during extraction.

## Materials:

Solvents - suggested materials are benzene or Carbon Tetra chloride.

## Procedure:

1. A representative sample about 400gm is exactly weighed and placed in the bowl of the extraction apparatus and covered with commercial grade of benzene. Sufficient time (not more than 1 hour) is allowed for the solvent to disintegrate the sample before running the centrifuge.
2. The filter ring of the extractor is dried, weighed and then fitted around the edge of the bowl. The cover of the bowl is clamped tightly. A beaker is placed under to collect the extract.
3. The machine is revolved slowly and then gradually, the speed is increased to a maximum of 3600 r.p.m. The speed is maintained till the solvent ceases to flow from the drain. The machine is allowed to stop and 200 ml. of the benzene is added and the above procedure is repeated.
4. A number of 200 ml. solvent additions (not less than three) are used till the extract is clear and not darker than a light straw colour. The filter ring from the bowl is removed, dried in air and then in oven to constant weight at 115$^{o}$ C and weighed. The fine materials that might have passed through the filter paper are collected back from the extract preferably by

centrifuging. The material is washed and dried to constant weight as before.

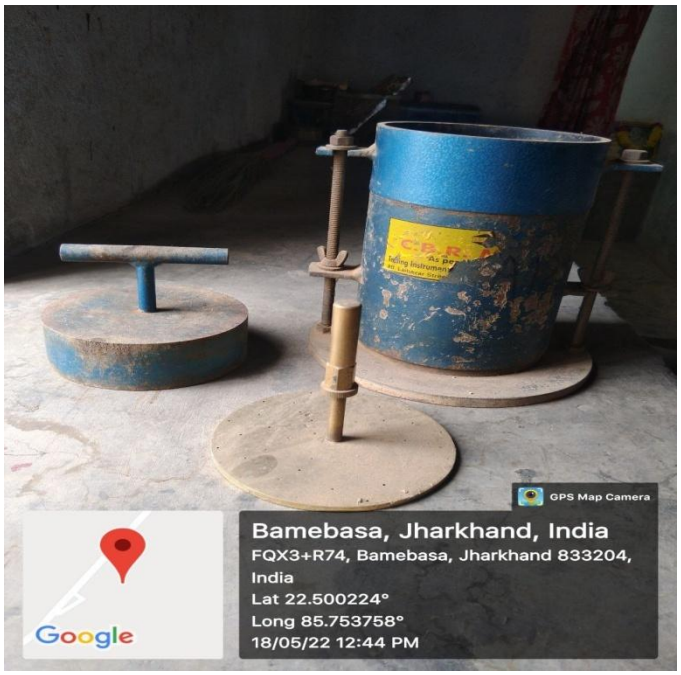
## 5.8 California Bearing Ratio Test (CBR Test)

AIM: TO FIND THE BEARING CAPACITY OF A MATERIAL WITH THAT OF A WELL-GRADED CRUSHED STONE.

## APPARATUS:

Mould, Steel Cutting collar, Spacer Disc, Surcharge weight, Dial gauges, IS Sieves,

Penetration Plunger Loading Machine, Miscellaneous Apparatus




## PROCEDURE:

Normally 3 specimens each of about 7 kg must be compacted so that their compacted densities range from 95% to 100% generally with 10, 30 and 65 blows. Weigh of empty mould Add water to the first specimen (compact it in five layer by giving 10 blows per layer) After compaction, remove the collar and level the surface. Take sample for determination of moisture content. Weight of mould + compacted specimen. Place the mold in the soaking tank for four days (ignore this step in case of unsoakedCBR. Take other samples and apply different blows and repeat the

whole process. After four days, measure the swell reading and find %age swell. Remove the mould from the tank and allow water to drain.

# 6. ROAD CONSTRUCTION ACTIVITY

## 6.1 EARTHWORK EXCAVATION

This item of work deals with earthworks in excavation in all types of soils is it for stacking of suitable soils or disposal of unsuitable soils inclusive of necessary lead for transporting materials as per the terms in contract documents.

Procedure:

1. These excavation works referred to herein shall be either pointing to the trench cutting at the existing ground level in order to engage in sand blanketing (in case of meeting with unsuitable soil) or this could be the case of excavations necessary to trim down the excessive earth masses in order to prepare the base for pavement layers. Or else this may be the case of excavation necessary for construction of side drains & waterways.

2. All the excavations shall be carried out in conformity with the directions laid down herein under and in a manner as approved by the Engineer. The work shall be so done that the suitable materials available from excavation works are satisfactorily utilized as decided upon before hand.

3. Dealing generally herein with the trench excavation for sand blanketing and applying generally the same mode of procedure in other forms of excavation, we append hereunder the broad steps of construction in thisregard.

4. On completion of site clearance, necessary ground survey shall be done in order to mark the lines of toeexcavation.

5. This shall be followed further by laboratory tests with regards to the samples of soil materials collected randomly (under the proximity of Engineer's representative) from the respective stretches. Existing ground levels contours shall be jointly recorded in the form of cross sections at 10 m intervals with the origin of base line being the proposed center line of the roadsector.

## 6.2 EMBANKMENT CONSTRUCTION

This item of work deals with construction of road embankment with approved materials as per the terms of contractagreement.

### General:

This item of work shall be dealt with in complete compliance to the technical specifications; placement and compaction shall be carried out in accordance with clause 305 of specifications.

Drawings used for construction in respect of the alignment, level, cross sections in respective stretches and other survey detail and relevant technical specifications viz. clause 305 of technical specification in terms of mandatory guidelines for ensuring the quality of work.

Prior to the commencement of this work, the materials proposed to be used for such embankment shall be sourced suitably. Different sources shall be earmarked for different stretches giving due regard to the load of haulage and most importantly the suitability and quantum of material availability.

The material used in embankment shall generally be soil, morrum, gravel, a mixture of these or any other approved material. In respect of quality of material, such material shall be ensured to be free of logs, stumps, roots, rubbish for any ingredients likely deteriorate or affect the stability of the embankment. The material resulting from the roadway excavation if found suitable will also be used.

## 6.3 SUBGRADE CONSTRUCTION

This item of work deals with construction of Sub grade (minimum 10% CBR) with approved materials as per the terms of contract agreement.

### General:

This item of work shall be dealt with in complete compliance to the technical specifications; placement and compaction shall be carried out in accordance with clause 305 of specifications.

The construction shall confirm to the specific alignment, lines and grades given in the drawing.

Prior to the commencement of this work, the materials proposed to be used for such subgrade shall be sourced suitably. Different sources shall be earmarked for different stretches giving due regard to the load of haulage and most importantly the suitability and quantum of material

availability.

The material used in subgrade shall generally be soil, morrom, gravel, a mixture of these or any other approved material. In respect of quality of material, such material shall be ensured to be free of logs, stumps, roots, rubbish for any ingredients likely deteriorate or affect the stability of the subgrade. The material resulting from the roadway excavation if found suitable will also be used. Material which is having CBR value mentioned in technical specification shall be used insubgrade.

6.4 GRANULAR SUB BASE CONSTRUCTION

This item of work deals with construction of Granular sub base with approved materials as per the terms of contract agreement.

General:

This item of work shall be dealt in compliance to the clause 401 of specifications.

The construction shall confirm to the specific alignment, lines and grades given in the drawing.

Prior to the commencement of this work, the materials proposed to be used for such work shall be sourced suitably. Different sources shall be earmarked for different stretches giving due regard to the load of haulage and most importantly the suitability and quantum of material availability.

The material used in Granular sub base shall be as per technical specification.

6.5 WET MIX MACADAM CONSTRUCTION

This item of work deals with construction of Wet mix macadam with approved materials as per the specifications of contract agreement.

General:

This item of work shall be dealt in compliance to the clause 406 of specifications. The construction shall confirm to the specific alignment, lines and grades given in the drawing.

Procedure:

Preparation of Mix:

- The individual materials gradation shall be checked combined, proportions shall be fixed and combined gradation confirming to table 400-11 shall be arrived. The individual bins of wet mix plant shall be calibrated for the particular size of material.
- Material shall be fed to the mixing plant bins provided for individual sizes of aggregates to meet the required gradation.
- Mixing plant shall be of suitable capacity having provision for controlled addition of water. While adding water, loss due to evaporation shall be taken in account.
- Water in the wet mix shall not vary from the optimum by more than in the limits of +l/-2 of OMC.

## Preparation of Base:

- The sub base shall be checked for proper lines and levels.
- It shall be made free from dust. Before the laying starts it should be made slightly wet and shall be given one plain pass.
- The lateral confinement for wet mix shall be provided by placing material before laying WMM in the adjoining shoulder portion.

## Lying of Wet Mix Macadam:

- The wet mix shall be transported from the mixing plant to the site with trippers.
- The mix shall be laid with paver finisher. The paver shall have suitable loading hoppers and distribution mechanism. The mix shall be laid manually in places where the paver movement is not possible. High or low spots shall be rectified as per MoRTH clause No406.6. The material shall be uniform and shall be free of pockets of fine material.
- The compaction of wet mix shall be done as per clause 406.3.5. The rolling shall be done with 80-100KN vibratory roller. The rolling pattern shall be established in the trialstretch.

## 6.6 APPLICATION OF PRIME COAT

### General:

The work is consisting of applying a single coat primer of approved quality Produced by refinery, the primer used shall be bitumen emulsion complying IS : 8887 & CSS1 grade confirming to ASTMD 2397 / AASHTO M140, the particular grade to be used for the work shall be got approved by the Engineer. The prime coat will be done only in good weather condition.

Machinery:

For this primer distributor of capacity '4 MT' shall be used. This distributing unit, so called as primer tanker is facilitating pneumatic tyre and self-propelled pressure distributor for spraying the material uniformly at the rate of 6 to 9 Kg/10 Sq .m under normal temperature and pressures. Sometimes few small patches near junctions, or narrow space where the primer tanker is not reachable then for those areas spraying of primer shall be done manually, after approval from the engineer.

**Preparation of Road Surface:**

Make clean the top surface of wet mix macadam by engaging labours with wire brush and all organic contents shall be blown up by using compressed air. The surface to be primed will be swept clean, free form dust and will remain dry.

### Application of Primer:

The primer will be sprayed uniformly over the dry surface using a self – propelled sprayer with the distribution bar. The sprayer proposed to use is having a self heating arrangement, with spraying bar with nozzles having constant pressure system and is capable of supplying primer at 6 to 9 Kg / 10 Sq meter and at temperature 30 degree C to 60 degree C, so that distributor will spray uniformly unbroken spread of primer. Some times during summer we will come across the surface to be primed will found, so dry or dusty in that case damp the surface with water lightly and uniformly because the dry or dusty surface will cause freckling of primer. All these exercises prior to priming will be done as directed by the Engineer.

The primed surface will be allowed to cure for 24 hours minimum or even more as directed by Engineer, so that the primer will penetrate in to the base of wet mix macadam layer. In case the primer is not absorbed beyond 24-hours after applying then we will spray sand over the surface to blot the excess primer. We will take care that there will not be over priming or any pools of excess primer left any part of the surface, which will be swept-out over the adjacent surface before spreadingsand.

Curing:

The Primed surface will be allowed to cure for not less than 24 hours or as directed by Engineer and during this period no vehicles of any kind will be permitted.

## 6.7 APPLICATION OF TACKCOAT

### General:

This work is consisting of application of a Single Coat Cationic emulsion of rapid setting type confirming to IS8887.

### Machinery:

For this tack coat distributor of capacity '4 MT' shall be used. This distributing unit, so called as tack coat tanker is facilitating pneumatic tyre and self-propelled pressure distributor for spraying the material uniformly at the rate of 2.0 to 3.0 Kg/10 Sq .m under normal temperature and pressures. Sometimes few small patches near junctions, or narrow space where the primer tanker is not reachable then for those areas spraying of primer shall be done manually, after approval from the engineer.

### Preparation of Road Surface:

The surface on which the tack coat is to be applied will be cleaned, of dust and extraneous material before the application of the binder.

Application of Tack Coat:

The tack coat "bituminous emulsion" will be heated to the temperature 20 degrees C – 60 degrees C. This tack coat will be applied uniformly at the rate of 0.25 to 0.30 Kg/Sq.m for granular surface and 0.20 to 0.25 kg/sq.m with the help of self propelled emulsion pressure Sprayer with self heating arrangement and spraying bar with nozzles having consistent volume or pressure system, capable of spraying emulsion at specified rates and at 20 deg C – 60 deg. C to provide unbroken spread of emulsion.

## 6.8 DENSE BITUMINOUS MACADAM CONSTRUCTION

This item of work deals with construction of Dense Bituminous Macadam with approved materials

as per the specifications of contract agreement.

## General:

This item of work shall be dealt in compliance to the clause 507 of specifications.

The construction shall confirm to the specific alignment, lines and grades given in the drawing.

## Procedure:

### Mix Design:

The mix design shall be carried out according to MS-2 of Asphalt Institute. The optimum bitumen content and job mix formula are arrived. The physical requirements of the aggregate shall confirm to table 500-8 and job mix shall confirm to grading 2 of table 500-10 of technical specifications. The mix properties shall confirm to table 500-11 of technical specifications. The permissible variations from the job mix formula shall be according to table 500-13.

## Preparation and Transportation of Mix:

The individual bins of hot mix plant shall be calibrated for the particular size of material. Material shall be fed to the mixing plant bins provided for individual sizes of aggregates to meet the required gradation. The temperature of binder at the time of mixing shall be in the range of 150'C-165'C and the aggregate in the range 150'C to 170'C .The difference between and the aggregate temperature shall not exceed 14'C any time. The mix shall be transported to the site with trippers properly covered with tarpaulins.

## Preparation of Base:

The sub base shall be checked for proper lines and levels.

The surface shall be swept free from dust with air compressor.

The tack coat shall be done if the WMM surface was primed and left for quite some time.

### Lying of Dense Bituminous Macadam:

The mix shall be laid with paver finisher. The paver shall have suitable loading hoppers and distribution mechanism. The paver shall have electronic sensor paver and string wire shall be run on steel pegs driven on both sides at 10m interval in straight portions and 5m interval in curved portions.

The mix shall be laid manually in places where the paver movement is not possible.

The compaction of DBM shall be done as per clause 501.6 and 501.7. The rolling shall be done with 80-100KN smooth wheeled tandem roller, 12-15 tones pneumatic tired roller. The rolling pattern shall be established in the trial stretch.

The DBM shall be laid in 2 layers or as per the GFC drawings.

The finished layer shall be checked for compaction. The compaction shall be checked by taking cores for every 250sq.m area and the degree of compaction shall not be less than 98% of lab Marshall Density or as specified by technical specification. The top shall be checked for level control and the levels shall be within ±6mm of designedlevel.

All relevant QA and QC documents will be maintained for all stages of Construction.

## 6.9 BITUMINOUS CONCRETE CONSTRUCTION

This item of work deals with construction of Bituminous Concrete with approved materials as per the specifications of contract agreement.

### General:

This item of work shall be dealt in compliance to the clause 509 of specifications.

The construction shall confirm to the specific alignment, lines and grades given in the drawing.

### Procedure:

### MixDesign:

The mix design shall be carried out according to MS-2 of Asphalt Institute. The optimum bitumen content and job mix formula are arrived. The physical requirements of the aggregate shall confirm to table 500-17 and job mix shall confirm to grading 1 of table 500-18 of technical specifications. The mix properties shall confirm to table 500-19 of technical specifications. The permissible variations from the job mix formula shall be according to table 500-13.

In case of modified binders the mix shall be conformed as per IRC: SP:53-2002.

## Preparation and Transportation of Mix:

The individual bins of hot mix plant shall be calibrated for the particular size of material. Material shall be fed to the mixing plant bins provided for individual sizes of aggregates to meet the required gradation.

The temperature of binder at the time of mixing shall be in the range of 150'C-165'C and the aggregate in the range 150'C to 170'C. The difference between and the aggregate temperature shall not exceed 14'C any time. In case of modified binder the temperature shall be maintained as per IRC: SP:53-2002. The mix shall be transported to the site with trippers properly covered with tarpaulins.

## Preparation of Base:

The base shall be checked for proper lines and levels.The surface shall be swept free from dust with air compressor. The tack coat shall be done if the DBM surface was old for quite some time.

## Lying of Bituminous Concrete:

The mix shall be laid with paver finisher. The paver shall have suitable loading hoppers and distribution mechanism. The paver shall be electronic sensor paver and string wire shall be run on steel pegs driven on both sides at 10m interval in straight portions and 5m interval in curved portions.

The mix shall be laid manually in places where the paver movement is not possible.

The compaction of BC shall be done as per clause 501.6 and 501.7. The rolling shall be done with 80-100KN smooth wheeled tandem roller, 12-15 tones pneumatic tyred roller. The rolling pattern shall be established in the trial stretch.

The finished layer shall be checked for compaction. The compaction shall be checked by taking cores for every 250sq.m area and the degree of compaction shall not be less than 98% of lab Marshall Density or as specified in technical specification. The top shall be checked for level control and the levels shall be within ±6mm of designed level.

All relevant QA and QC documents will be maintained for all stages of construction.

# 7.Plant and Machinery

## 7.1 Excavators

Excavators are heavy construction equipment consisting of a boom, stick, bucket and cab on a rotating platform (known as the "house"). The house sits atop an undercarriage withtractorwheels. They are used for many purposes:

- Digging of trenches, holes, foundations
- Material handling
- Brush cutting with hydraulic attachments
- Forestry Work
- Demolition
- General grading/landscaping
- Heavy lift, e.g. lifting and placing of pipes
- The number of excavators used at the site is six. Three types of excavators are used. They are:
- Excavator 100
- Excavator 200
- Excavator 300

The 100,200 and 300 here represent the size of the bucket.

## 7.2 Motor Grader

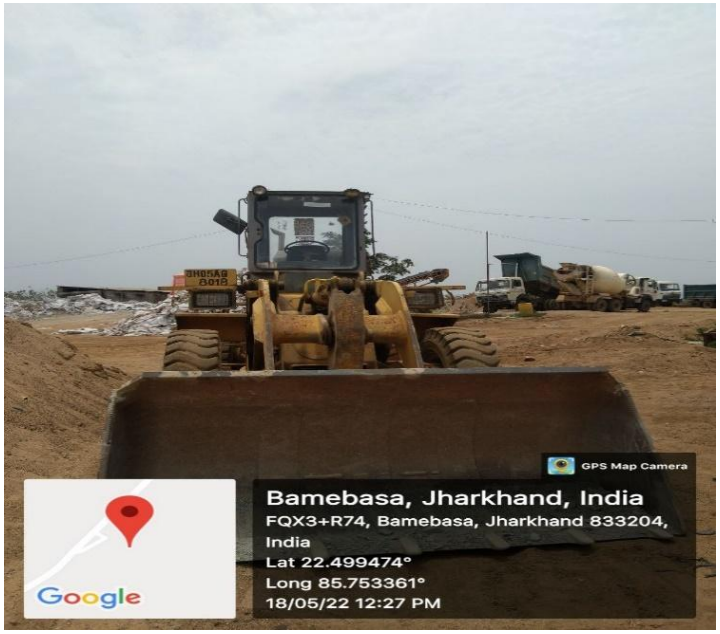
A motor grader is a machine with a long blade used to create a flat surface. The grader's purpose is to "finish grade" the "rough grading" performed by heavy equipment such as scrapers and bulldozers. Motor graders are commonly used in the construction and maintenance of dirt roads and gravel roads. In the construction of paved roads they are used to prepare the base course to create a wide flat surface for the asphalt or bitumen to be placed on. Graders can produce inclined surfaces, to give cant(camber) to roads.

## 7.3 Bulldozer:

A bulldozer is equipped with a substantial metal plate known as a blade used to push large quantities of soil, sand, rubble, or other such material during construction or conversion work and is also equipped at the rear with a claw-like device known as a ripper to loosen densely-compacted materials. Bulldozers are large and powerful tracked heavy equipment. The tracks give them excellent ground hold and mobility through very rough terrain. Wide tracks help distribute the bulldozer's weight over a large area (decreasing pressure), thus preventing it from sinking in sandy or muddy ground.

## Wheel Loader:

a. A wheel loader is a heavy equipment machine primarily used to load material such as bitumen, demolition debris, dirt, gravel, logs, raw minerals, recycled material, rock, sand, and woodchips into or onto another type of machinery such as a dump truck, conveyor belt. A wheel loader has a front-mounted square wide bucket connected to the end of two arms to scoop up loose material from the ground, such as dirt, sand or gravel, and move it from one place to another without pushing the material across the ground. A wheel loader is commonly used to move a stockpiled material from ground level and deposit it into an awaiting dump truck or into an open trench excavation. wheel loaders are used mainly for uploading materials into trucks, laying pipe, clearing rubble, and digging. A loader is not the most efficient machine for digging as it cannot dig very




deep below the level of its wheels, like an excavator can.

## 7.5 Stone crusher:

A crusher is a machine designed to reduce large rocks into smaller rocks, gravel, or rock dust. Crushers may be used to reduce the size, or change the form, of waste materials so they can be more easily disposed of or recycled, or to reduce the size of a solid mix of raw materials (as in rock ore), so that pieces of different composition can be differentiated.

## 7.6 WMM Plant:

This Central Mixing Plant for base and sub-base provides higher production with close control on quality of mix and production cost. The Wet Mix Plant is specially designed to suit the typical Indian site conditions. Capacity Range from 60 to 250 TPH. The plant can be constructed to meet tailor made requirements.

## 7.7 Hot Mix Plant:

A hot mix plant is a plant used for the manufacture of asphalt, macadam and other forms of coated road stone, sometimes collectively known as blacktop.

The manufacture of coated road stone demands the combination of a number of aggregates, sand and a filler (such as stone dust), in the correct proportions, heated, and finally coated with a binder, usually bitumen based or, in some cases, tar. The temperature of the finished product must be sufficient to be workable after transport to the final destination. A temperature in the range of 100 - 200 degrees Celsius is normal.

## 7.8 Batching Plant:

A batching plant, also known as a concrete plant, is a device that combines various ingredients to form concrete. Some of these inputs include sand, water, aggregate (rocks, gravel, etc.), fly ash, potash, and cement. There are two types of concrete plants: ready mix plants and central mix plants. The center of concrete batching plant is the mixer.

## 7.9 ROAD ROLLER

Road roller (sometimes called a roller-compactor or just roller) is a compactor type engineering vehicle used to compact soil, gravel, concrete, or asphalt in the construction of roads and foundations, similar rollers are used also at landfills or in agriculture.

A road roller (sometimes called a roller-compactor, or just roller) is a compactor-type engineering vehicle used to compact soil, gravel, concrete, or asphalt in the construction of roads and foundations. Similar rollers are used also at landfills or in agriculture. Road rollers are frequently referred to as steamrollers, regardless of their method of propulsion.

## 7.10DUMPERS

A dumper truck is primarily used to transport materials to and from a construction site. It is the safest way to quickly transport loose materials from a site, and is especially important in the early phases of a project where the ground is being prepared for work to commence. It is at this stage that there might be plenty of loose soil, gravel, dirt and other materials that must be removed in order for the next phase to continue. This is also the case in demolition work where plenty of damaged materials must be removed before work can continue. In these cases material lying around on site could be problematic and cause potential hazards for other workers, so a strong dumper truck is vital at this stage in proceedings.

Dumper trucks are also used to transport materials, such as sand and gravel, that are to be used within construction, not just to be removed from site. This is how dumper trucks have become an essential part of everyday life on construction sites and with the right choice you can streamline operations on your project.

## 7.11 BACKHOE LOADER

- the backhoe loader is an engineering and excavation vehicle that consists of a tractor, front shovel and bucket and a small backhoe in the rear end. Due to the small size and versatility, backhoe loaders are common with small construction projects and excavation type work. Originally invented in Burlington Iowa back in 1857, the backhoe loader is the most common variation of the classic farm tractor. As the name implies, it has a loader assembly on the front and a backhoe attachment on the back.

- A backhoe loader is one of the most used heavy equipment across the world which is often called digger in a layman's language. There are lots of heavy equipment companies in UAE who has a great deal to offer on backhoe loaders and one of them is Machinery Planet who offers backhoe loader in affordable rates. Backhoe Loader is the heavy equipment that has uses in the construction field and farm. As it is a digger there are lots of fields where backhoe loader will be useful.

- Let's see the advantages of having a backhoe loader.

- The buyers for almost 80 percent of their tasks like construction, small demolitions, and light transportation of building materials, digging holes excavation, landscaping, breaking asphalt, and paving roads prefer buying backhoe.

- Another use of backhoe loader is planting the cable wire antiestablishment; locate the buildings and therefore the systems of drainage.

- It can also be used in projects like fencing on different kinds of soils.

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## 7.12 WATER TRUCKS

Water trucks – specialized vehicles equipped with large tanks in the rear for transporting water and controlled spray nozzles for distributing it – are a familiar sight in a variety of sectors such as civil construction, mining, farming and fire control.

The advantages they offer by transporting and disbursing both potable and recycled water can be put to a variety of uses too, and we will discuss them below so you can see how the addition of a water truck can actually improve operations in your own business.

## 7.13 TRANSIT MIXER

A transit mixer provides a fast and easy way to produce concrete mixtures thereby giving an easy access for concrete mixture forming to the construction contractors when it is necessary. It fastens up the tasks of concrete production at sites and eliminates the problems of inefficiency in mixing, material wastage, concrete production and delivery delays at the construction sites. The transit mixers can be transported all around a job site and therefore allow the easier, faster and more convenient concrete production and placement at the site. The transit mixers are therefore popular concrete mixing units and are widely used for applications like residential driveways, sidewalks, walkways, patios, pool areas, steps, park areas and retaining wall blocks. However, the industrial applications of transit mixers include construction of dams, bridges, canals, high rise apartments, industrial buildings, distant highways, factories and many such infrastructure development projects.

For those looking to possess transit mixing units for their construction projects or requirements, Apollo Infratech offers the best and latest versions of portable concrete mixers for better concrete mixing and transport requirements at job sites. Apollo Infratech is a leading concrete construction equipment supplier in India offering high quality concrete construction equipment including ready mix concrete plant, batching plant, transit mixers, self-loading transit mixers, concrete pumps, concrete pavers and precast concrete application products.

# CONCLUSIONS

Design of flexible pavement as per IRC-37and quality control methods for construction of fully access control express highway as ORR –package (@km 72 to 83)

As per the Design of the pavement the thickness of each layers are observed as follows:

| | |
|---|---|
| Sub Grade: | 500mm. |
| GSB: | 200mm. |
| WMM: | 250mm. |
| DBM: | 130mm. |
| BC: | 50mm. |

For the above design the material properties of the aggregate and bitumen tests conducted as per the IS code and are within the allowable limits.

Quality control of the project comprises of material and methodology as per the standards of ISO 9001:2008 code Quality control methods.

Quality management used in the project as per the guidelines of network methods (Ganpt,bar charts, mile stone chats, critical part method and program evaluation review technique ).

# References:


- Highway Engineering by S.K. Khanna and Justo. MORT and H specifications.
- Traffic engineering and transport planning by Dr. L. R. Kadiyali
- ROAD CONSTRUCTION DEPARTMENT CHAIBASA (RCD)
- TRIVANI ENGICONE PRIVATE LIMITED (TEPL)