DESIGN ASPECTS OF FLEXIBLE PAVEMENT AND QUALITY CONTROL MANAGEMENT

A REPORT SUBMITTED TO **JNTU UNIVERSITY** IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR BACHELOR OF ENGINEERING

IN

CIVIL ENGINEERING

SUBMITTED BY:

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NIZAMPET ROAD, HYDERABAD-500090 APRIL 2012

CERTIFICATE

This is to certify that project entitled "DESIGN ASPECTS OF FLEXIBLE PAVEMENT AND QUALITY CONTROL MANAGEMENT**"** that is being submitted by S.Bharat Kumar (08241A0110), CH. Siddartha (08241A0143), T.Surya Vamshi (08241A0150), M.Tejendra Varma (08241A0153), V.Vamshi Krishna (08241A0154) in partial fulfillment of the requirement for the award of Degree of Bachelor of Technology in **Civi Engineering**, **GOKARAJU RANGARAJU INSTITUTE of Engineering and Technology** (Affiliated to Jawaharlal Nehru Technological University, Hyderabad) Is a record of bonafide work carried out by them under my guidance and supervision. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree.

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Consultancy Services for Construction Supervision of Outer Ring Road to Hyderabad City from Shamirpet to Pedda Amberpet (Km. 61.700 to Km. 95.000) Under JICA Phase-2

EXPERIENCE CERTIFICATE

Hyderabad,

13-04-2012.

This is to certify that the following students participated in project work (Construction of Eight Lane Access Controlled Expressway as Outer Ring Road to Hyderabad;JICA PHASE2 from Keesara(km.72.000) to GHATKESAR(km.83.000))

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ACKNOWLEDGEMENT

Success is epitome of hard work, cogency for fulfilling the mission, indefatigable perseverance and most of all encouraging guidance and steering.

We express our sincere thanks to, **MR. Jandhyala Murthy** Principal, GRIET for the support and motivation provided to us.

It gives us an immense pleasure to express our gratitude to Prof. **Dr.G.Venkata Ramana** , Head of Department of Civil Engineering and **Associate Prof. V.Gajendra**, for their esteemed guidance and able supervision during the course of the project. Their constant encouragement and co-operation made this project a success.

We would like to express our sincere thanks to M/s Aarvee Associates Pvt. Ltd, for providing us an opportunity to complete our Industrial oriented project successfully, which is a part of course curriculum. This training would not have been successfully completed without the guidance and support of Mr. P. Sudheer Kumar (Highway Engineer) and the entire Aarvee Associates Team. We are deeply indebted to the project team members who were always ready to help us during project time.

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ABSTRACT

Highway and pavement design plays an important role in the DPR projects

Regarding the pavement design, it forms an important part of detailed engineering study. The satisfactory performance of the pavement will result in higher savings in terms of vehicle operating costs and travel time, which has a bearing on the overall economic feasibility of the project. This project discusses about the design methods that are traditionally being followed and examines the relative merits of flexible pavement.

Currently, majority of the Indian roads are flexible pavements, the ones having bituminous layer/s. earlier, there used to be scarcity of cement and India went for flexible pavements with bituminous toppings. Now, flexible pavement are preferred over cement concrete roads as they have a great advantage that these can be strengthened and improved in stages with the growth of traffic. Another major advantage of these roads is that their surfaces can be milled and recycled for rehabilitation. The flexible pavements are less expensive also with regard to initial investment and maintenance.

Organization and duties of each individual is framed in this and the same is followed. This stands as the standards for the Quality Control Team. Using this, existing practical conditions are checked and reached to a conclusion about how the quality is maintained

Main focus is on the Quality Control Management in a construction activity. Thesis is to be prepared on how the Quality control management exist and the way it is being functioned. It can be done by drawing comparisons with the standard way and practical way.

Contents

1. INTRODUCTION

Hyderabad Growth Corridor Limited (HGCL), a Joint Venture of Hyderabad Metro Development Authority (HMDA) and Infrastructure Corporation of Andhra Pradesh (INCAP), has awarded "The Consulting Services for Construction Supervision of Construction of Eight lane access Controlled Expressway as Outer Ring Road to Hyderabad City in the State of Andhra Pradesh, India in the Stretches from Shamirpet to Pedda Amberpet -From Km.61.700 to Km.95.000(Northern Arc)" to NIPPON KOEI – aarvee associates (JV) in association with Nippon Koei India Pvt. Ltd, being taken up with the loan assistance of Japan International Cooperation Agency Under JICA Phase -2 Programme and Loan Agreement No ID-P:198 and the Agreement has been signed on 29th March'2010.

The monthly progress report is prepared and submitted with respect to the Terms of Reference (TOR) to the agreement between Nippon Koei, Japan in joint venture with Aarvee Associates, India in association with Nippon Koei India Pvt. Ltd. The report includes Project background, salient features of Civil Works, scope of Consulting Services and monthly progress of works in comparison with the approved Work Programme in accordance with Clause 11 of the General Condition of Contract. The report also covers the mobilization of the Consultant and the Contractors.

1.1 PROJECT BACKGROUND

Hyderabad Growth Corridor Limited has contemplated construction of Outer Ring Road all around the City of Hyderabad. The entire construction has been planned in two Phases viz. Phase I and Phase II of total length of 158.01 Km. Phase I of Outer Ring Road is of length 24.38 Km under implementation with domestic funding. Balance Length of 133.63 Km is taken up as Phase II. The Phase II is further divided in to Phase IIA & Phase IIB. Government of Andhra Pradesh has secured loan from JICA. JICA has agreed for funding of a part of the northern arc from km. 23.7 to km. 95 (Phase IIB). The Phase IIB, Northern Arc further divided into six contract packages, out of which three contract packages from km 23.7 to km 61.70 have already been awarded and the works are in progress.

The project section from km. 61.700 to km. 95.00 is supposed to establish linkage between Hyderabad-Karimnagar-Ramagundam Road and Hyderabad-Vijayawada section on NH-9. This section also intersects the Warangal-Hyderabad section of NH-202 and two other radial roads proposed to intersect the Outer Ring Road. It connects Shamerpet, Keesara, Padmasalguda, Ghatkesar, Taramatipet and Pedda Amberpet in the northern sector of the Hyderabad Suburban area.

The project road is 8-lane access controlled expressway with two lane service road on either side. A 25 m dedicated railway corridor is reserved between the expressway and right side service road. Underpasses are provided at all cross roads and suitable interchanges have been provided at major junctions. Original Contract provision contemplates one partial cloverleaf and 2 rotary interchanges in this section which is being revised into double trumpet interchange based on the Toll Consultants requirements. Pedestrian underpasses have been provided to facilitate connectivity between the service roads. The project is supposed to be tolled road. Closed toll system is proposed with a provision to collect toll on the exit/entry ramps at the interchanges. The traffic plying on the service roads will not be tolled as per current system. Accordingly toll system would be design. ITS is another important feature of this road, which would bring the Hyderabad Outer Ring Road in the list of expressways of international standard.

1.2 TECHNICAL FEATURES OF THE PROJECT

Project Right of Way (PROW)	:	150.00 M.
No. of Lanes for Main Carriageway	:	8(4 + 4)
No. of Lanes for Service Road	:	2 both sides
Main Carriageway width	:	15.7M both sides
Median Width	:	5.00 M
Paved Shoulder on Main Carriageway	:	2.50 M both sides
Earthen Shoulder	:	3.00M both side
Service Road width	:	7.25 M
Paved Shoulder on inner sides	:	1.50 M
Earthen Shoulder on inner sides	:	1.00 M
Footpath on outer sides	:	2.50M
Railway Corridor	:	25.00 M in between Main carriageway and right side service road

Pavement:

Main Carriageway:

Bituminous Concrete (BC)	:	50 mm
Dense Bit. Macadam (DBM)	:	130 mm
Wet Mix Macadam (WMM)	:	250 mm
Granular Sub-Base (GSB)	:	200 mm
Sub grade (SG)	:	500 mm

Service Road:

Bituminous Concrete (BC)	:	40 mm
Dense Bit. Macadam (DBM)	:	75 mm
Wet Mix Macadam (WMM)	:	250 mm
Granular Sub-Base (GSB)	:	200 mm
Sub grade (SG)	:	500 mm

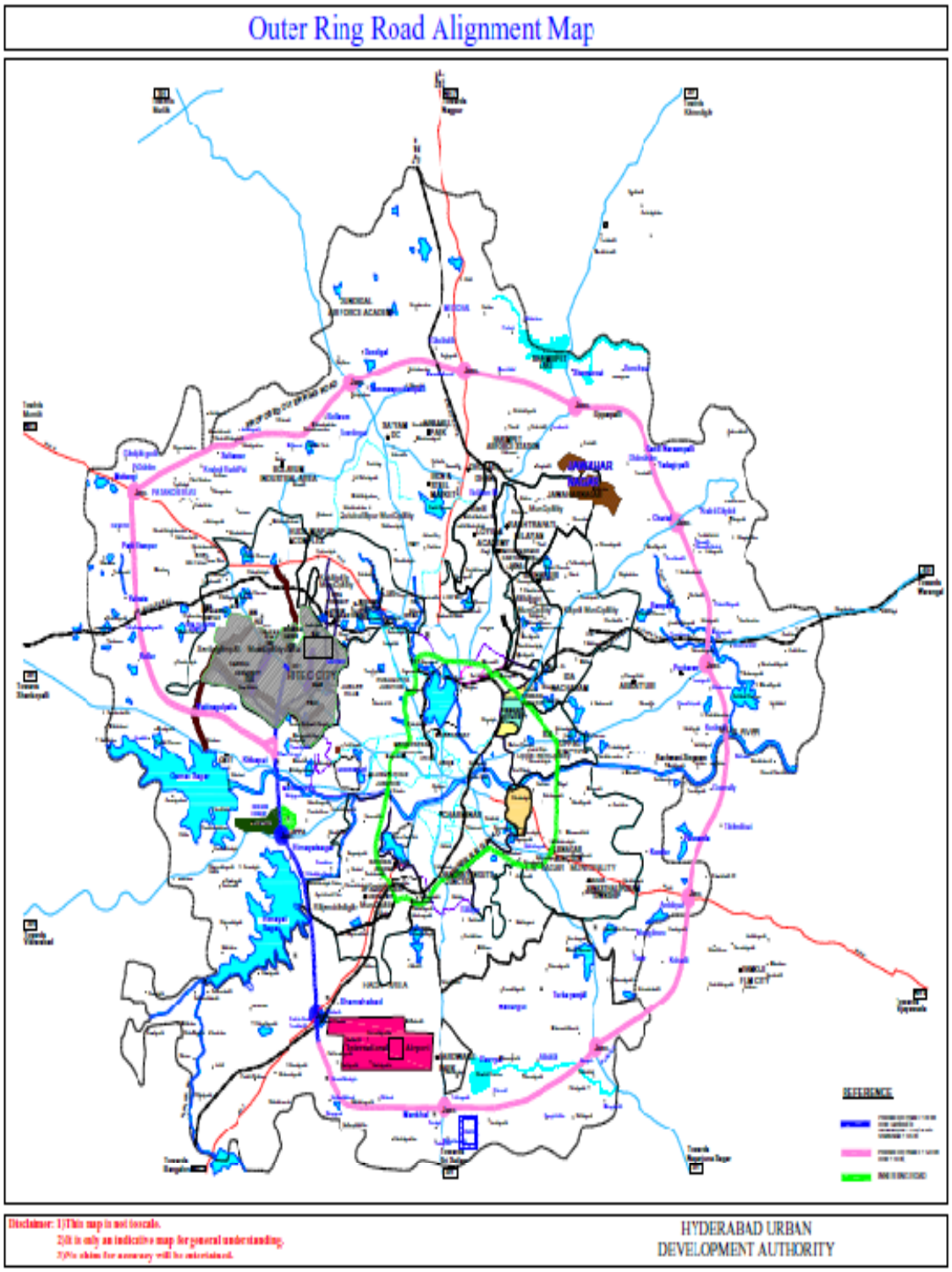
Value of Work	:	INR 347,83,92,840/-
Commencement date	:	26th May 2010
Contract Period	:	30 Months
Project Completion date	:	25th November 2012
Minimum amount of IPC	:	INR 10,000,000/-

1.3 PROJECT ROADS/ APPROVED CONTRACTORS

The remaining works of Phase II-B or JICA Phase II (Northern Arc) composed of 3 packages from km. 61.70 to km 95.00 have been awarded to the following:

Contract No.	**From**	**To**	**Length**	**Contractor**
ORR/JICA2/ Pkg-2/ 08-09	Km. 72.00 Keesara	Km. 83.00 Ghatkesar	11.0	M/s. Nagarjuna Co. Ltd India (Now NCC Ltd)

1.4 LOCATION PLAN OF THE PROJECT



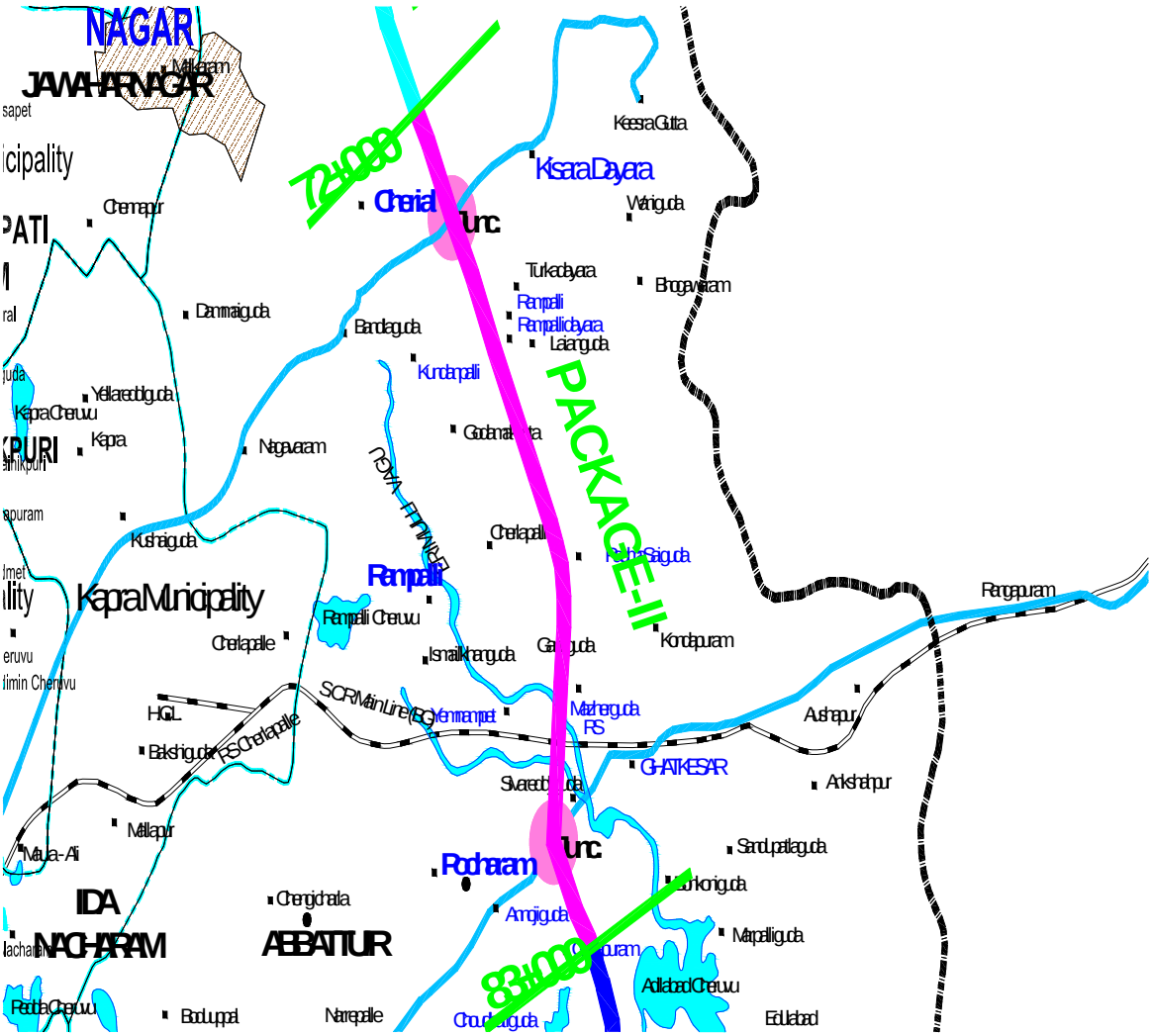
1.5 CONTRACT PACKAGE –II

SALIENT FEATURES

Construction of eight lane access controlled expressway as outer ring road to Hyderabad city in the state of Andhra Pradesh, India in the structures from Shamirpet to Pedda Amberpet from Km. 61.7 to Km. 95.00 (Northern Arc).

(Package – 2 from Keesara to Ghatkesar from Km. 72.000 to 83.000).

LOCATION OF THE MAP



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
- sub base course
- soil sub grade

Fig 1: A view of Flexible pavement components

2.3 Rigid Pavement:

Rigid pavements are those posses note worthy 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

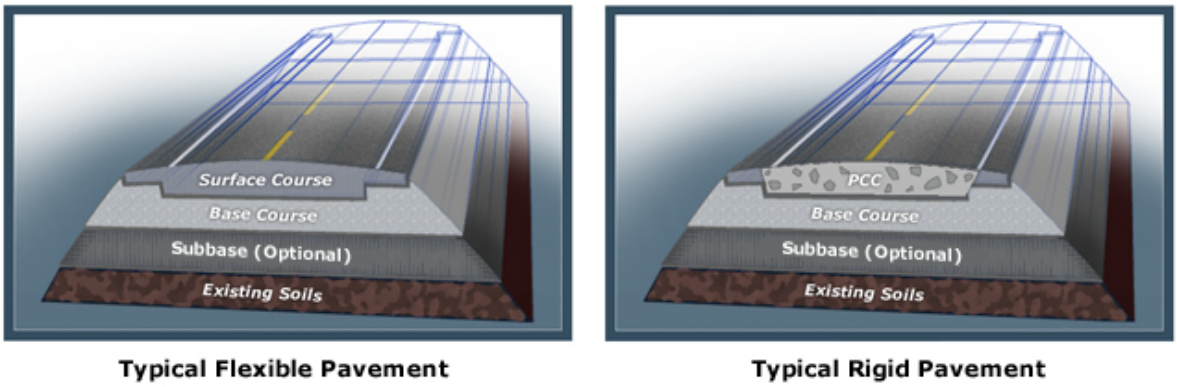


Fig 3: The difference between flexible and rigid pavement

2.4 Functions of Pavement Components:

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

2.4.1 Soil Subgrade:

The soil subgrade 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 subgrade for dispersion to the earth mass. It is essential that at no time, the soil subgrade is overstressed. It means that the pressure transmitted on the top of the subgrade 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 subgrade. 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 upto 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 subgrade 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 subgrade 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 tyres 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 consists 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:

i. Design wheel load
ii. Subgrade soil
iii. Climatic factors
iv. Pavement component materials
v. Environmental factors
vi. 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.

Table 1: Terrain Classification Recommended by IRC

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

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 / K 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

Table 2: Design Speeds to be adopted for Different Terrain

Sl 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

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 speed was

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 Kmph and for the rest of the ORR the design speed is taken as 120 Kmph.

3.2.3 Basic Principles of Geometric Design:

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 SECTIONAL ELEMENTS:

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.

Table 3: Right of Way

Sl No	Road classification	Right of way (m)
1	Outer Ring Road (ORR)	150m

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.

Table 4: Recommended Lane width on main carriageway

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

3.3.3 Width 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.

Table 5: Recommended Shoulder width

Type of Shoulder	Shoulder width (m)
Paved Shoulder (including edge strip) Will serve as emergency lane	3.0m
Earthen Shoulder	3.0m

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.

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

Height of Embankment (m)	**Slope (H:V)**
Upto 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

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 required at a later date, it was felt that an 8-lane divided carriageway with lane widths of

3.5m (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:

Table 7: Camber for different surface types

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

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 superelevation, 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 Superelevation:

Superelevation 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.

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

Where

‘e’ is Superelevation

‘V’ is the design speed in Km/h

‘R’ is the radius in meters

Table 8: Radii beyond which superelevation not required

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

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.

Table 9: Gradients for Roads in Different Terrain

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)

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.

Table 10: Conventional design speed for accesses

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

4. DESIGN OF PAVEMENTS

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.

4.2.2 Design Traffic:

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.

Table 1: Present and Projected traffic volume (PCUs) along the Project Corridor

Leg	2006	2011	2016	2021	2026	2031	2036
Leg-1	34,931	49,271	69,123	96,126	129,534	172,687	225,540
Leg-2	35,450	49,959	70,112	97,636	131,723	175,936	230,206
Leg-3	34,672	49,053	68,990	96,126	129,709	173,103	226,264
Leg-4	52,136	73,043	101,663	140,201	187,741	248,553	322,651
Leg-5	57,655	80,801	112,350	154,619	206,695	272,957	353,470
Leg-6	58,305	80,936	111,911	153,769	205,433	271,819	352,899
Leg-7	38,276	52,340	71,260	96,491	127,501	166,864	214,624
Leg-8	58,761	79,977	108,461	146,443	193,112	252,380	324,302
Leg-9	64,463	87,702	119,014	160,945	212,526	278,330	358,380
Leg-10	37,924	51,184	69,225	93,747	124,017	163,264	211,411
Leg-11	32,589	44,342	60,433	82,371	109,487	144,719	187,993
Leg-12	31,861	43,366	59,150	80,721	107,397	142,137	184,856

***** Legs as detailed in Table 4.

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 Main carriageway
- Design of Flexible Pavement for Service roads

In the design of flexible pavements, a subgrade CBR of 10% has been considered. Wherever the CBR of existing soils was found to be less than 10%, select subgrade 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 20-year design period (2009 - 2029) 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.

Table 2: Summary of Vehicle Damage Factors

Location	**2-Axle Truck**	**3-Axle Truck**	**M-Axle Truck**	**LCV**	**Buses**
Shamshabad (NH-7)	3.21	2.41	2.57	0.23	0.50
Amberpet (NH-9)	2.66	3.17	4.92	0.36	0.30
Medchal (NH-7)	3.90	2.42	7.60	0.40	0.44
Pathancheruvu (NH-9)	1.50	2.60	2.65	0.14	-
Average	**2.82**	**2.65**	**4.44**	**0.28**	**0.41**

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.

Table 3: Design Lane MSA

S.No.	Stretch	MSA as per IRC: 37-2001	MSA as per observed VDF	Suggested Value (MSA)
1	Shamshabad to APPA	101	65	100
2	APPA to Gandipet	99	64	100
3	Gandipet to Patancheru	101	65	100
4	Patancheru to Narsapur Rd	154	100	100
5	Narsapur Rd to Kandlakoya	179	116	100
6	Kandlakoya to Shameerpet	158	104	100
7	Shameerpet to Keesara rd	106	70	100
8	Keesara rd to Ghatkesar	160	106	100
9	Ghatkesar to Amberpet	172	115	100
10	Amberpet to Bongulur	86	58	100
11	Bongulur to Srinagar	75	51	100
12	Srinagar to Shamshabad	72	49	100

* 100 MSA has been considered in the design of pavement for phase II.

4.5 Sub grade Strength:

The new pavement will be constructed on a sub grade with minimum soaked CBR of 10%.

4.6 Design Lane MSA:

The base year traffic, traffic growth rates and the projected traffic for the design period for each category of vehicles have been extracted from the Chapter 4 of main volume. The new facility is expected to be opened for traffic in the year 2010 and for a design period of 20

years, the horizon year is 2029. Keeping in view the potential of the Outer Ring Road, and the amount of traffic that could be diverted on the ORR, the pavement design was carried out for a 100 Msa. The new pavement will be constructed on a sub grade with minimum soaked CBR of 10%.

4.7 Design Composition:

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

- BC 50mm
- DBM 130mm
- WMM 250mm
- GSB 200mm
- Selected Sub grade 500mm

4.8 AASHTO:

The AASHTO methodology for the design of pavements uses the following parameters while calculating the crust thickness. They are

- Pavement structure or Structural Number (SN)
- Resilient Modulus of Roadbed soil
- Climate related factors
- Loss of Serviceability
- Overall Standard Deviation
- Reliability
- Standard Normal Deviate

The pavement composition or crust thickness is expressed in terms of Structural Number (SN, an abstract number) and is calculated as:

$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3 + \ldots + a_i D_i m_i$

Where:

D_i: Layer thickness (inches);

a_i: Layer Coefficient

m_i: Drainage Coefficient

The roadbed soil strength is expressed in terms of resilient modulus M_R. The climate is mainly related to the drainage as expressed in the factor m, and the pavement condition is expressed in the pavement serviceability index PSI. Further, the traffic is expressed in "W_{18}", being the cumulative number of equivalent standard axle loads of 18kip. Thus, AASHTO uses the following equation:

$Log_{10}(W_{18})=Z_R*So+9.36log_{10}(SN+1)-0.20+((Log_{10}(\Delta$ Psi/Po-Pt))/$(0.40+(1094/(SN+1)^{5.19}))+ 2.32 * log_{10}M_R-8.07$

Where:

W18: Cumulative Number of standard axles in design life

ΔPsi: Initial Serviceability (Po)-Terminal Serviceability (Pt)

So: Standard Deviation

Z_R: Standard normal deviate for particular reliability(R)

S_N: Structural number for the crust composition

The following values have been considered in the design

- Resilient modulus of the roadbed soil, M_R computed from the empirical relation between MR and CBR of the road bed soil
- Serviceability loss (ΔPsi) of 1.7 considering Po = 4.2 and Pt = 2.5
- Standard Normal Deviate Z_r of -1.282 for a Reliability level of 90 %
- Overall standard deviation S_0 is 0.49

Within the equation $SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$ the "m" value depends on the quality of the drainage and the exposure time to moisture levels approaching saturation. A value of 1 has been considered for m2 and m3. (Table 2.4 of AASHTO).

The layer coefficients can be determined respectively from Figures 2.5, 2.6 and 2.7 (AASHTO, part II):

a_1 for AC/DBM: 0.33

(For an elastic modulus of 1695 MPa at 35°C derived from IRC: 37-2001)

a_2 for WMM: 0.14 with CBR = 100

a_3 for GSB: 0.11 with CBR > = 30

4.9 Design Composition:

Based on the guidelines given in AASHTO Pavement Design Guide, 1993, for a subgrade CBR of 10% and a design lane Msa of 100, the following composition has been worked out.

- BC 50mm
- DBM 300mm
- WMM 175mm
- GSB 100mm
- Selected Subgrade 500mm

4.10 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 been adopted.

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

- BC 50mm
- DBM 130mm
- WMM 250mm
- GSB 200mm
- Select Subgrade 500mm

4.11 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 40mm
- DBM 75mm
- WMM 250mm
- GSB 200mm
- Select Subgrade 500mm

5. LABORATORY TESTS

5.1 Tests:

1. Grain Size Analysis (GSA)
2. Free Swell Index (FSI)
3. Field Density Test by Sand Replacement Method
4. Modified Proctor Compaction Test
5. Bitumen Extraction Test
6. California Bearing Ratio Test (CBR Test)

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.

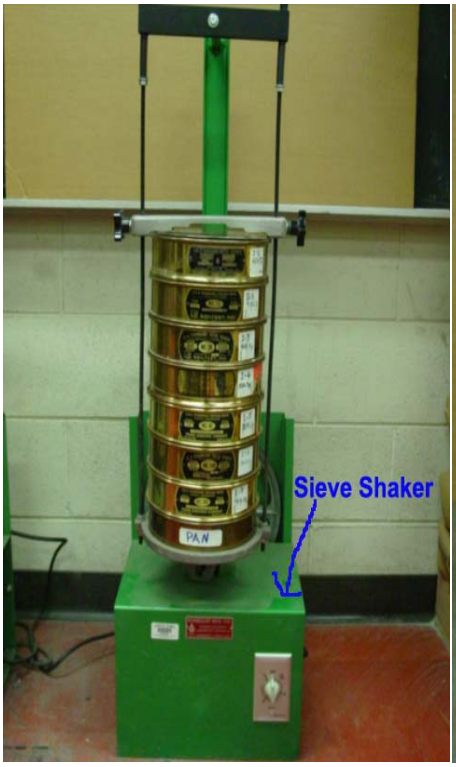
Equipment:

Balance, Set of sieves, Cleaning brush, Sieve shaker, Mixer (blender), 152H Hydrometer, Sedimentation cylinder, Control cylinder, Thermometer, Beaker, Timing device.

Test Procedure:

Sieve Analysis:

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 10 minutes.
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.


Sieve Shaker
PAN


Set of Sieves
Soil Specimen
PAN
Balance


PAN


Adventurer

2. Free Swell Index (FSI)

Object: To determine the free swell index of soils.

Apparatus:

1) 425 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 read out.

3. 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 level surface.
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 open end.
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 10mm thick.
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 105^0C to 110^0C.
11. A dessicator 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 yhe of 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 sqcm 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.

4. 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 30 cm.
3. Sample Extruder.
4. A sensitive balance.
5. Straight edge.
6. Squeeze bottle
7. Mixing tools such as mixing pan, spoon, trowel, spatula etc.
8. Moisture cans.
9. Drying Oven.

Test procedure:

1. Obtain approximately 10 lb (4.5 kg) of air-dried soil in the mixing pan, break all the lumps so that it passes No. 4 sieve.
2. Add approximate amount of water to increase the moisture content by about 5%.
3. Determine the weight of empty proctor mould without the base plate and the collar.
W1, (lb).
4. Fix the collar and base plate
5. Place the first portion of the soil in the Proctor mould as explained in the class and compact the layer applying 25 blows.
6. Scratch the layer with a spatula forming a grid to ensure uniformity in distribution of compaction energy to the subsequent layer. Place the second layer, apply 25 blows, place the last portion and apply 25 blows.
7. The final layer should ensure that the compacted soil is just above the rim of the compaction mould when the collar is still attached.

8. Detach the collar carefully without disturbing the compacted soil inside the mould and using a straight edge trim the excess soil leveling to the mould.
9. Determine the weight of the mould with the moist soil W2, (lb). Extrude the sample and break it to collect the sample for water content determination preferably from the middle of the specimen.
10. Weigh an empty moisture can, W3, (g) and weigh again with the moist soil obtained from the extruded sample in step9, W4, (g). Keep this can in the oven for water content determination.
11. Break the rest of the compacted soil with hand (visually ensure that it passes US Sieve No.4). Add more water to increase the moisture content by 2%.
12. Repeat steps 4 to 11. During this process the weight W2 increases for some time with the increase in moisture and drops suddenly. Take two moisture increments after the weights starts reducing. Obtain at least 4 points to plot the dry unit weight, moisture content variation.
13. After 24 hrs recover the sample in the oven and determine the weight W5, (g).
14. Fill out the following table completely; Calculate rows 9 and 10, these two will give one point of the plot.

5. 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:

Centrifuge extractor with a bowl. The extractor must be capable of rotating the bowl at controlled variable speeds up to 3600 rpm.

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.

Heating equipment such as electric stove.

500 ml cup or beaker.

Hand Tools - spatula, small brush, scoop, large pan for collection of a representative bitumen mix sample, pan for test sample.

Container for collection of bitumen laden solvent thrown from the bowl during extraction.

Materials:

Solvents - suggested materials are benzene or Carbon Tetra chloride.

Procedure:

A representative sample about 400gm is exactly weighed and placed in the bowl of the extraction appartatus 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.

The filter ring of the extractor is dried, weighed and then fitted around the edge of the bowl. The cover of the bowl is clampled tightly. A beaker is placed under to collect the extract.

The machine is revolved slowly and then gradually, the speed is increased to a maximum of 3600 r.p.m. The speed is maintained til 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.

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.

6. 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 unsoaked CBR.

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.

Then place the specimen under the penetration piston and place surcharge load of 10lb.

Apply the load and note the penetration load values.

Draw the graphs between the penetration (in) and penetration load (in) and find the value of CBR.

Draw the graph between the %age CBR and Dry Density, and find CBR at required degree of compaction.

6. ROAD CONSTRUCTION ACTIVITY

6.1 EARTHWORK EXCAVATION

General:

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 beforehand.

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 this regard.

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

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 road sector.

6. While the joint survey recording is being plotted the laboratory tests shall be carried out and the results obtained thus submitted to the Engineer for further instructions. On instructions by the Engineer, necessary excavation works shall be commenced. Prior to such commencement, however, necessary lines shall be marked and jointly recorded for extension of excavation works.

7. Excavation shall be done with the help of excavators EX-200, EX-100 or other suitable plants depending upon the stretches & quantum of work.

8. Excavated earth shall either be required to be disposed off or stacked at site. This shall be done as per the directions of the Engineer. In case of disposal of materials to other place, required number of tippers compatible with the capacity of excavator & the haulage shall be engaged to do the job.

9. Excavation shall be done up to the depths as detailed in the drawings or as directed by the Engineer. However the works in normal course shall conform to the lines, grades & slopes as specified.

10. While planning or executing excavations we will take adequate precautions against causing of any water stagnation or soil erosion or water pollution.

11. Under special circumstances, not in the case of excavation for sand blanketing, where we require blasting of rocks for excavation works, this shall be done only with the written permission of the Engineer after complying with the necessary state formalities.

12. In the case of intercepting with water table, water pumps shall be deployed immediately to pump out the excessive water for working conditions. However no delay shall be caused in this regard for obtaining further instructions from safety of works and plant considerations.
13. As a necessary quality procedure, in order to record the instructions and works and keep a regular documentation of inspections, checking, approvals or disapprovals with necessary observations at all stages of the work from commencement till completion of the excavation works, RFI shall be initiated by us with full endorsement of Engineer or his representative obtained before closing the document.

6.2 EMBANKMENT CONSTRUCTION

This item of work deals with construction of road embankment 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.

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.

Procedure:

1. The toe line and centre line are marked and pegs will be driven.
2. The material shall be dumped in site at respective location.

3. The material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thicknesses over the entire width of the embankment by mechanical means and will be graded with motor grader to the required camber.

4. Moisture content of the material shall be checked and extra required will be added.

5. The moisture content of each layer shall be checked and it should be within the range of OMC +1% to OMC -2 percent. If moisture content is found out of these limits the same will be brought within limits by addition of water or by aeration as the case may be.

6. The compaction shall be done with the help of vibratory roller of 8 to 10 ton static weight. Each layer shall be thoroughly compacted to the densities specified in the specifications which are mentioned at the end of this document for reference. The rolling pattern will be finalized in trial stretch.

7. On compaction of the particular stretch, necessary field testing shall be carried out Field density shall be done in the manner and frequency as specified below.

8. If the required field density is not achieved, compaction shall be continued till required density is achieved.

9. Loose pockets if any will be removed and replaced with approved material.

10. The above stages shall be repeated till the top level of the embankment is reached to the specified levels and grades. The top levels shall be checked and shall be within +20mm and -25mm of designed level.

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

12. Where the ground supporting embankment is found to be unsuitable (material mentioned in clause 305.2.1.1) or the original ground material is having free swell index greater than 50% the same will be removed up to 500mm and will be replaced with approved material as per clause 305.3.4.

Equipment/Machinery:

Motor Grader	**:** 1 No. as a minimum
Tippers	**:** 10 -20 No. as a minimum
Water Sprinkler	**:** 1 No. as a minimum
Vibratory Roller	**:** 80 to 100KN 1 No. as a minimum

6.3 SUBGRADE CONSTRUCTION

This item of work deals with construction of Subgrade (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, 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 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 in subgrade.

Procedure:

1. The toe line and centre line are marked and pegs will be driven.
2. The material shall be dumped in site at respective location.
3. The material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thicknesses over the entire width of the subgrade by mechanical means and will be graded with grader to the required camber.
4. Moisture content of the material shall be checked and extra required will be added.

5. The moisture content of each layer shall be checked and it should be within the range of OMC +1% to OMC -2 percent. If moisture content is found out of these limits the same will be brought within limits by addition of water or by aeration as the case may be.

6. The compaction shall be done with the help of vibratory roller of 8 to 10 ton static weight. Each layer shall be thoroughly compacted to the densities specified in the specifications which are mentioned at the end of this document for reference. The rolling pattern will be finalized in trial stretch.

7. On compaction of the particular stretch necessary field testing shall be carried out Field density shall be done in the manner and frequency as specified below.

8. If the required field density is not achieved, compaction shall be continued till required density is achieved.

9. Loose pockets if any will be removed and replaced with approved material.

10. The above stages shall be repeated till the top level of the subgrade is reached to the specified levels and grades. The top levels shall be checked and shall be within +20mm to -25mm of designed level.

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

12. In case the original ground is in subgrade level or is in cutting and if the density after compaction is not 97% minimum the ground will be loosened up to a depth of 500mm and will be compacted as per MoRT&H 305.3.

Equipment/Machinery:

Motor Grader : 1 No. as a minimum
Tippers : 10 – 20 No. as a minimum
Water Sprinkler : 1 No. as a minimum
Vibratory Roller : 80 to 100KN 1 No. as a minimum

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.

Procedure:

1. The toe line and centre line are marked and pegs will be driven.
2. The material shall be dumped in site at respective location.
3. The material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thicknesses over the entire width of the subgrade by mechanical means and will be graded with grader to the required camber.
4. Moisture content of the material shall be checked and extra required will be added.
5. The moisture content of each layer shall be checked and it should be within the range of OMC +1% to OMC -2 percent. If moisture content is found out of these limits the same will be brought within limits by addition of water or by aeration as the case may be.
6. The compaction shall be done with the help of vibratory roller of 8 to 10 ton static weight. Layer shall be thoroughly compacted to the densities specified in the specifications

which are mentioned at the end of this document for reference. The rolling pattern will be finalized in trial stretch.

7. On compaction of the particular stretch necessary field testing shall be carried out Field density shall be done in the manner and frequency as specified below.
8. If the required field density is not achieved, compaction shall be continued till required density is achieved.
9. Loose pockets and segregated area if any will be rectified/removed and replaced with approved material. The top levels shall be checked and shall be within +10mm to -20mm of designed level.
10. All relevant QA and QC documents will be maintained for all stages of Construction.

Equipment/Machinery:

Motor Grader	: 1 No. as a minimum
Tippers	: 10 - 20 No. as a minimum
Water Sprinkler	: 1 No. as a minimum
Vibratory Roller	: 80 to 100KN 1 No. as a minimum

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.

Laying 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 trial stretch.

Care shall be given at every stage so that there will not be any segregation.

The finished layer shall be checked for compaction in accordance to the specifications given below. The top shall be checked for level control and shall be within +10mm and -10mm of designed level.
All relevant QA and QC documents will be maintained for all stages of construction.

Equipment/Machinery:

WMM Plant : 1 No.

Grader : 1 No. as a minimum.

Tippers : 10 - 20 No. as a minimum

Roller (Vibratory) : 80 to 100KN 1 No. as a minimum

Paver Finisher : 1 No.

A view of Subgrade, GSB & WMM

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 spreading sand.

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 TACK COAT

General:

This work is consisting of application of a Single Coat Cationic emulsion of rapid setting type confirming to IS 8887.

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.

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

Equipment/Machinery:

Hot Mix Plant (Batch Mix Type)	: 1 No.
Tippers	: 10 - 20 No. as a minimum
Rollers	: 80 to 100KN Smooth wheeled tandem rollers 2 No. as a minimum & 12-15Tones PTR 2 No. Minimum
Paver Finisher (Hydraulic)	: 1 No.
Steel pegs	: 50 No. minimum.
Mechanical broomer/Air Compressor	: 1 No.
Wheel borrow	: 2 No.
Edge cutter	: 1 No.

A view of DENSE BITUMINOUS MACADAM

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:

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 500-17 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.

Laying 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.

Equipment/Machinery:

Hot Mix Plant(Batch Mix Type)	: 1 No.
Tippers	: 10 - 20 No. as a minimum
Rollers	: 80 to 100KN Smooth wheeled tandem rollers 2 No. as a minimum & 12-15Tones PTR 2 No. Minimum
Paver Finisher (Hydraulic)	: 1 No.
Steel pegs	: 50 No. minimum.
Mechanical broomer/Air Compressor	: 1 No.
Wheel borrows	: 2 No.
Edge cutter	: 1 No.

A VIEW OF LAYING OF BITUMINOUS CONCRETE

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 with tracks or wheels. 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 are six.

Three types of excavators are used. They are:

i. Excavator 100
ii. Excavator 200
iii. Excavator 300

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

7.2 Motor Grader:

A motor grader is a construction 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.

7.4 Wheel Loader:

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 roadstone, sometimes collectively known as blacktop.

The manufacture of coated roadstone 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 Dumpers:

A dumper is a truck used for transporting loose material such as sand, gravel, and dirt for construction. A typical dump truck is equipped with a hydraulically operated open-box bed hinged at the rear, the front of which can be lifted to allow the contents to be deposited on the ground behind the truck at the site of delivery.

7.9 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.

7.10 Sensor Paver:

Trusted for its performance with precision, Sensor Paver Finisher is one of the most reliable products by Shiv Shakti Road Equipments. A mix of power, sensibility and sharpness. This machine has been ultimate in its league unfailingly living upto the requirements and needs of Road Constructing Company over the years. Presenting a unique mix of technology, functionality, and quality, Sensor Paver Finisher guarantees best operational results.

8. Quality Management

8.1 Introduction:

The Globalization and developing Technology in the Construction Industry is leading to High competition in the Current market. The best response to a competitive challenge in the Construction Industry is to become more competitive. The best means of achieving this is by improving the product quality and meeting the project schedule through a well designed Quality Management system.

The Quality Management system shall focus on providing improved control on processes and practices, thus enhancing customer satisfaction through its effective implementation.

8.2 Quality Policy, Quality System and Quality Strategy:

The Quality Policy is communicated and made understood at all level of the organization through awareness program an display of the Quality Policy boards at all the Project sites/departments. The Quality Policy shall be reviewed annually for continual improvement and suitability to the purpose of the division.

Taking Quality Policy as guide, the quality objectives are established in related functions and monitored in the monthly steering committee meetings and periodic Management Review meetings.

Management review includes review of Quality objectives and specific policy statements with the view to achieve Quality objectives and meeting the requirements of the policy statement.

8.3 Quality Policy:

aspires to fulfill the expectations of our customer by a dedicated and organized approach, which is amenable to skill and knowledge enhancement.
shall improve the competence of our Quality management System continually.

Focus is to accomplish this aim shall be on:

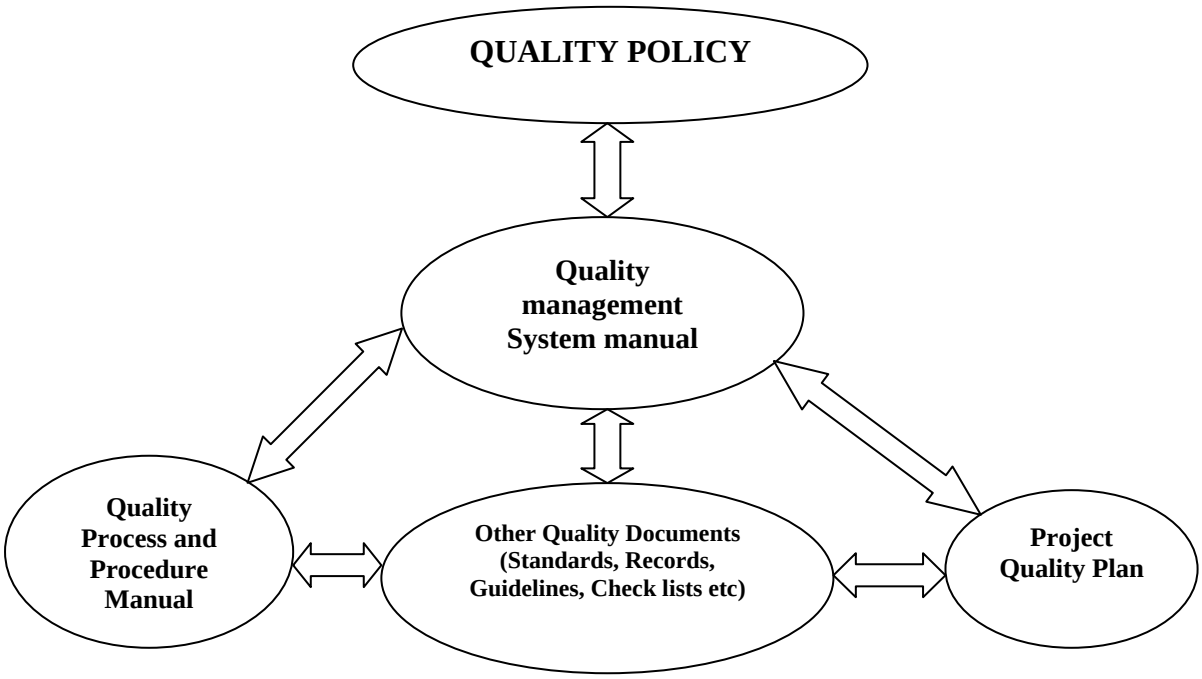
- Effective design.
- Effective Implementation of planning and Methodology.
- Effective Supplier Management.
- Proficient Management of Workforce.
- Training and development of Human Resource.

8.4 Quality System:

The Quality System has been designed to ensure that the Quality Policy, objectives and the requirements of ISO 9001:2008 are implemented. The system has been determined in terms of the following main processes.

1. Estimation, Costing and Tendering
2. Design and Engineering
3. Quality planning and Control
4. Planning, Monitoring and Control
5. Plant and Machinery provision
6. Project Operation
7. Commercial, Contract and Procurement
8. Personnel and training
9. Finance
10. Quality System

Structure of Quality Management System documentation



8.5 Quality Strategy:

Implementation of the Quality Management system and its effectiveness is ascertained by periodical monitoring as well as by structured internal quality audit and corrective and preventive action to ensure improvement in effectiveness of the Quality system in operation.

A continuous process of feasible Technology up gradation and value analysis is initially targeted at persisting un solved non-conformities to be attended to as well as potential problems.

Management review of the quality system is conducted periodically, to check for continued suitability for effectiveness, towards meeting the requirement of the organization's Quality Policy and objectives.

The integrity of Quality Management System is ensured when changes are planned and implemented.

8.6 Planning:

This Project Quality Manual is the document which details the Quality System to be planned, established, implemented and maintained as part of the contract for the road works for the project.

The Project Quality Plan consists of the following:

(i) The Project Quality Statement of the company.

(ii) Project Specific Details including Organization and System Element Description.

(iii) Inspection and Test Plans (including Construction Process Flowcharts and Quality Verification Checklists).

(iv) Project specific Procedures as required by the contract specification / concession agreement.

The inspection and test plan shall identify necessary inspections and tests to verify conformance of the work during performance of the identified project tasks. It shall include acceptance criteria and details for performance of inspection and test activities, as applicable.

8.7 Control:

Control shall be achieved by implementing the requirements of the Project Quality Manual including construction process controls, inspection and test plan and audit requirements. Continuous monitoring and the investigation of timely corrective action shall form the basis of control. System Element Descriptions shall detail the methods by which the quality system is controlled. The agreed Inspection and Test Plans shall be used for controlling the work and detecting nonconformance.

8.8 Verification:

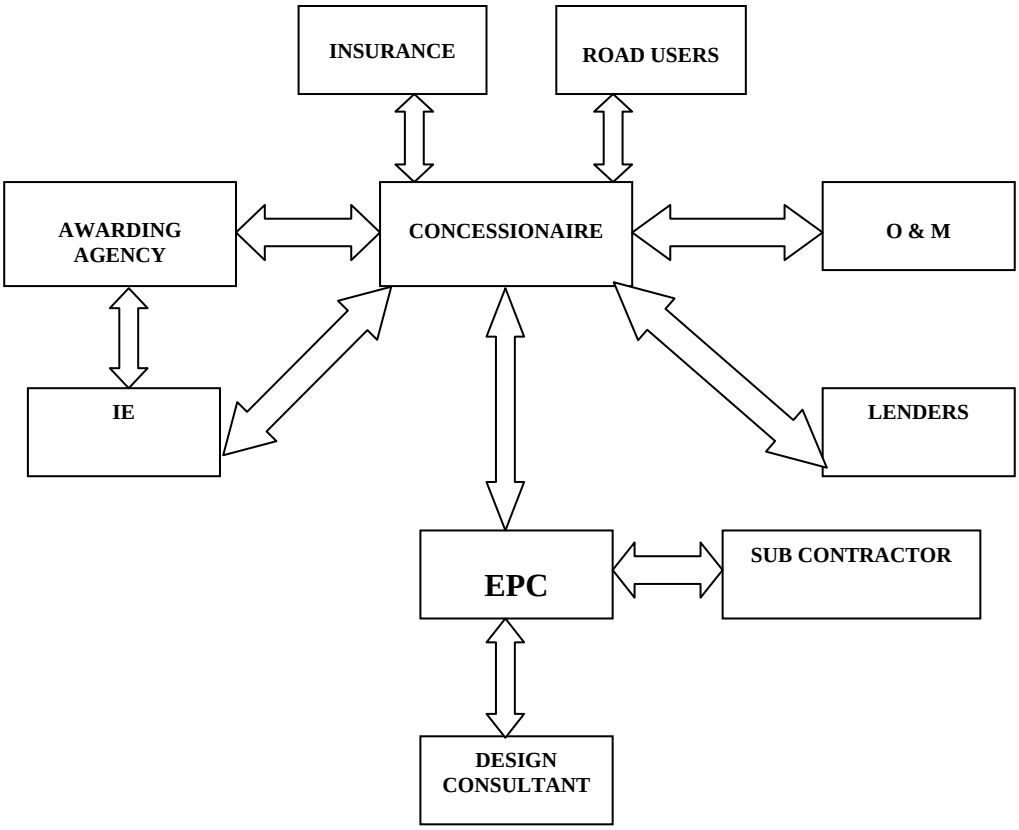
Verification processes shall be established to ensure that the planning and controls have been effective and the Quality System and constructed works conform to the specified requirements. The outcome of all verification activities shall be documented and maintained as quality records. Records of conformance shall be available for inspection by the Concessionaire's Representative / IE upon request to provide evidence of the outcome of activities undertaken to achieve conformance.

8.9 Quality Management in Construction and Reporting

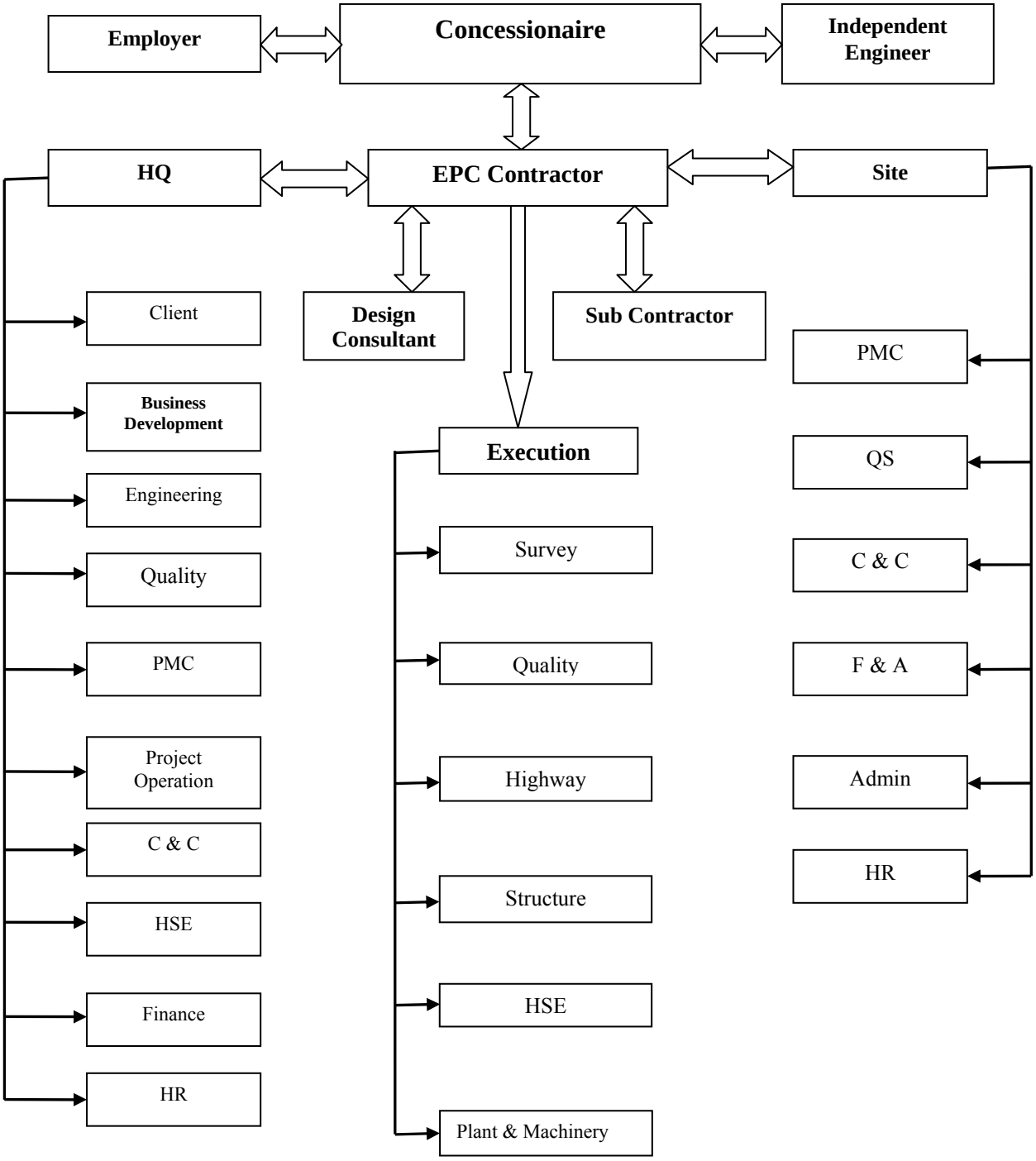
8.9.1 Management Responsibilities:

The Head – Project Operations (Roads) has the overall responsibility for construction of the project, ensuring Customer (Concessionaire) satisfaction. The Chief Project Manager of Project will be in charge of this Project and will be reporting to the Head – Project Operations (Roads). Project Quality Plan will be implemented by the Chief Project Manager. The Project QA/QC team will interact with QA /QC team of Concessionaire for review of material tests, mix designs and QA/QC procedures as per the Project Quality Plan and reports functionally to Head – QA/QC H.O. The Head – QA/QC H.O will report to the top management and act independently to implement QA policy of the Organization. He has the responsibility for formulating, implementing, reviewing, monitoring, verifying and assessing the effectiveness of Quality Assurance program. He has also been delegated the authority to take corrective measures in case of any significant quality related problems are noticed, with the intimation to the Chief Project Manager.

8.9.2Contractual Link between key players:



8.9.3 Organization set up of the Project:



8.9.4 Functions of QA / QC system:

For each major activity of work, method statement *(can be seen in the latter part)* will be prepared indicating the quality checks for incorporated materials and stage of construction.

i. Ensure that equipment and testing instruments are calibrated properly and adjusted to maintain their accuracy within acceptable limits. (*Calibration reports are maintained and calibrated according to the frequency)*

ii. Provide day to day routine / sudden spot checks on materials and finished products. *(Day to day tests are done on the materials according to the frequency)*

iii.

iv. Identify problems and initiate action, which results in solution. *(Not encountered)*

v. Verify implementation of solutions / corrections. *(Not encountered)*

vi. Report regularly on effectiveness of the system.

vii. Tests to be performed jointly by EPC contractor in presence of Concessionaire's & IE Representative at site before start of any activity and after review/approval there of the same activity has to start. In case of non availability of Concessionaire/ IE 's representative, tests will be carried out by EPC's QC Engineer under information in the interest of work. *(Done in the same way)*

viii. All the test reports have to be certified by the EPC, Concessionaire's, representative and IE. *(Certified in the same way & each will be given a copy at the end of the project*)

ix. All records of Source qualifying and routine tests / checks will be jointly maintained

x. at the AGM (QA/QC)'s office of EPC. *(Maintained at the office)*

xi. Monthly Project QA report will be prepared by project AGM (QA/QC), summarizing the activities of QA department which is to be submitted to Concessionaire's Management. *(Monthly reports are updated)*

xii. Project Manager / AGM (QA/QC) through his representative at site will point out the non-conformity of Product/Work to standards & Specifications if any, to the contractor's authorized representative in writing and a copy of the same to be sent to the Chief Project Manager for getting the work done as per quality standard required as specified in concession agreement, quality specifications or drawings.

xiii. The Client, Concessionaire, Independent Engineer, EPC Contractors, Sub contractors, Material supplier and Manufacturer, each form a link of the quality chain. The strength of this chain is dependent on each and every link. The AGM (QA/QC) is to keep a continuous watch on this chain and spot the weak link before it snapped.

8.9.5 Quality Management Reports:

The AGM (QA/QC) at site shall prepare a monthly Quality Management Report for review by the Chief Project Manager / Project Manager. The Quality Report shall be subdivided into the following headings:

Summary of Inspection and Test Activities. (Field & Laboratory)

Registers of Nonconformance & Corrective Action.

Status of Approvals of all Materials.
Pending approvals by the Concessionaire/ IE.
Items of specific concern.
General Notes.

8.9.6 Distribution of the Quality Management Report shall be as follows:

Concessionaire
Chief Project Manager
Project Manager
Head (QA/QC) (HO)
The Quality Management Report shall be submitted to the CPM within one week of the close of the monthly reporting period and in turn Site shall forward this to **Head Office (QA)** within 3rd of the every month for record and distribution to the respective section in charge for record and action required if any.

8.9.7 Management Reviews:

The operation and effectiveness of the Project Quality Plan shall be regularly reviewed by Management Review meetings held once in Two months for the duration of the project. The monthly Quality Management Report together with Audit Reports shall form the basis of the review.

The Management Review meetings will be attended by the CEO, Head – Project Operations (Roads), Management Representative, and Project Management team. Minutes of the management review meeting will be taken by the MR. He shall be responsible to prepare and distribute minutes to the members of the review Committee for their information and action.

8.9.8 Monthly Progress Reports:

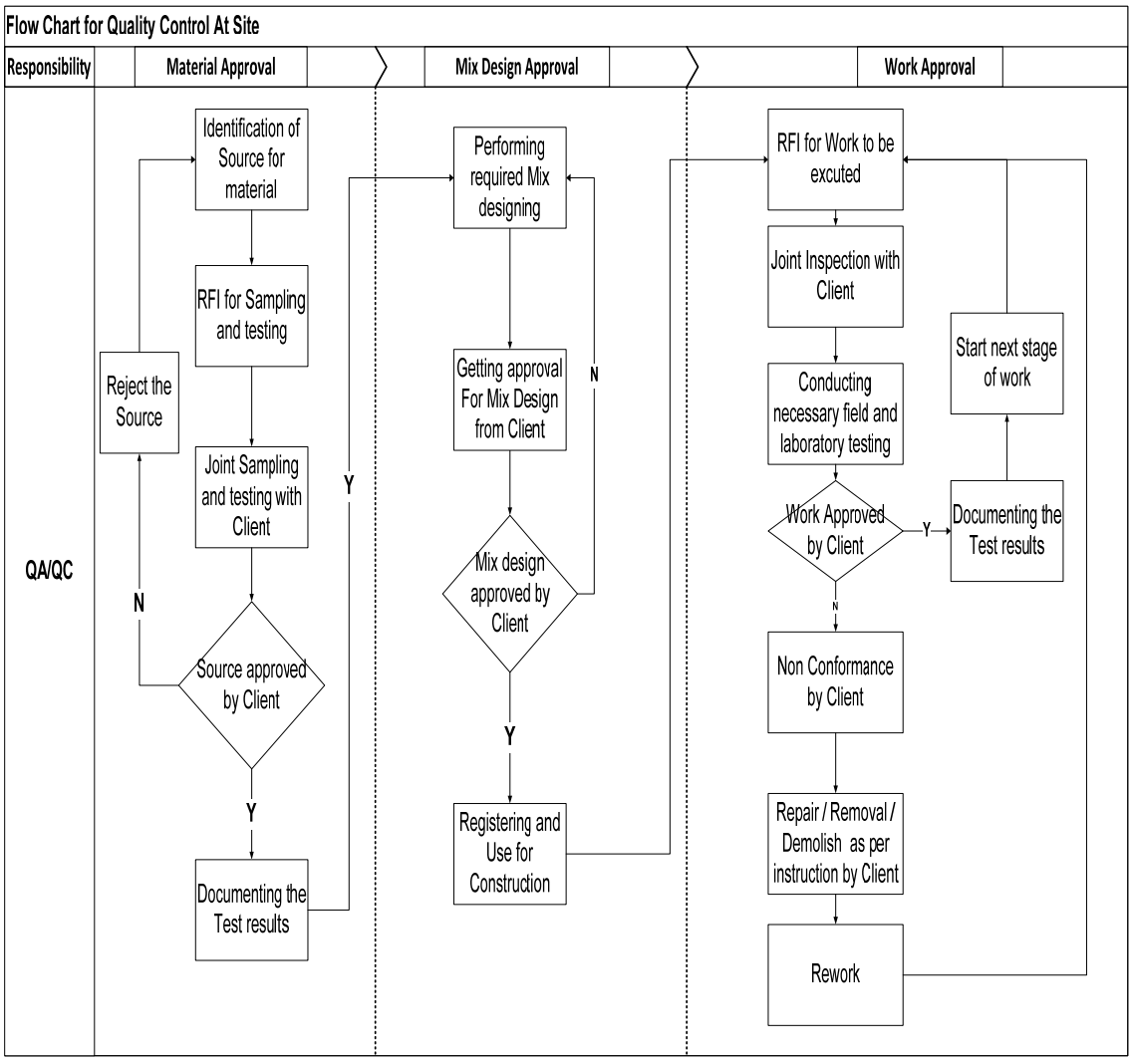
The Monthly progress shall be prepared at site and submitted to the Concessionaire as per requirements of contract agreement. The detailed format for the report contained all the activities of the month, major achievements, mile stone achieved, progress, quality control reports, problems, issues etc. The contents of the Monthly progress report shall be as per the Contract agreement.

8.9.9 PROGRESS CONTROL:

The EPC Contractor is required to undertake its activities in accordance with the approved work program. Each month the contractor shall indicate the actual work completed as compared to work scheduled. In the event portions of the work are in danger of being delayed, or actually are delayed, the contractor is to determine a plan for remedial action.

8.10 Quality Control and Assurance in Construction

8.10.1 Quality Control of Road Works:



8.11 CONSTRUCTION QUALITY CONTROL:

8.11.1 General:

Quality control of materials forms an integral part of the overall construction and supervision function. Taken properly into account, it provides the link between the design and the finished works.

Testing of construction materials is carried out for a variety of reasons and purposes including:

- Screening Tests (e.g. choosing a borrow source, an aggregate supplier, a manufacturer / supplier of cement *etc*.)
- Control Tests (e.g. sampling and testing of cement material delivered to site to confirm adherence to project specifications and to confirm manufacturer's Test Certificate)
- Audit Tests to verify independently the reported properties of materials
- Trial Mixes (selection of appropriate concrete mix designs, design of bituminous mixtures etc.)
- Acceptance Tests (e.g. testing of cubes cast of produced concrete to confirm that required strength is achieved and is consistent)
- Special testing as may be deemed necessary and prudent.

Suppliers of manufactured materials such as Cement, Steel, Bitumen, Bearings, Expansion Joints, Road Furniture etc. shall be screened based on submissions, review of sample Manufacturer's Test Certificates and experience on previous projects of the manufacturer. Independent testing by third party in the presence of Concessionaire's / IE may also be required.

Control and approval of construction materials shall be based on the following:

- Test reports for materials tested , such as cement, sand, water, soil, aggregates and bitumen; and
- Manufacturer's certificates for materials such as steel, cement, admixtures etc.

The details of input materials should be recorded in a Materials Register. All test results shall be entered into a testing register maintained at site laboratory, with an indication of conformance/non-conformance. A format for testing register is given.

This section hereinafter provides an overview of control requirements for materials, including site testing and manufacturers' certification.

Laboratory at locations shall be set up by the EPC/Sub contractor. The laboratory will be equipped with sufficient number of modern and efficient equipment suitable to carry out the tests prescribed for different materials and work according to the concession agreement and specifications.

- The laboratory will be manned by a qualified Material Engineer assisted by experienced Engineers , Technicians, Laboratory helpers and the set-up will be got approved by the Concessionaire.

- Tests shall be carried out Quality Controls on the materials and work to the frequency in subsequent paragraphs. In the absence of clear indications about method and or frequency of tests for any item, the direction of the Concessionaire's representative and IE shall be followed.

- For satisfying himself about the Quality of the materials and work, Quality Control tests will also be conducted by the Concessionaire's representative / IE , (by himself, by his Quality Control units or by any other agencies deemed fit by him), generally to the frequency set forth herein under. Additional tests may also be conducted where in the opinion of the Concessionaire's representative / Independent Engineer need for such tests exists.

- Provision of necessary cooperation and assistance in obtaining the samples for test and carrying out the field test as required by the Concessionaire's representative from time to time. This may include provision of labours, attendance, assistance in packing and dispatching any other assistance considered necessary in connection with the test.

- For the work of embankment, sub grade and pavement, construction of subsequent layer of some or other material over the finished layer will be done after obtaining approval from the Concessionaire. Similar approval from the Concessionaire will be obtained in respect of all other items of works to proceeding with the next stage of construction.

- Defective /Inferior quality of work shall be modified in the procedure of work, if found necessary, as directed by IE during inspection. Works falling short of quality at our own cost and as directed by the IE.

- All the tests to be conducted at laboratory and at site shall be documented as per the format specified. Usually the documentation shall be maintained in such a fashion that it shall be very easy traceable with a specific RFI No. mentioned with date in schematic diagram for each Structure and layer chart for Roads and in turn this shall be filed in KM basis for Roads with Bituminous and Non-Bituminous in a separate file / volume as a lot with several sub lot. For structures each structure shall be defined as a single lot.

9. 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

APPENDIX