A Study of Construction And Operation of Outer Ring Road In Kandlakoi

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Abstract*- We have opted our project on "A STUDY OF CONSTRUCTION AND OPERATION OF OUTER RING ROAD IN KANDLAKOI" as this projects describes briefly about the development of pavements in detail. It includes different types of pavements and there reaction towards the load acting on it. It deals with the layers of flexible pavement in detail and the tests conducted to the soil, to check the soil whether it can with stand the wheel load acting on the pavement.*

The Govt. of Telangana, proposed major infrastructure facilities in Hyderabad city and one of them is the orbital linkage to decongest the traffic flow on the existing major arterials. The Outer Ring Road should be viewed as road -cum- area development project since the aim is the development of well planned and well connected urban settlements around the Hyderabad Metropolitan area. The 158 km long ring road connects Patancheru – Shamshabad – Hayathnagar – Medchal - Patancheru providing connectivity to various State Highway and National Highways, to bypass the city of Hyderabad.

Considering the anticipated growth in the region and development of the proposed satellite townships around the ring road and beyond, and the traffic thereby generated, an 8-lane divided carriage way is planned for a design life of 20 years.

ORR to have an eight lane divided carriageway with a design speed of 120 Kmph and one emergency lane for break down vehicles.

I. INTRODUCTION

ABOUT HYDERABAD METROPOLITHAN DEVELOPMENT AUTHORITY (HMDA)

Hyderabad is one of major growing cities in India. It contains the entire area of Greater Hyderabad Municipal Corporation and its suburbs. The enlarged jurisdiction of HUDA now extends to 54 Mandal's located in five districts with a total area of nearly 7,100 km^2.It is the 2nd largest urban development area in India, after the Bangalore Metropolitan Region Development Authority (8,005 km^2). The area under the former HUDA had nearly 300 villages to which 600 villages are now added.

HMDA was formed by the merging of the following erstwhile entities: Hyderabad Urban Development Authority (HUDA), Hyderabad Airport Development Authority (HADA), Cyberabad Development Authority (CDA) and Buddha Purnima Project Authority (BPPA). HMDA was set up for the purposes of planning, coordination, supervising, promoting and securing the planned development of the Hyderabad Metropolitan Region. It coordinates the development activities of the municipal corporations, municipalities and other local authorities, the Hyderabad Metropolitan Water Supply & Sewerage Board, the Telangana state Transmission Corporation, the Telangana State Infrastructure Corporation. The total population of HMA is about 77.49 lakhs as per 2011 census.

Hyderabad Metropolitan Development Authority (HMDA) is a statutory agency of Government of Telangana, with the responsibility of planning and developing the HMA in association with various other sect oral agencies. HMDA has planned to develop outer ring road (ORR) system around the Hyderabad Metropolitan area to relieve congestion within the city and to act as a catalyst for dispersal of urban growth. The outer ring road is envisaged to give a boost to the road cum area development and to connect the proposed urban settlements around the Hyderabad Metropolitan area.

Hyderabad Metropolitan Development Authority has decided to take up the development of outer ring road project where the intensity of traffic has increased significantly and there is requirement of providing access controlled corridor connecting areas like Cyberabad, International airport, Singapore Township, Bio-Tech park etc., for safe and efficient movement of traffic. The Phase – II of outer ring road includes construction of Eight lane divided access controlled Expressway along with service road on either side in the corridor except from Gachibowli to Shamshabad which is covered in Phase –I.

Major modern highways that connect cities in populous developed and developing countries usually incorporate features intended to enhance the road's capacity, efficiency, and safety to various degrees. Such features include a reduction in the number of locations for user access, the use of dual carriageways with two or more lanes on each carriageway, and grade-separated junctions with other roads and modes of transport. These features are typically present on highways built as motorways (freeways).

PROJECT BACKGROUND

HMDA prepares various planning documents including the Master Plan for HMA and formulates Urban Development schemes at the metropolitan level with specific reference to infrastructure development decongestion etc.

The Master Plan prepared by HMDA lays emphasis on land use, transportation network and development of satellite townships in the Hyderabad Metropolitan Area. The Master Plan envisages a system of Ring roads viz., Inner Ring Road, and Outer Ring Road (ORR) for providing access for the increased radial and orbital movements.

The Inner Ring Road has already been put into operation. The proposed “Greater Hyderabad Growth Corridor” is 162 km long and connects 2 major National Highways namely NH-7 and NH-9. Overall, it intersects 3 National highways and 5 State highways. It primarily passes through Shamshabad, Hayatnagar, Medchal and Patancheru. However, it has more significance than merely serving as a bypass to the city.

BRIEF DETAIL OF OUTER RING ROAD (ORR)

The Outer Ring Road or ORR is a 158 kilometer, 8-lane ring road encircling the City of Hyderabad, Telangana. It is built by Hyderabad Metropolitan Development Authority at a cost of Rs.6696 crores. The Japan International Cooperation Agency is giving a loan of Rs 3,123 crore. The road aims to improves connectivity and decongest the traffic flow on the existing major arterials between the outer suburbs of Greater Hyderabad.

The construction of ORR started in December 2005 during the Congress party regime. It is expected to complete in a phased manner by December 2012.

The road passes through the villages in Rangareddy district viz. Shamshabad, Tukkuguda, Kollur, Narsingi, Gachibowli, Patancheru, Bowrampet, Goudelli, Shamirpet, Ghatkesar, Pedda Amberpet, Bongloor and Medchal.

The proposed Outer Ring Road, Phase – IIA is envisaged to connect Shamshabad on NH – 7 to Pedda Amberpet on NH – 9 and Narsingi with Patancheru. The stretch between Patancheru & Pedda Amberpet for a length of 71.300 km is being treated as Phase II of ORR project. The road of length 71.300 km would intersect major arterial roads of the city including Narsapur State highway, NH 7 at Medchal, Karimnagar State highway, Keesara road and NH-202 at Ghatkesar. It consists of six segments:

- ✓ Patancheru to Mallampet from 23.700 km to 35.000 km
- ✓ Mallampet to Dundigal from 35.000 km to 46.000 km
- ✓ Dundigal to Shamirpet from 46.000 km to 59.000 km
- ✓ Shamirpet to Keesara from 59.000 km to 72.000 km
- ✓ Keesara to Ghatkesar from 72.000 km to 83.000 km and
- ✓ Ghatkesar to Pedda Amberpet from 83.000 km to 95.000 km

HMDA proposes to take up the outer ring road project for providing one more orbital linkage to the major arterial roads, so as to decongest the traffic flow on existing major arterials and inner ring road. This would also facilitate in dispersal of urban growth

II. OBJECTIVE OF THE PROJECT

Identify, document, and communicate causes of premature pavement failures so that they may be prevented in the future.

Provide remedial solutions for premature pavement failures or chronic pavement distresses.

Select appropriate pavement and surfacing materials, types, layer thicknesses and configurations to ensure that the pavement performs adequately and requires minimal maintenance under the anticipated traffic loading for the design life adopted.

III. SCOPE OF THE PROJECT

The work to be executed under this Specification consists of the design of the road pavement to meet the required design life, based on the subgrade strength, traffic loading and environmental factors, and including the selection of appropriate materials for select subgrade, sub-base, base and wearing surface

IV. METHODOLOGY LABORATORY TEST

FREE SWELL INDEX TEST

ObjectiveTo determine the fee swell index of the soils

Apparatus425 microns IS sieve,lass graduated cylinders – 2 nos. – 100 ml capacity,Distilled water and kerosene

ProcedureTake 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 100 ml capacity. One cylinder shall then be filled with kerosene oil and the other with distilled water up to the 100 ml mark. 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 volume of the soils. The final volume of the soils in each of the cylinders shall be read out

CalculationsThe level of the soil in the kerosene- graduated cylinder shall be read as the original volume. The soil samples, kerosene being a non-polar liquid does not cause swelling of the soil. The level of the soil in the distilled water cylinder shall be read as the free swell level. The free swell index of the soil shall be calculated as follows.

Free swell index percentage = (Vd – Vk * 100)/Vk

Where,
Vd = The volume of the soil specimen read from the graduated cylinder containing distilled Water.
Vk = The volume of soil specimen read from the graduated cylinder containing kerosene.
Type of material: cut soil
Proposed use: Embankment / sub-garde

S .No	Sample Level in water (V1)	Sample level in kerosene (V2) (ml)	Free swell in water (V1-V2) (ml)	Free swell index 100*(V1=V2)/V2 %	Remarks
1	11.5	10.0	1.5	15.0	

Table 1

Result: The free swell index of the given soil is 15%.

GRAIN SIZE ANALYSIS

The Grain size distribution (particle size distribution) is found by Mechanical Analysis. Course grained soil is analyzed by sieve analysis method and that of fine grained by sedimentation analysis.

The sieve analysis is made to pass through these successive sieves and the weight retained on each sieve is expressed as a percentage of total weight of soil. For the soil passing through 75-micron sieve, sedimentation analysis is carried out to find the particle size distribution. It is based on the principle that larger grains in suspension settle faster.

Type of material: cut soil

Weight of dry sample in grams after washing through 75-micron sieve: 1803.0 Table 2 observations of grain size analysis

IS Sieve size (mm)	Weight retained(gm)	Cumulative weight retained(gm)	Cumulative percentage Retained (%)	Cumulative percentage passing (%)
37.5	0	0	0	100
26.5	218	218	0.80	99.20
19.0	4115	4333	15.90	84.10
13.2	5858	10191	57.40	62.60
4.75	6104	16295	59.80	40.20
2.36	2071	18366	67.40	32.60
0.300	4469	22836	83.80	16.20
0.075	3351	26186	96.10	3.90

Table 2

MARSHALL STABILITY TEST

Introduction

The original Marshall method is applicable only to hot-mix asphalt paving mixtures containing aggregates with maximum sizes of 25mm or less. A modified Marshall method has been proposed for aggregates with maximum sizes up to 38mm.

This method covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixtures loaded on the lateral surface by means of the Marshall apparatus.

Objective

To determine the stability, flow, voids, voids in mineral aggregates, voids filled with asphalt and density of the asphalt mixture by Marshall Stability test.

Apparatus

Specimen Mould Assembly:

Mould cylinders 101.6mm in diameter by 75mm in height, base plates and extension collars. For modified Marshall, mould diameter is 152.4mm and height is 95.2mm.

Specimen Extractor: Steel disk with a diameter 100mm and 12.7mm thick for extracting the compacting specimen from the specimen mould with the use of the mould collar. A suitable bar is required to transfer the load from the proving ring adapter to the extension collar while extracting the specimen.

Compaction Hammer: The compaction hammer shall have a flat circular tamping face and a 4.5kg sliding weight with a free fall of 457mm. For modified Marshall, weight is 10.2kg and drop height is 457mm. Two compaction hammers are recommended.

Compaction Pedestal: The compaction pedestal shall consist of 200*200*460mm wooden post capped with a 305*305*25mm steel plate. The pedestal should be installed on concrete slab so that the post is plumbed and the cap is level. Mould holder is provided which consists of spring tension device designed to hold the compaction mould centered in place on compaction pedestal.

Breaking head: It consists of upper and lower cylindrical segments or test heads having an inside radius of curvature of 50mm. the lower segment is mounted on a base having two vertical guide rods which facilitate insertion in the holes of upper test head.

Loading Machine: The loading machine is provided with a gear system to lift the base in upward direction. On the upper end of the machine, a calibrated proving ring of 510 capacities is fixed. In between the base and proving ring, the specimen contained in test head is placed. The loading machine produces a movement at the rate of 50mm per minute. Machine is capable of reversing its movement downward also.

Flow meter: One dial gauge fixed to the guide rods of the testing machine can serve the purpose. Least count of 0.25mm is added to it.

Oven/Hot plates
Mixing apparatus
Thermostatically controlled water bath.
Thermometers of range 0-360 with sensitivity of 1.

Procedure:

In the Marshall method, each compacted test specimen is subjected to the following tests and analysis in the order listed below:

a) Bulk density determination
b) Stability and flow test
c) Density and voids analysis

At least three samples are prepared for each binder content.

Preparation of test specimens: The course aggregates, fine aggregates and the filler material should be proportioned and mixed in such a way that final mix after blending has the gradation within the specified range. The aggregates and filler are mixed together in the desired proportion as per the desired requirements and fulfilling the specified gradation.

The required quantity of the mix is taken so as to produce a compacted bituminous mix specimen of thickness 63.5mm by 95.2mm approximately.

Preparation of mixtures: Weigh in to spate pans for each test specimen, the amount of each size fraction required to produce a batch that will result in a compacted specimen (63.5 ± 1.27mm) / (95.2 ± 1.27mm) in height. This will normally be about 1200 grams by 4000 grams. It is generally to prepare a trial specimen prior to preparing the aggregate batches. If the trail specimen height falls outside the limits, the amount of aggregate used for the specimen may be adjusted using.

Take the sample as mentioned above, and heat it to a temperature of 175-190. The compaction mould assembly and hammer are cleaned and kept pre-heated to a temperature of 100-145. The bitumen is heated to a temperature of 121-138 and the required quantity of first trial percentage of bitumen (say 3.5% by weight of mineral aggregates) is added to the heated aggregates and thoroughly mixed using the mechanical mixer or by hand, mixing with trowel. The mixing temperature may be 153160. The mix is placed in a mould and compacted by hammer with 75 blows by 112 blows (1.5 times of standard Marshall) on either side. The compaction temperature may be 138-149. The compacted specimen should have a thickness of (63.5 ± 3.0mm) / (95.2 ± 3.0mm). Three specimens should be prepared at each trial bitumen content which may be varied at 0.5% increments up to about 7.5 or 8.0%.

Marshall Stability and Flow Values:

The specimens to be tested are kept immersed under water in a thermostatically controlled water bath maintained at 60 ± 1 for 30-40 mins. The specimens are taken out one by one and are placed in the Marshall Test head and the Marshall Stability value (maximum load carried in kg before failure) and the Flow Value (thedeformation the specimen undergoes during loading up to the maximum load in 0.25mm units) are noted. The corrected Marshall Stability value of each specimen is determined by the appropriate correction factor.

BITUMEN EXTRACTION METHOD

Objective

To determine the binder content in the mix by cold solvent extraction.

Apparatus

Centrifugal Extraction Machine (electrically operated)

- Balance (15kg capacity) - Sensitivity 0.1gm
- Cold solvent (commercial grade of Benzene) - Watt 60
- Filter paper

Oven

Procedure

A representative sample about 1000 grams is weighed and placed in the bowl of the extraction apparatus and covered with commercial grade of benzene. Sufficient time (not more than one hour) is allowed for the solvent to disintegrate the sample before running the centrifuge.

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

The machine is revolved slowly and then gradually increases the speed, maximum of 3600 rpm. This speed is maintained till the solvent ceases to flow from the drain. The machine is allowed to stop and 200 ml of 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 color.

The filter paper is removed from the bowl; dried in air then in oven to constant weight at 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. The percentage of binder in the sample is calculated as below:

Percentage of binder = W1 - (W2 + W3 + W4) * 100 / W1

W1 = Weight of the sample
W2 = Weight of the sample after extraction
W3 = Weight of fine material recovered from the extract
W4 = Increase in weight of the filter paper

AGGERGATIVE IMPACT TEST

Introduction

Toughness is the property of a material to resist impact. Due to traffic loads, the road stones are subjected to the pounding action or impact and there is a possibility of stones breaking into smaller pieces. The road stones should therefore be tough enough to resist fracture under impact. A test designed to evaluate the toughness of stones, i.e., the resistance of the fracture under repeated impacts may be called an Impact Test for road stones.

Objective

To determine the toughness of road stone materials by Impact Test.

Apparatus:

Impact testing machine.

Measure: A cylindrical metal measure having internal diameter 75mm and depth 50 mm for measuring the aggregates.

Tamping rod: A straight metal tamping rod of circular cross-section, 10mm in diameter and 230mm long, rounded at one end.

Sieve: IS sieves of sizes 12.5mm, 10mm, and 2.36mm for sieving the aggregates

Balance: A balance of capacity not less than 500 grams accurate up to 0.1 grams.

Oven: A thermo plastically controlled drying oven capable of maintaining constant temperature between 100 to 110

Fig 1 Impact testing machine

Procedure:

Preparation of Sample:

I) The test sample should conform to the following grading: - Passing through 12.5mm IS Sieve – 100% - Retention on 10mm IS Sieve – 100% ii) The sample should be oven-dried for 4hrs. At a temperature of 100 to 110oC and cooled. 83
iii) The measure should be about one-third full with the prepared aggregates and tamped with 25 strokes of the tamping rod.

A further similar quantity of aggregates should be added and a further tamping of 25 strokes given. The measure should finally be filled to overflow, tamped 25 times and the surplus aggregates struck off, using a tamping rod as a straight edge. The net weight of the aggregates in the measure should be determined to the nearest gram (Weight A). Procedure to determine Aggregate Impact Value:

i) The cup of the impact testing machine should be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by 25 strokes of the tamping rod.

The hammer should be raised to 380mm above the upper surface of the aggregates in the cup and allowed to fall freely onto the aggregates. The test sample should be subjected to a total of 15 such blows, each being delivered at an interval of not less than one second.

Calculations:

I) The sample should be removed and sieved through a 2.36mm IS Sieve. The fraction passing through should be weighed (Weight „B"). The fraction retained on the sieve should also be weighed (Weight „C") and if the total weight (B+C) is less than the initial weight (A) by more than one gram, the result should be discarded and a fresh test done. 84
ii) The ratio of the weight of the fines formed to the total sample weight should be expressed as a percentage.

Aggregate Impact Value = (B/A) * 100% iii) Two such tests should be carried out and the mean of the results should be reported.

CORE CUTER METHOD

Objective

To determine the in-place density of a soil using core cutter method

Apparatus

A core cutter of mild steel provided with a cutting edge at its bottom and with a 25mm high dolly to fit its top.

A metal rammer
A steel scale
A spaturba
A balance with a weight box

Procedure: The apparatus consists of mild steel cylindrical in shape open at top and bottom and provided with a cutting edge and dolly of 25mm in height to fit its top and a metal rammer
The core cutter is 10cm in diameter and 12.5cm in height. The core cutter is manufactured to give of 1000cc. the dolly fitted to its top is 2.5cm in height. The bottom 1cm of the core cutter is sharpened in to a cutting edge. The empty weight of the core cutter without dolly is found W1gm. The site where the soil in-situ density is to be determined is cleaned and levelled. The core cutter with dolly in positions placed on the levelled portion. It is gently driven into the soil completed with dolly by means of rammer. After driving completely, the soil surrounding the core cutter is excavated with excavation machine. The surface of the soil at top and bottom are then trimmed with a spatula gently so as to be flush with the top and bottom of core cutter.

The core cutter in this position is cleaned carefully from outside.

Now the weight of core cutter with the wet soil is determined as W2 gm.

Now the weight of the soil = W2 – W1 gm.
The in-situ soil is generally assumed to be moist.
In-situ moist density = Weight of moist/volume of soil
The volume of soil is equal to the volume of core cutter.
A small but representative sample from the core cutter is then taken and its moisture content is determined (w)
The dry density = wet or moisture density/ (1+w)
It is always preferable to express the soil density because the dry density for the soil at any given place and at any time is constant.

SOFTENING POINT TEST (RING AND BALL TEST)

Objective:

To determine the softening point of the bitumen by ring and ball apparatus
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Apparatus:

Ring and Ball Apparatus:

Steel balls: 2 nos. each having a diameter 9.5 mm and weighing 2.50 ± 0.05 g.

Brass rings: 2 nos. The rings shall be tapered and shall conform to the following dimensions:

a) Depth 6.4 mm
b) Inside diameter at bottom 15.9 mm
c) Inside diameter at top 17.9 mm
d) Outside diameter 20.6mm

Support: Any means of supporting the rings maybe used provided the following conditions are observed:

a) The rings shall be supported in a horizontal position with the upper surface of the rings 50 mm below the surface of the bath liquid.
b) There shall be a distance of exactly 25 mm below the bottom of the rings and the top surface of the bottom plate of support, if any, or the bottom of the bath.

Ball guide: A convenient form of ball centering guide.

Thermometer: 0-350with sensitivity 0.1. The thermometer shall be suspended so that the bottom of the bulb is level with the bottom of the rings, and within 10 mm of the rings, but not touching them.

Bath: A heat resistant water vessel not less than 85 mm in diameter and 120 mm in depth. The bath liquid shall be freshly boiled with distilled water when testing materials having softening points below 80and pure glycerin for materials having softening points above 80.

Stirrer: Which operates smoothly to ensure uniform heat distribution at all times throughout the bath. The stirrer shall be so placed that the moulds are not disturbed during its operation.

SOFTENING POINT: It is the temperature at which the substance attains a particular degree of softening under specified conditions of test.

Fig 2 Softening test by ring and ball test

Procedure:

Sample material is heated to a temperature between 75-100, above the approximate softening point until it turns completely fluid and is poured in heated rings placed on a metal plate.

To avoid sticking of bitumen to metal plate, quoting is done to these with a solution of glycerin and dextrin. After cooling the rings in air for 30 minutes, the excess bitumen is trimmed and rings are placed in the support as mentioned above. At this time, the temperature of distilled water is kept at 5. This temperature is maintained for 15 minutes after which the balls are placed in position. The temperature of water is raised at a uniform rate of 5 per minute with a controlled heating unit until the bitumen softens and touches the bottom plate by sinking of balls. At least two observations are made.

Result:

The temperature at the instant when each of the ball and sample touches the bottom plate of the support is recorded as softening value.

V. LITERATURE REVIEW

PAVEMENT

Definition

Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load commuting upon it. Pavement grants friction for the vehicles thus providing comfort to the driver and transfers the traffic load from the upper surface to the natural soil.

In earlier times before the vehicular traffic became most regular, cobblestone paths were much familiar for animal carts and on foot traffic load.

Pavements are primarily to be used by vehicles and pedestrians. Storm water drainage and environmental conditions are a major concern in the designing of a pavement. The first of the constructed roads date back to 4000 BC and consisted of stone paved streets or timber roads. The roads of the earlier times depended solely on stone, gravel and sand for construction and water was used as a binding agent to level and give a finished look to the surface. All hard road pavements usually fall into two broad categories namely

Requirements of a pavement

An ideal pavement should meet the following requirements:

- Sufficient thickness to distribute the wheel load stresses to a safe value on the sub-grade soil,
- Structurally strong to withstand all types of stresses imposed upon it,
- Adequate coefficient of friction to prevent skidding of vehicles,
- Smooth surface to provide comfort to road users even at high speed,
- Produce least noise from moving vehicles,
- Dust proof surface so that traffic safety is not impaired by reducing visibility,
- Impervious surface, so that sub-grade soil is well protected, and long design life with low maintenance cost.

VI. TYPES OF PAVEMENTS

FLEXIBLE PAVEMENT

Flexible pavements are so named because the total pavement structure deflects, or flexes, under loading. A flexible pavement structure is typically composed of several layers of material. Each layer receives the loads from the above layer, spreads them out, and then passes on these loads to the next layer below. Thus, the further down in the pavement structure a particular layer is, the less load (in terms of force per area) it must carry

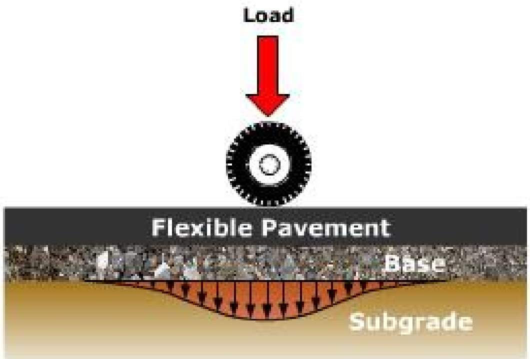


Fig 3 load on flexible pavement

In order to take maximum advantage of this property, material layers are usually arranged in order of descending load bearing capacity with the highest load bearing capacity material (and most expensive) on the top and the lowest load bearing capacity material (and least expensive) on the bottom. This section describes the typical flexible pavement structure consisting of:

- Surface course: This is the top layer and the layer that comes in contact with traffic. It may be composed of one or several different HMA sub-layers.
- Base course: This is the layer directly below the HMA layer and generally consists of aggregate (either stabilized or un-stabilized).
- Sub-base course: This is the layer (or layers) under the base layer. A sub-base is not always needed.

Basic Structural Elements

A typical flexible pavement structure consists of the surface course and the underlying base and sub-base courses. Each of these layers contributes to structural support and drainage. The surface course (typically an HMA layer) is the stiffest (as measured by resilient modulus) and contributes the most to pavement strength.

The underlying layers are less stiff but are still important to pavement strength as well as drainage and frost protection. A typical structural design results in a series of layers that gradually decrease in material quality with depth

Surface Course

The surface course is the layer in contact with traffic loads and normally contains the highest quality materials. It provides characteristics such as friction, smoothness, noise control, rut and shoving resistance and drainage.

Base Course

The base course is immediately beneath the surface course. It provides additional load distribution and contributes to drainage and frost resistance. Base courses are usually constructed out of:

Aggregate. Base courses are most typically constructed from durable aggregates that will not be damaged by moisture or frost action. Aggregates can be either stabilized or un-stabilized.

Sub-base Course

The sub-base course is between the base course and the subgrade. It functions primarily as structural support but it can also:

1. Minimize the intrusion of fines from the subgrade into the pavement structure.
2. Minimize frost action damage.
3. Provide a working platform for construction.

The sub-base generally consists of lower quality materials than the base course but better than the subgrade soils. A sub-base course is not always needed or used. For example, a pavement constructed over a high quality, stiff subgrade may not need the additional features offered by a sub-base course so it may be omitted from design. However, a pavement constructed over a low quality soil such as a swelling clay may require the additional load distribution characteristic that a sub-base course can offer. In this scenario the sub-base course may consist of high quality fill used to replace poor quality subgrade

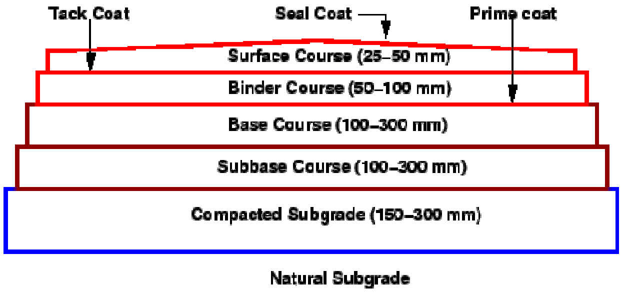


Fig 4 Layers of flexible pavements

Typical layers of flexible pavement

Typical layers of a conventional flexible pavement include:

1. Bituminous concrete (50MM)
2. Dense bituminous macadam (130MM)
3. Wet mix macadam (250MM)
4. Granular sub-base (200MM)

Subgrade (500MM)

RIGID PAVEMENT

Rigid pavements are so named because the pavement structure deflects very little under loading due to the high modulus of elasticity of their surface course. A rigid pavement structure is typically composed of a PCC surface course built on top of either the subgrade or an underlying base course. Because of its relative rigidity, the pavement structure distributes loads over a wide area with only one, or at most two, structural layers.

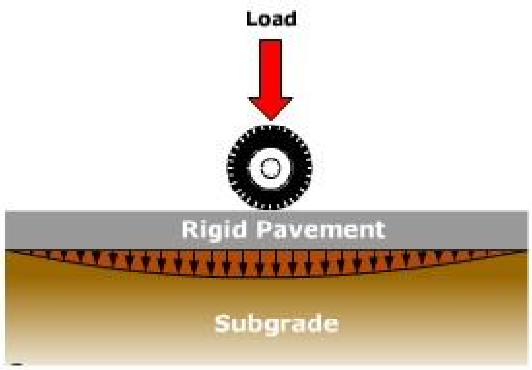


Fig 5 Load on rigid pavement

Basic Structural Elements

A typical rigid pavement structure consists of the surface course and the underlying base and sub-base courses (if used). The surface course (made of PCC) is the stiffest (as measured by resilient modulus) and provides the majority of strength

Surface course

The surface course is the layer in contact with traffic loads and is made of PCC. It provides characteristics such as friction, smoothness, noise control and drainage. In addition, it serves as a waterproofing layer to the underlying base, sub-base and subgrade. The surface course can vary in thickness but is usually between 150 mm (6 inches) (for light loading) and 300 mm (12 inches) (for heavy loads and high traffic).

Base course

The base course is immediately beneath the surface course. It provides (1) additional load distribution, (2) contributes to drainage and frost resistance, (3) uniform support to the pavement and (4) a stable platform for construction equipment (ACPA, 2001). Bases also help prevent subgrade soil movement due to slab pumping.

Base courses are usually constructed out of:

Aggregate base. A simple base course of crushed aggregate has been a common option since the early 1900s and is still appropriate in many situations today.

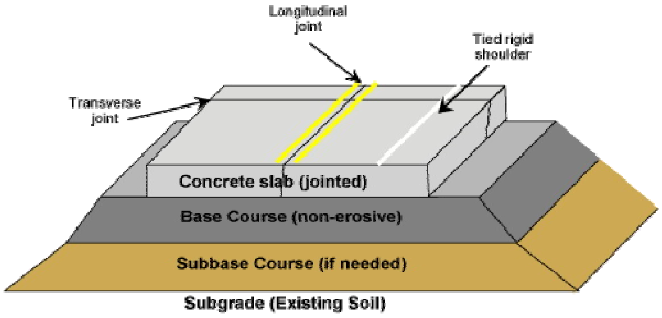
Stabilized aggregate or soil. Stabilizing agents are used to bind otherwise loose particles to one another, providing strength and cohesion. Cement treated bases (CTBs) can be built to as much as 20 - 25 percent of the surface course strength (FHWA, 1999). However, cement treated bases (CTBs) used in the 1950s and early 1960s had a tendency to lose excessive amounts of material leading to panel cracking and settling

Sub-base course

The sub-base course is the portion of the pavement structure between the base course and the subgrade. It functions primarily as structural support but it can also:

1. Minimize the intrusion of fines from the subgrade into the pavement structure.
2. Improve drainage.
3. Minimize frost action damage.
4. Provide a working platform for construction.

The sub-base generally consists of lower quality materials than the base course but better than the subgrade soils. Appropriate materials are aggregate and high quality structural fill. A sub-base course is not always needed or used



LITERATURE REVIEW

Fig 2.4 Layers

Fig 6 Layers of Rigid Pavement

Types of Rigid Pavements

- **Jointed Plain Concrete Pavement (JPCP**
- **Jointed Reinforced Concrete Pavement (JRCP)**
- **Continuous Reinforced Concrete Pavement (CRCP)**
- **Pre-stressed concrete pavement (PCP)**

Jointed Plain Concrete Pavement (JPCP):

Are plain cement concrete pavements constructed with closely spaced contraction joints. Dowel bars or aggregate interlocks are normally used for load transfer across joints. They normally has a joint spacing of 5 to 10m.

Jointed Reinforced Concrete Pavement (JRCP):

Although reinforcements do not improve the structural capacity significantly, they can drastically increase the joint spacing to 10 to 30m. Dowel bars are required for load transfer. Reinforcement's help to keep the slab together even after cracks.

Continuous Reinforced Concrete Pavement (CRCP):

Complete elimination of joints is achieved by reinforcement.

Pre-stressed concrete pavement (PCP):

To minimize the effects of traffic congestions, a method with the speedy construction and lower user impact cost is needed. This paper introduces a relatively new pavement construction method lately developed in United States. The method is called Pre stressed Concrete Pavement (PCP)

ADVANTAGES of flexible pavement

- Adaptability to stage construction
- Availability of low-cost types that can be easily built
- Ability to be easily opened and patched
- Easy to repair frost heave and settlement
- Resistance to the formation of ice glaze

Disadvantages of flexible pavement

- Higher maintenance costs
- Shorter life span under heavy use
- Damage by oils and certain chemicals
- Weak edges that may require curbs or edge devices

FAILURES of flexible pavement

Bleeding

Description

A film of asphalt binder on the pavement surface. It usually creates a shiny, glass-like reflecting surface (as in the first photo) that can become quite sticky. Sometimes referred to as “flushing

Figure 7.1 Figure 7.2 Figure 7.3
Figure 7.1: Bleeding as a Figure 7.2: BST bleeding in Figure 7.3: BST bleeding in the result of over asphalting the wheel paths wheel paths
Fig 7 Bleeding

Problem

Loss of skid resistance when wet

Possible Causes

Bleeding occurs when asphalt binder fills the aggregate voids during hot weather and then expands onto the pavement surface. Since bleeding is not reversible during cold weather, asphalt binder will accumulate on the pavement surface over time. This can be caused by one or a combination of the following:

- Excessive asphalt binder in the HMA (either due to mix design or manufacturing)
- Excessive application of asphalt binder during BST application (as in the above figures)
- Low HMA air void content (e.g., not enough room for the asphalt to expand into during hot weather)

Repair

The following repair measures may eliminate or reduce the asphalt binder film on the pavement’s surface but may not correct the underlying problem that caused the bleeding:

Minor bleeding can often be corrected by applying coarse sand to blot up the excess asphalt binder.

Major bleeding can be corrected by cutting off excess asphalt with a motor grader or removing it with a heater planer. If the resulting surface is excessively rough, resurfacing may be necessary (APAI, no date given).

Block Cracking

Description

Interconnected cracks that divide the pavement up into rectangular pieces. Blocks range in size from approximately 0.1 m^2 (1 ft^2) to 9 m^2 (100 ft^2). Larger blocks are generally classified as longitudinal and transverse cracking. Block cracking normally occurs over a large portion of pavement area but sometimes will occur only in nontraffic areas.

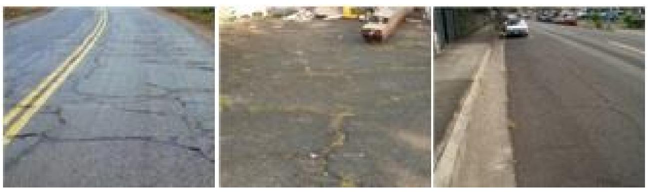


Figure 8.1 Figure 8.2 Figure 8.3
Figure 8.1: Block cracking on Figure 8.2: Block cracking in Figure 8.3: Block cracking in a low volume pavement a residential driveway a curbside parking area.
Fig 8 Block Cracking

Problem

Allows moisture infiltration, roughness

Possible Causes

HMA shrinkage and daily temperature cycling. Typically caused by an inability of asphalt binder to expand and contract with temperature cycles because of:

- Asphalt binder aging
- Poor choice of asphalt binder in the mix design

Repair

Strategies depend upon the severity and extent of the block cracking:

- **Low severity cracks (< 1/2 inch wide)**. Crack seal to prevent (1) entry of moisture into the subgrade through the cracks and (2) further raveling of the crack edges. HMA can provide years of satisfactory service after developing small cracks if they are kept sealed (Roberts et. al., 1996).
- **High severity cracks (> 1/2-inch-wide and cracks with raveled edges)**. Remove and replace the cracked pavement layer with an overlay.

Potholes

Description

Small, bowl-shaped depressions in the pavement surface that penetrate all the way through the HMA layer down to the base course. They generally have sharp edges and vertical sides near the top of the hole. Potholes are most likely to occur on roads with thin HMA surfaces (25 to 50 mm (1 to 2 inches)) and seldom occur on roads with 100 mm (4 inch) or deeper HMA surfaces (Roberts et al., 1996).


Figure 9.1


Figure 9.2


Figure 9.3

Figure 9.1: Pothole as a result Figure 9.2: Fatigue cracking
Figure 9.3: Pothole on a of fatigue cracking. showing the
beginning of a residential road after heavy potholes rains
Fig 9 Potholes

Problem

Roughness (serious vehicular damage can result from driving across potholes at higher speeds), moisture infiltration

Possible Causes

Generally, potholes are the end result of fatigue cracking. As alligator cracking becomes severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them. The remaining hole after the pavement chunk is dislodged is called a pothole.

Repair

In accordance with patching techniques.

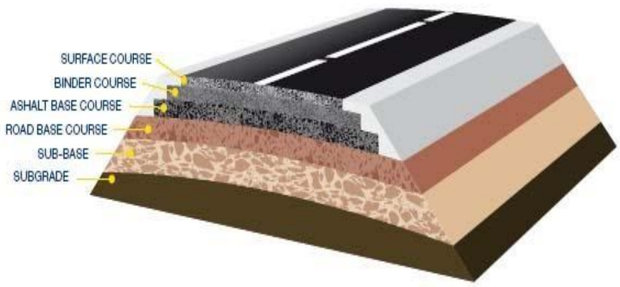
SITE OBSERVATIONS

FLEXIBLE PAVEMENT

Typical layers of flexible pavement:

Typical layers of a conventional flexible pavement include:

1. Bituminous concrete (50MM)
2. Dense bituminous macadam (130MM)
3. Wet mix macadam (250MM)
4. Granular sub-base (200MM)
5. Subgrade (500MM)
6.



OBSERVATIONSSITE OBSERVATIONS
Fig 10 Layers of Flexible Pavement

BITUMINOUS CONCRETE

Asphalt concrete is a composite material commonly used in construction projects such as road surfaces, airports and parking lots. It consists of asphalt (used as a binder) and mineral aggregate mixed together, then laid down in layers and compacted. It is also increasingly used as the core for embankment dams.

Fig 11 Bituminous Asphalt concrete

The terms "asphalt (or asphaltic) concrete", "bituminous asphalt concrete" and the abbreviation "AC" are typically used only in engineering and construction documents and literature. Asphalt concrete pavements are often called just "asphalt" by laypersons who tend to associate the term concrete with Portland cement concrete only. The engineering definition of concrete is any composite material composed of mineral aggregate glued together with a binder, whether that binder is Portland cement, asphalt or even epoxy. Informally, asphalt concrete is also referred to as "blacktop", particularly in North America.

Bituminous concrete is a type of construction material used for paving roads, driveways, and parking lots. It's made from a blend of stone and other forms of aggregate materials joined together by a binding agent. This binding agent is called "bitumen" and is a by-product of petroleum refining. It has a thick, sticky texture like tar when heated, then forms a dense solid surface once it dries.

Bituminous concrete is also widely known as asphalt in many parts of the world.

A layer of asphalt concrete. In road construction, a base layer of crushed rock is usually laid down first to increase durability.

Despite its name, bituminous concrete is quite different than standard concrete, and contains no cement. While most cement-based surfaces are white or gray, bituminous concrete is known for its distinctive black appearance. It is often laid right over a gravel base layer to form new roads and parking lots, but may also be poured over existing concrete to repair or smooth out bumps and voids. Once the bituminous concrete has been poured onto the roadway, installers use large paving machines to smooth and compact the surface.

- Aggregate (coarse and Fine) and cement as filler were blended in the ratio by weight of total aggregate as follows: 10mm – 38%

6mm – 60%

Cement – 2%

DENSE BITUMINOUS MACADAM

This surfacing uses a more traditional type of material called dense bituminous macadam. The material is hot applied on the road surface by a machine. To gain adequate strength the material is laid in thickness between 30-40mm. DBM provides a good quality smooth surface and improved skid resistance.

This treatment is used on roads with less demanding traffic flows and severe irregularities or structural problems

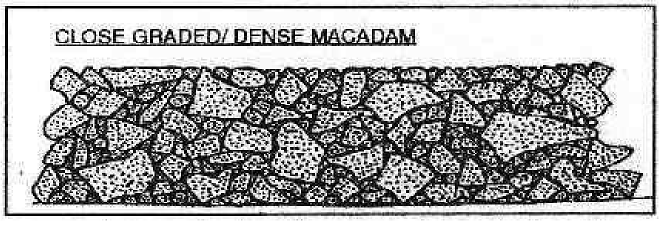


Fig 12 Dense macadam

The nature of an asphalt concrete (bitumen macadam) is that the aggregate is a through grading of a combination of all sizes of aggregate particles according to the largest size of the aggregate. The particles knit together to produce a tight aggregate mass held together by the bitumen binder. Wheel load is distributed through the layer by aggregate particle contact, and interlock. Asphalt Concrete (Bitumen Macadam) provides a range of excellent cost effective materials for surface course, binder course and base.

The principles that apply to a 14mm. Close Graded Macadam will be very similar, if not the same for ALL coated macadam’s, i.e. surface courses (wearing courses), binder courses (base courses) and base (road base). ALL bituminous materials are basically a mixture of aggregate (coarse and fine) and bitumen (of various grades), the properties and uses of these mixtures will depend upon the proportions (recipe) of the mixture, i.e. the "design".

WET MIX MACADAM

In continuing the tradition of providing automation excellence in road construction machinery, ORR has designed & engineered their Wet Mix Macadam Plant for achieving homogenous mix material to prepare base and sub base in road construction projects

Wet Mix Macadam Plant comprises of:

1. Pug mill
2. Surge Hopper/ Storage Hopper
3. Conveyors
4. Control Panel


Fig 13 Pug mill


Fig 14Surge Hopper/ Storage Hopper


Fig 15 Conveyors


Fig 16 Control Panel

GRANULAR SUB-BASE

The sub-base layer is often the main load-bearing layer of a pavement. It is designed to evenly spread the load of the paving, and any traffic thereon, to the subgrade below. A well-constructed sub-base will prevent settlement and channelization - the phenomenon common on cheap installations of block paving, where two 'ruts' develop in the paving. These 'ruts' are caused when a car travels over the same line of paving to the garage, every morning and every night.

Channelization is also apparent on carriageways, particularly at the approach to traffic lights and on upward gradients. The sub-base is intended to prevent channelization and settlement.
Once a good sub-base has been installed, it can be re-used without any further work, if you decide to change the surfacing/paving of your driveway. Many newer houses have tarmac drives with a good sub-base beneath. In such cases, the tarmac can be stripped off, the sub-base checked and re-levelled if required, and the new paving can be laid over the old sub-base.

A finished sub-base should not deviate from the correct level by more than 10mm, and should reflect the final profile of the paving. The bedding layer above the sub-base ought to be a constant thickness to avoid differential settlement


Fig 17 Laying of granular sub base layer (GSB)

SUBGRADE

In transport engineering, subgrade is the native material underneath a constructed road, pavement or railway (US: railroad) track. It is also called formation level.

The term can also refer to imported material that has been used to build an embankment.

Subgrades are commonly compacted before the construction of a road, pavement or railway track, and are sometimes stabilized by the addition of asphalt, soil cement, Portland cement or lime. It is the foundation of the pavement structure, on which the sub-base is laid.

Preparation of the subgrade for construction usually involves digging, in order to remove surface vegetation, topsoil and other unwanted material, and to create space for the upper layer of the pavement. This process is known as subgrade formation or reduction to level.

The load-bearing strength of subgrade is measured by California Bearing Ratio (CBR) test, falling weight deflectometer back calculations and other methods

Fig 18 Subgrade preparation

TOLL MANAGEMENT SYSTEM

Toll Administrative Buildings (TAB)

It is Proposed to construct Toll Administrative Buildings at all Interchanges (20 Nos) including Traffic Control Center (TCC) at Nanakramguda & Sub –TCC at Ghatkesar to house, Toll related equipments and personnel for day to day operations of managing the traffic on ORR. The work is expected to be completed by December 2015.

Fig 19 Toll Administrative Buildings

Toll canopies

It is proposed to construct Toll Canopies at 19 Interchanges locations. The work is expected to be completed by December, 2015.

Fig 20 Toll canopies

Operation & Maintenance (O&M) of ORR

Along the ORR Stretch opened to traffic, O&M activity on day to day basis is taken up through an O&M contract agency at a cost of Rs. 33.0 Crores for a period of three
(3) years.

Toll collection

Toll from the road users of Outer Ring Road is being collected through User Fee Collecting Agency. The Agency M/s Eagle Infra Limited have been entrusted the work of Toll collection on Tender basis. The Agency is paying an amount of Rs 392 Lakhs per month to HGCL. This is a temporary arrangement of user fee collection till a full fledged TMS system comes into operation. After TMS system is introduced the User fee collection on Outer Ring Road will be taken up by the department.

Fig 21Toll collection

VII. CONCLUSION

In this way load transfer mechanism occurs. Almost 90% pavements are flexible pavements. Therefore, flexible pavements are only placed where underlying strata has good load bearing capacity properties. In case when underlying strata lacks loadbearing capacity then we go for rigid pavement, because rigid pavements not depend on the properties of underlying strata.

The pavement alternatives evaluated ranged from flexible, semi rigid to cement treated pavement

The most viable pavement alternative is the cement treated pavement since it is the most cost effective pavement structure while optimizing the level of service to the road users

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