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Study on Pavement Quality Cement Concrete Road

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CHAPTER-1

INTRODUCTION

1.1 Objective of Study

The objective of study of pavement concrete road paving is to provide better comfort in ridding quality of road , reduce shrinkage cracks in concrete panel ,use of fly ash to reduce environmental hazard at thermal power plant, and pot free roads and savings on maintenance

1.2 Introduction

A highway pavement consist of superimposed layers of processed materials above the soil sub-grade, whose basic function is to distribute the applied load to the sub-grade. The pavement structure should be able to provide a surface of good riding quality, adequate skid resistance, favourable light reflecting characteristics and low noise pollution. The ultimate aim is to insure that the induced stresses due to wheel load are sufficiently reduced .The rigid pavement structure consist of a cement concrete slab, below which a granular base or sub-base course may be provided. Providing a good base or sub-base course layer under the cement concrete slab, increases the pavement life and therefore works out more economic in longer run . Due to rigidity and high tensile strength, a rigid pavement tends to distribute the load over a relatively wide area of sub-grade and the major portion of structural capacity is supplied by the slab itself . The rigid pavements are used for heavier loads and can be constructed over relatively poor sub-grade .Due to increase in demands and decrease in availability of aggregate for production of concrete in road construction there is need to identify new source of aggregate from Recycled (waste) materials. In previous years the use of recycled materials has been considered in road construction with great interest in many industrialized and developing countries because it reduces the environmental impact and economize cost. Such waste materials include coconut shell; scrap tire, recycled aggregate, crushed bricks etc . For proper designing of pavements all such parameters are needed to be studied carefully so that better economy is achieved.

Cement concrete pavement has distinct initial advantage over bitumen pavement in this regard, as surface texturing forms integral part of the normal construction practice for such pavements. They also have superior night visibility by virtue of their lighter colour. In area of low rainfall intensity, hydroplaning not being the governing consideration, it a possible to design the concrete mix for adequate skid resistance even after the loss of textured surface finish, subject to availability of appropriate quality material. Poorly designed and constructed concrete pavements are known to have very long service life. The cement concrete road constructed in the country in the past, though extremely limited in length, have an excellent service track, having given good service under condition much sever than those for which they are originally intended. Cement concrete develops very fine, small, discontinuous micro-cracks in initial stages due to hydrothermal changes. Under increasing or repetitive loading, the micro-cracks tend to extend and join, resulting in fracture and failure. To minimize them inherent micro-cracking, only minimally essential water for ensuring full compaction of concrete should be used. Construction of rigid pavement is also financially viable as rigid pavements require less thickness than the bituminous pavements when same and equal traffic load is applied to the pavement [1]. The main disadvantage is rigid pavement requires a high initial cost for rectification compare to bitumen roads as the entire concrete slab needs to be replaced when it damages. In addition the rigid pavement tends to fail across the construction joints provided between the adjacent slab panels as it acts as a weak plane across the section. Furthermore there is a delaying for allowing normal traffic to newly constructed rigid pavements since concrete requires 28 days for achieving utmost compressive strength [2]. Attention should be taken to design and construct of subgrade and subbase since it is essential to ensure the structural capacity and ride quality of all types of pavements. Pavement performances with respect to bearing strength, consolidation and moisture susceptibility are strongly influenced by subgrade and subbase [3]. During rain storm the damage to bituminous surfaced roads are faster than concrete roads, while gravel roads become very dusty in dry weather condition causing safety and health problems. Problems of dust formation and wet weather damage to roads can be easily overcome by constructing concrete roads [4]. Rigid pavements have a life span of more than 40 years compared to the bituminous which has 10 years life span [5]. Rigid pavements require little maintenance; whereas bituminous roads need frequent repairs due to damage occurred by traffic and weather, high surface resistant to automobile fuel spillage and environmentally friendly since concrete is 100% recyclable [6].

2.5 Types of Rigid Pavements There are three basic types of rigid pavement:

I. Jointed Unreinforced Concrete Pavements (JUCP)
II. Jointed Reinforced Concrete Pavements (JRCP)
III. Continuously Reinforced Concrete Pavements (CRCP)

I. Jointed Unreinforced Concrete Pavement

In Jointed Unreinforced Concrete Pavements (JUCP) the pavement consists of unreinforced concrete slabs cast in place and divided into bays of predetermined dimensions by the construction of joints. The dimensions of the bays are made sufficiently short to ensure that they do not crack through shrinkage during the concrete curing process. In the longitudinal direction the bays are usually linked together by dowels to prevent vertical movement and to help maintain aggregate interlock across the transverse joints. The bays are also connected to parallel slabs by tie bars, the main function of which is to prevent horizontal movement (i.e. the opening of warping joints).

II. Jointed Reinforced Concrete Pavement

In Jointed Reinforced Concrete Pavements (JRCP) the pavement consists of cast in place concrete slabs containing steel reinforcement and divided into bays separated by joints. The reinforcement is to prevent cracks from opening and this allows much longer bays to be used than for JUCP. The bays are linked together by dowels and tie bars as in JUCP. Although longitudinal reinforcement is the main reinforcement, transverse reinforcement is also used in most cases to facilitate the placing of longitudinal bars.

III. Continuously Reinforced Concrete Pavement

Continuously Reinforced Concrete Pavements (CRCP) are made of cast in place reinforced concrete slabs without joints. The expansion and contraction movements are prevented by a high level of sub-base restraint. The frequent transverse cracks are held tightly closed by a large amount of continuous high tensile steel longitudinal reinforcement

Flexible pavement	Rigid pavement
It consists of a series of layers with the highest quality materials at or near the surface of pavement.	It consists of one layer portland cement concrete or relatively high flexural strength.
It reflects the deformations of subgrade and subsequent layers on the surface.	It is able to bridge over localized failures and area of inadequate support
Its stability depends upon the aggregate interlock, particle friction and cohesion	Its structural strength is provided by the pavement slab itself by its beam section
Pavement design is greatly influenced by the subgrade strength	Flexural strength of concrete is a major factor for design
It functions by a way of load distribution through the component layers	It distributes load over a wide area of subgrade because of its rigidity and high modulus of elasticity
Flexible pavements have self healing properties due to heavier wheel loads are recoverable due to some extent	Any excessive deformation occurring due to heavier wheel loads are not recoverable i.e. settlements are permanent

CHAPTER-2
LITERATURE SURVEY

2.1. Literature Survey-

Cement concrete roads mix are now a day's design with

Cement Opc grade + Natural sand / manufactured sand
Cement Ppc grade + Natural sand / manufactured sand
Cement Opc grade + fly ash + Natural sand / manufactured sand
Cement ppc grade + fly ash + marble dust / gypsum powder

Cement concrete roads are generally design with 20 mm size nominal size of aggregate and also design with 40 mm nominal size resulting saving of cement concrete

Cement concrete roads are designed for flexural strength 4.5 mpa to 5 mpa as per codal requirements

Minimum requirement of cement for cement concrete road per cumtr of mix is 350 kg as per MOR&TH specifications

Steel fibres are now a days used to achieve flexural strength as it replaces dowel bars in the pavement

Minimum thickness of cement concrete road is kept 300 mm as per MOR&TH specifications

CHAPTER-3

CEMENT CONCRETE ROAD CONSTRUCTION

Cement concrete road is generally monolithic slab serves as two purpose namely load carrying base and wearing course

Cement concrete road is a **highly rigid surface** and hence, for the success of such roads, the ***following two conditions should be satisfied***:

(i) They should rest on ***non-rigid surface*** having uniform bearing capacity.

(ii) The combined thickness or depth of the concrete pavement and the non-rigid base should be sufficient to distribute the wheel load on a sufficient area of the sub-base so that the pressure on the unit area remains within the permissible safe bearing capacity of the soil.

The cement concrete roads are becoming popular because of the fact that concrete of desired quality can be prepared by the moderm techniques of cement concrete construction.

Concrete-Pavements

1.2 Construction of Cement concrete pavement:

There are three techniques of sophistication in the construction of concrete roads.1.

Conventional method,2.

Vacuum dewatering method by tremix,3.

Slip Form Paving. At one extreme there is conventional labour-intensive method employing a minimum of mechanical plant. In the middle comes the use of mechanicalskimfloter, double beam surface vibratos, vacuum pump and finishers with the side – forms being placed to correct line and level by hand (Tremix) At the other extreme there are slip form pavers in which the side forms are carried on the machine with wire guidance or lasers, to secure correct line and level. The increasing mechanization has undoubtedly made high outputs possible. The construction of rigid pavement should normally be done by slip-form paver. Stringent quality control is absolutely essential for long term performance of rigid pavement and therefore, the same should be executed with utmost quality control and as per procedure laid down in IRC:15 (IRC:SP:73-2007).

2.0 Slip Form Paving:

Slipform paving is defined as a process used to consolidate, form into geometric shape and surface finish a PCC mass by pulling the forms continuously through and surrounding the plastic concrete mass. Slip form paving is most appropriate for larger jobs that require high production rates. In 1947 engineers at the Lowa State Highway Commission in USA conceived the idea of a slip forms. Initially considered by many highway engineers as acute toy which would never be used for major highway construction, slip form paving has now become a conventional method of concrete road building throughout the world

With the slip form pavers, the objective is to lay uninterrupted flow of concrete without the need of pre-fabricated and pre-set joint assembles, this machine carries the side forms with it along the road way. It also mounts elements that spread and vibrate and strike off the surface to grade as the pavers go by. By the use of slip form paving, the preparation of the sub grade and sub base is similar to that for the fixed form method, only now the rest for the conventional train is replaced by a single machine frame within which, the mainoperations of spreading, compaction and finishing are combined. The need and accuracy required in setting side forms for the fixed paving train is time consuming. Also constituent parts of the train demand careful control requiring a relatively high number of operators. These disadvantages have largely been removed with the development of slip form paving machine. With this the carpet of concrete is cast without side forms. However much stiffer mixes; with slump of 30-40 mm are necessary for the concrete to maintain its shape without the side support (Natarajan 2003). This is an essentially a highly advance derivative of the oscillating beam type vibrating screeds. Slip form means the formwork mounted on the pavers and slips along the pavements the paving continues. The brief working principle is, “the concrete mix which is fed to the machine, is vibrated and is extruded through a mould profile”. These moulds are custom made as per specific job requirements. The machine spreads the concrete, vibrates and finally performs tamping and finishing.

2.1 Types of Slip Form Pavers:

The slip form pair may either be of the confirming plate or oscillating beam type (Purifoy1986).

- **Confirming Plate:**

This type of machine is built in a round pair of parallel side forms, which are linked together by horizontal top plate. These shapes the concrete slab as the machine move forward.

- **Oscillating beam type:**

In this type of machine, the side forms give the shape to the edge of the road slab and oscillating beams compact and give the shape to the top of the road slab. When a confirming plate is used, the amount of concrete passed below the plate will depend upon to some extent on the head of concrete in front; thus the level at its rare may be subjected to slight vibrations. The action of oscillating beam on the other hand is to strike off excess concrete or to make good deficiencies with concrete carried in front of them. For this reason, oscillating beam type is prefer confirming plate type

Working Cycle:

This section presents PCC placement, consolidation, finishing and curing as it is typically done in slipform paving. Most often, these steps are accomplished by three pieces of equipment: the placer/spreader (used for rough placement), the concrete paver (used for final placement, consolidation and initial finishing), and the texturing and curing machine. These machines usually travel together in series down the length of the project. Following are the different stages during lying of the wearing course (Jeuffroy 1996).Stage 1 – Line and level Stage 2 – Preparation of surface Stage 3 – Placing and spreading of concrete Stage 4 – Integrated paving train Stage 5 – Trimming and levelling, Stage 6 – Joints Stage 7 – Texturing Curing and Covering.

3.1 Stage 1 – Line and Level:

The paver has electronic sensing system which picks signals from contact with the guide wire not more than eight m. apart at a constant height. These signal sanitate alterations at the controls, either the raising or lowering the level of slab surface, or causing the machine to veer to the left or right.

3.2 Stage 2 – Preparation of Surface:

Before application of the wearing coat the base layer is clean thoroughly using an air compressor unit. A separation membrane which is 125 micron thick plastic sheet, laid flat and nailed in sub base without creases, with minimum 300 mm overlap at all joints in plastic.

3.3 Stage 3 – Placing and Spreading of Concrete:

Although not always used, placer/spreaders are quite common. They place a metered supply of PCC in front of the paver using a series of conveyor belts, augers, plows and strike off devices. Using a placer/spreaderallows the contractor to receive material from transport vehicles and place a uniform amount of PCC in front of the entire paver width, while minimizing segregation. The unit of spreader consists of two independent augers which are reversible, rotary type, controlled separately. The concrete is fed with the conveyor belt to the auger. The movement of auger enables the proper spreading of concrete. sheet, laid flat and nailed in sub base without creases,with minimum 300 mm overlap at all joints in plastic.

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.4

Stage 4 – Integrated Paving Train:

Figure 3.4.1: Integrated Paving Train

This consists of following sections (Figure 3.4.1),

•

Auger Section:

Two independent augers permit accurate control of side to side and uniform concrete spread.

•

Strike of Section:

Also known as front metering screed moves in a vertical plane for metering concrete flow to the enclosed vibrator and tamper section.

•

Vibratory Box:

The paver consolidates the fresh PCC using a series of vibrators (Figure3.4.2). Internal vibration is accomplished by meansof a set of poker vibrators, which are generally 20 in single row. Typically, the most effective vibrator position is after the strike-off mechanism and at the final slab elevation. Depending upon mix design and slab depth, vibrators are usually set in the 7,000- 9,000 vibrations per minute (VPM) range. Vibrators are positioned next to one another suchthat their influence zones overlap by about 50 - 75mm (2 - 3 inches) at normal paver speed. Gaps between the influence zones (caused by incorrect vibrator settings or excessively fast paver operation) can cause segregation. Most pavers use fully adjustable vibrator spacing to account for different conditions and mix types, while still providing adequate influence zone overlap.

Figure 3.4.2: PCC Vibrators on the Underside of a Paving Machine

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Profile Pan:

Casting of slab i.e. Extrusion and trimming is done by filling the lower mould. It comprising a base, two metallic forms rested against the base and upper plate (Figure 3.4.3).

Figure 3.4.3: Side forms and Profile Pan

•

Dowel Bar Placing and Insertion:

An attachment to a slipform paver is provided which has side plates and surface plates engaging the sides and top surface respectively of a freshly formed slab of concrete, the slide plates being movable laterally to conform to deviations in the direction of the path of the concrete slab and the surface plate inclining upwardly toward the slab edge to maintain the slab contour during insertion of the dowel bars through the side plate into the side edge of the slab. Dowels are then inserted in the concrete at the required depth with the help of vibrating tongs having an inverted Y shape

3.5 Stage 5 – Trimming, and levelling assembly:

Augers spread the concrete evenly but it gets disturbed by the dowel bar insertion. This and excess concrete in profile pan is trimmed and levelled by lateral movement of oscillating beam mounted behind the auger.

3.6

Stage 6 – Joints:

The transverse and longitudinal joints are cut at required locations. Diamond blades are used to cut the joint at specified depth and width as soon as the concrete hardens. Joints are sealed 3-4 days after cutting with approved quality cold pour sealant.

3.7 Stage 7 –Texturing, Curing and Covering:

Texturing and curing unit consist of a comb shaped wire brush. It moves in the lateral direction and perforated pipe having perforations at equal spacing through which curing compound is sprayed on the textured surface. The texturing and curing machine follow the paver and is used to impart macrotexture (usually by dragging a tined instrument across the fresh pavement -Figure 3.7.1) and apply a curing membrane over the pavement. Sometimes the paver is equipped with atoning machine, while a separate machine is used for applying the curing membrane. Although it used to be quite common, slip formed PCC pavement is rarely if ever water cured due to the high material and labour costs. Figure 3.7.2 and Figure 3.7.3 show curing machines in operation. Curing is typically done once finishing of an area is complete and the original wet sheen has nearly disappeared. On tined pavements, curing is usually

specified to occur in two passes, one forward and one in reverse, to ensure both sides of the texture ridges are coated with curing membrane. After the initial cut the paved surface is covered with Jute hasian cloth. It will be kept moist for14 days after lying of concrete. The concrete will be covered till curing compound is getting set. This is done by mobile tents to prevent drying and evaporation.

Figure 3.7.1: Tined Texturing Carriage Figure 3.7.2: Spraying the Curing Membrane Figure 3.7.3:

Spraying Curing Membrane Close-up

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Figure 3.7.1: Tined Texturing Carriage Figure 3.7.2: Spraying the Curing Membrane Figure 3.7.3:

Spraying Curing Membrane Close-up

WEATHER LIMITATIONS

Concreting in Hot Weather: No concreting shall be done when the concrete temperature is above 30°C. As placing of concrete in air ambient temperatures above 35°C, is associated with defects, like, loss of workability through accelerated setting, formation of plastic shrinkage cracks etc. It is recommended that unless adequate precautions are taken, no concreting shall be done in conditions more severe than the above.

As the temperature of concrete mix is not to exceed 30°C, it is desirable to install a chilling plant so that the temperature of the mix can be controlled in hot weather.

The air temperature above 35°C, relative humidity below 25 percent and/or wind velocity of more than 1 5 km/h constitute conditions necessitating precautions to be taken for concreting. The associated problem involved in concreting in hot weather concern the production, placement and curing of concrete.

A higher temperature of the fresh concrete results in rapid hydration and leads to accelerated setting of concrete. The slump of concrete decreases and hence the water demand increases in hot weather.

Plastic shrinkage cracks may develop in concrete due to evaporation of water from the surface of the concrete. No concreting should be done IRC: 15-2011 when the concrete temperature is above 35°C. To bring down the temperature of concrete, chilled water or ice flakes should be used. It is advisable to install a chilling plant, so that the temperature of the concrete mix can be controlled in hot weather.

A ready to use chart to calculate the rate of evaporation of water from the concrete for the construction of cement concrete pavement is given in Fig. 1 . If the rate of evaporation is expected to be above1 kg/m2 per hour , precautions against plastic shrinkage cracking are necessary. The surface shall be continuously kept wet by slight fogging, or slight spraying of water, use of tents/ covers to minimize wind speed or providing wet hessian cloth before continuous curing i.e. after 24 hours of laying.

Plastic shrinkage crack of width 0.3 mm in case of normal weather condition and 0.2 mm in case of moderate/severe weather condition may be the nucleus for other types of damage due to water penetrating through them. Due to increased tensile stresses, these cracks may develop into structural cracks also with passage of time.

A good quality concrete, which is strong, impermeable and durable against abrasion, chemical attack and adverse effects of weather can only be achieved with suitable choice of materials, proper mix proportioning and satisfactory controls at all stages of manufacturing, placing and curing of concrete.

Mixing water has the greatest effect on lowering the temperature of concrete. The temperature of water is easier to control than that of other ingredient. The use of cold mixing water will reduce the temperature of placing of concrete to some extent. The reduction of water temperature can be most economically accomplished by adding ice flakes to it. The ice should be manufactured from non-chlorinated water.

Due to high temperature, the hydration of concrete is faster and rapid stiffening of concrete results in increased water demand. Use of rapid hardening cement or 53 grade OPC shall be avoided in case of hot weather concreting. The aggregates may be kept shaded to protect from direct sun rays. They may be sprinkled with cold water or may be cooled by circulating refrigerated air through pipes.

To off-set the accelerating setting of concrete in hot weather and to reduce increased demand, set retarding and water-reducing admixture should be used. However, as some of the admixture can cause undesirable secondary effects such as reduction in ultimate strength of concrete or increase of bleeding of concrete, it is recommended that prior experience or test data should be available, before their use. The temperature of aggregates, water and cement should be maintained at the lowest practical levels, so that the temperature of concrete is below 30℃, at the time of placement. IRC: 15-2011 Fig. 1

Weather has profound impact on curing. The process of hydration of cementis faster in summer then in winter. Immediately after consolidation and surface finish, concrete shall be protected from evaporation of moisture. Initial curing shall be done usingcuring compound which will be sprayed on the cement concrete surface when no freewater is visible on the surface and texturing has been completed. Wet hessian cloth shouldbe gently placed after the curing compound has lost its sheen. Wet curing shall continuethereafter atleast for 14 days in case of OPC and 16 days where blended cement hasbeen used. There shall be sufficient supply of wet hessian cloth for initial curing

IRC: 15-2011

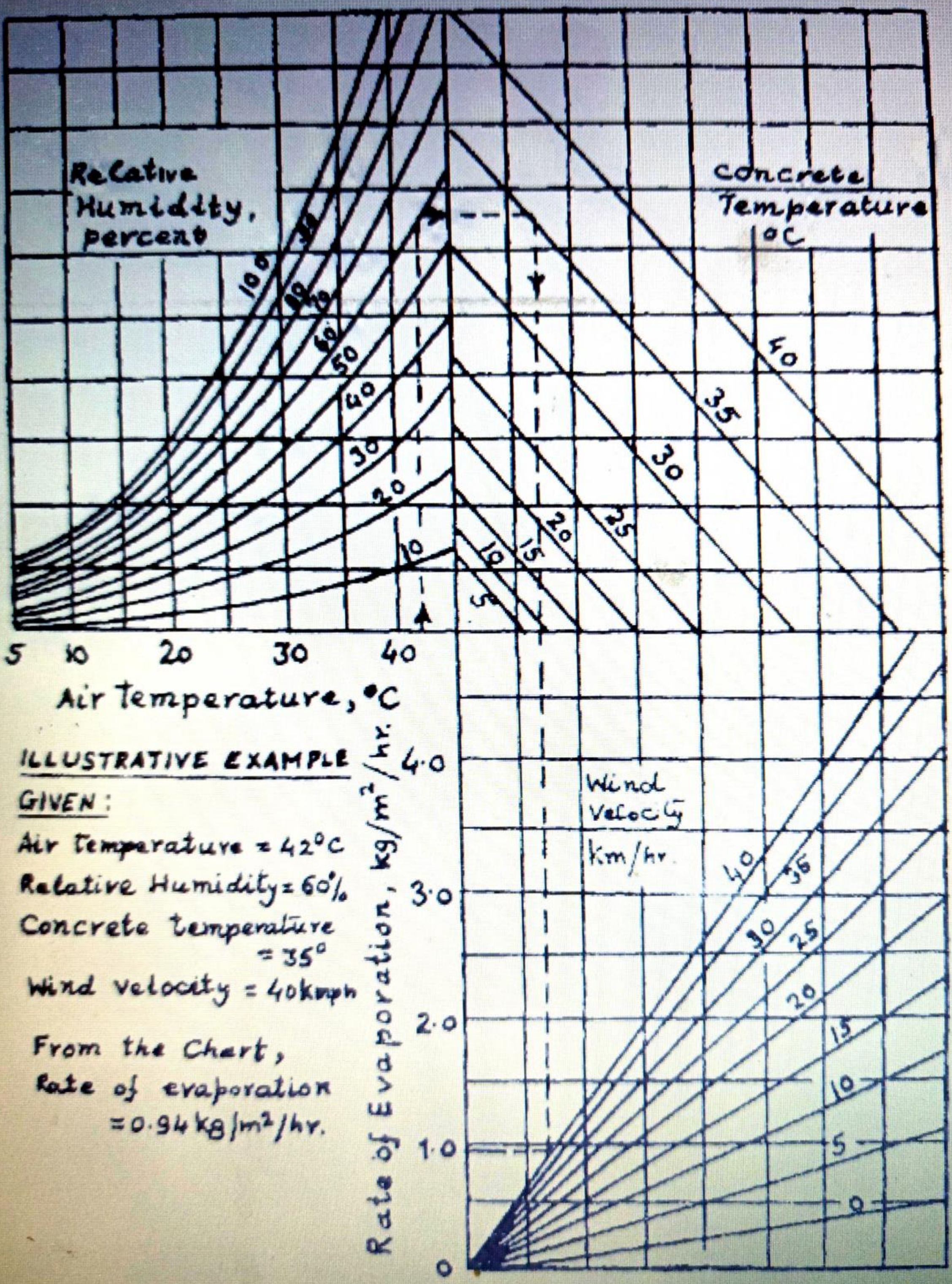

Fig. 1 Chart for Calculation of Rate of Evaporation of Surface Moisture of Concrete from Air Temperature and Relative Humidity, Concrete Temperature and Wind Velocity. (Enter The Chart on The Temperature Scale and Proceed as Shown by Dotted Line, Till The Rate of Evaporation is Reached

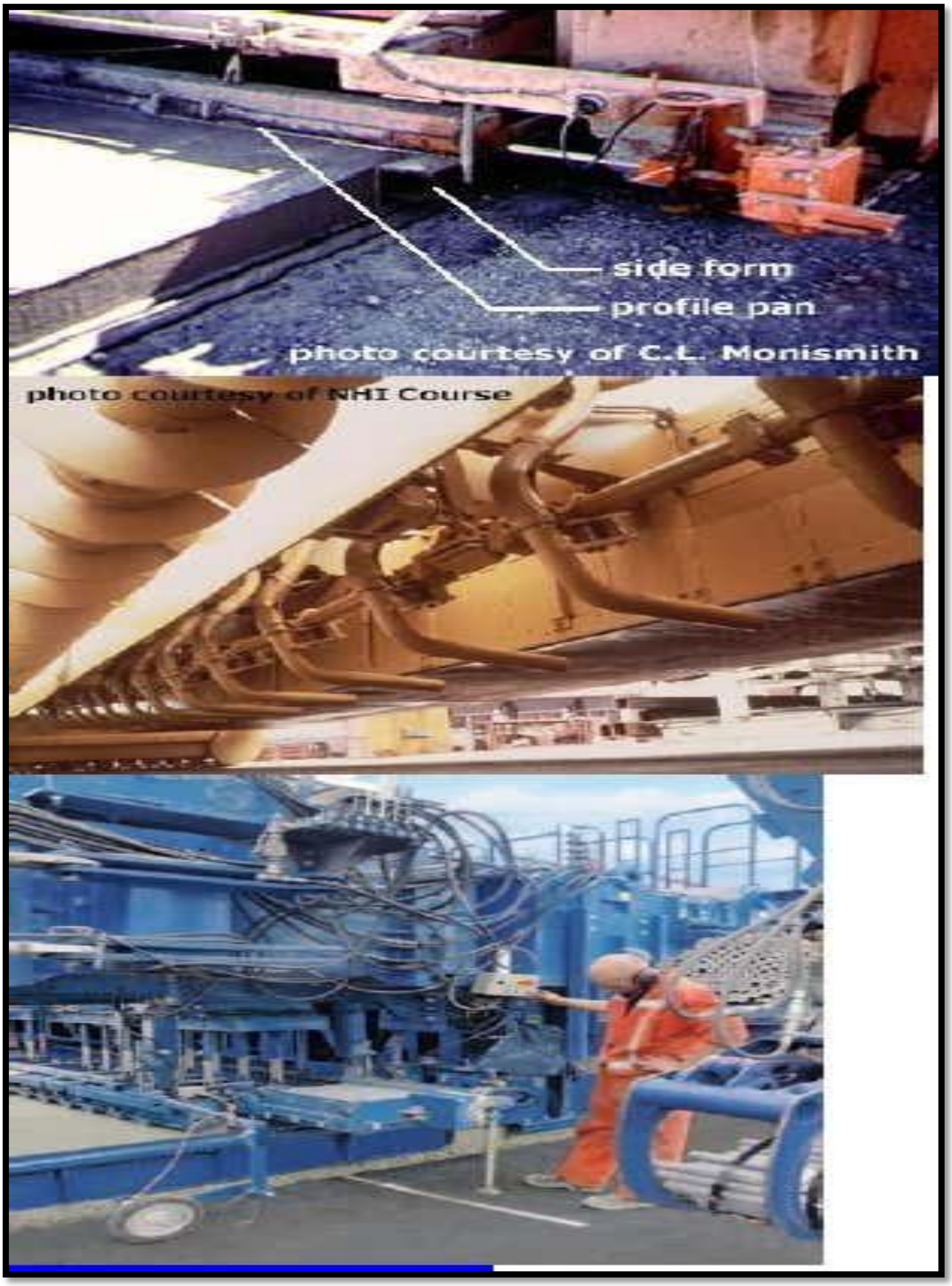
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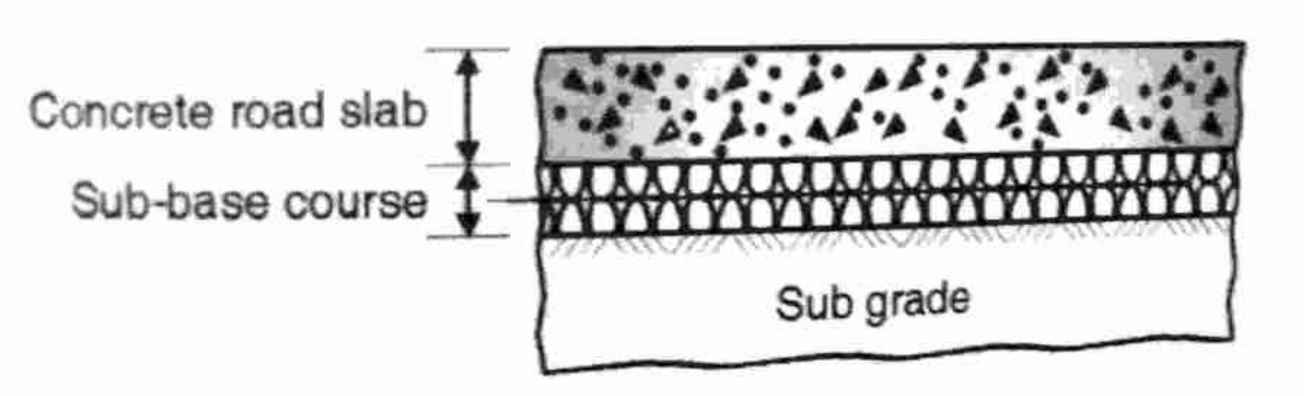
photo courtesy of NHI Course

CHAPTER 4

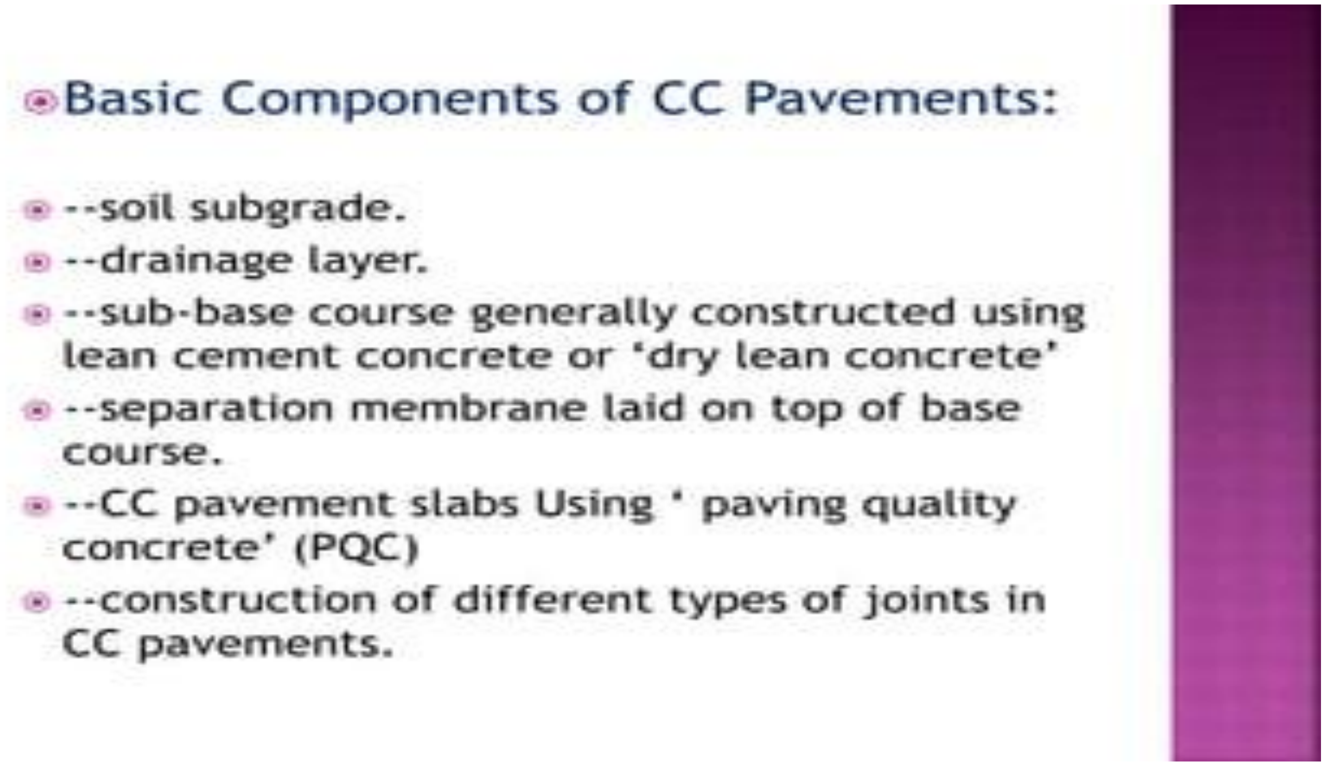
BASIC COMPONENTS OF CEMENT CONCRETE ROAD

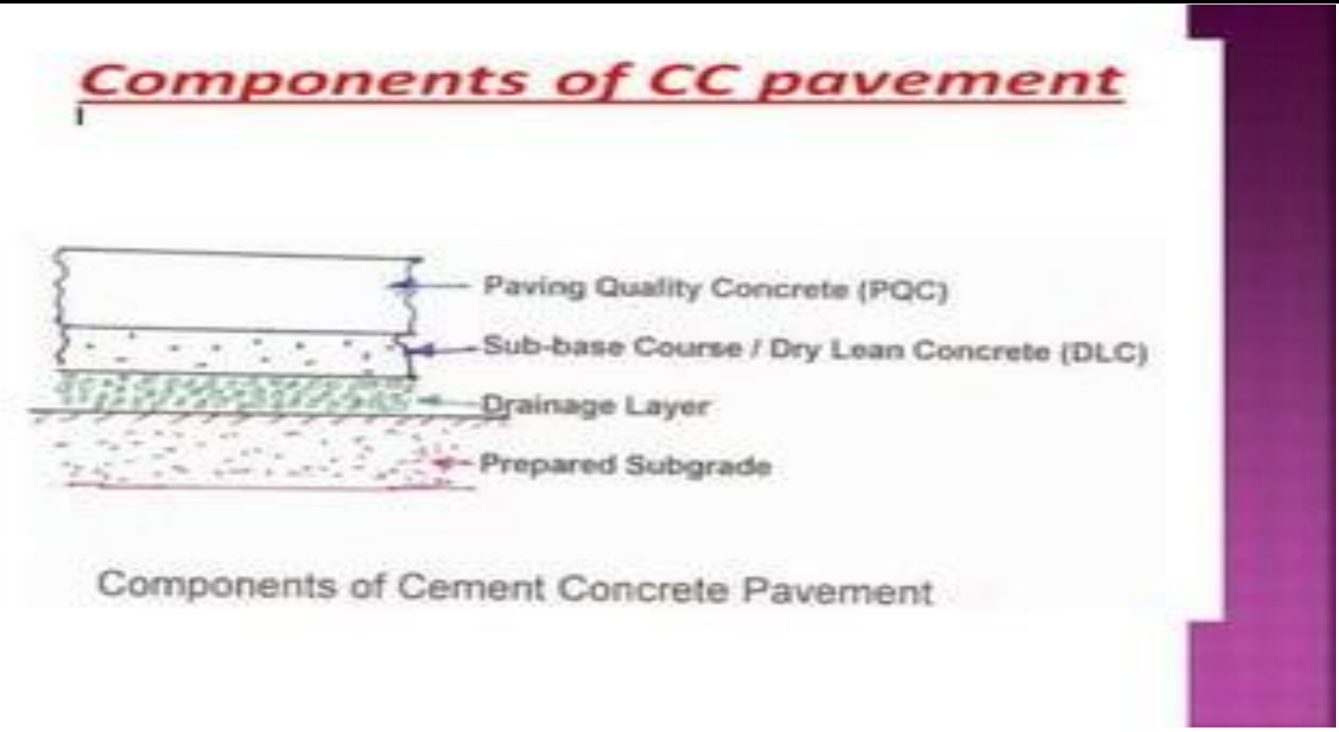


Structural components of concrete pavement

Starting from bottom such roads consist of following components :

- Sub-grade
- Sub-base
- Concrete Slab





Types of Joints in Concrete Constructions

Types of joints in concrete constructions are:

1. Construction Joints
2. Expansion Joints
3. Contraction Joints

1. Construction Joints

Construction joints are placed in a concrete slab to define the extent of the individual placements, generally in conformity with a predetermined joint layout. Construction joints must be designed in order to allow displacements between both sides of the slab but, at the same time, they have to transfer flexural stresses produced in the slab by external loads. Construction joints must allow horizontal displacement right-angled to the joint surface that is normally caused by thermal and shrinkage movement.

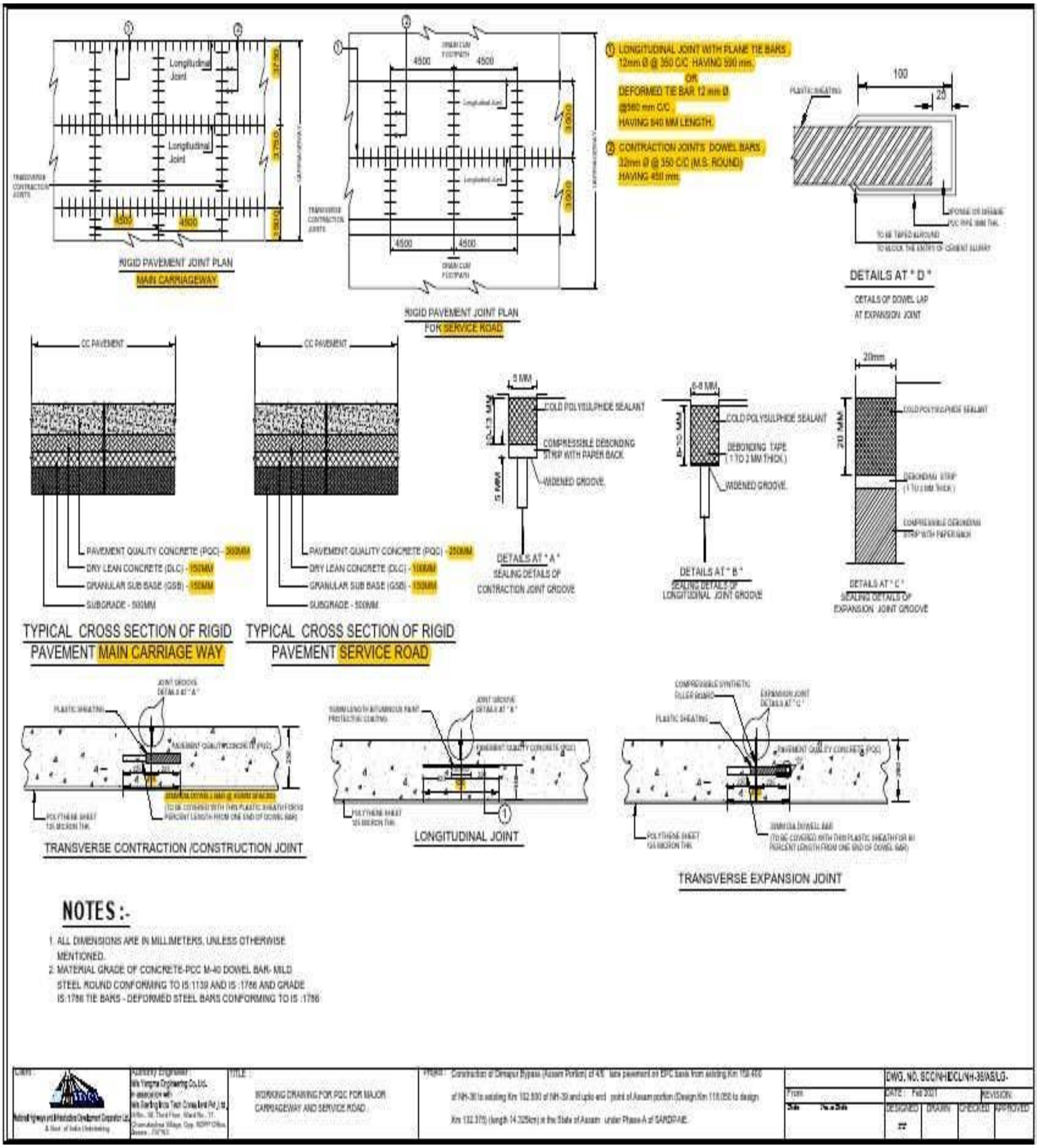
2. Expansion joints

The concrete is subjected to volume change due to many reasons. So we have to cater for this by way of joint to relieve the stress. Expansion is a function of length. It shall be provided at the end of the paving day .Next day paving shall start by placing sailteck board of 10 mm thick on the vertical surface of cement concrete road

3. Contraction Joints

A contraction joint is a sawed, formed, or tooled groove in a concrete slab that creates a weakened vertical plane. It regulates the location of the cracking caused by dimensional changes in the slab. Unregulated cracks can grow and result in an unacceptably rough surface as well as water infiltration into the base, subbase and subgrade, which can enable other types of pavement distress. Contraction joints are the most common type of joint in concrete pavements, thus the generic term "joint" generally refers to a contraction joint.

Contraction joints are chiefly defined by their spacing and their method of load transfer. They are generally between 1/4 - 1/3 the depth of the slab and typically spaced every 4.5 – 5.0 m



CHAPTER NO 5

COST COMPARISION BETWEEN CEMENT CONCRETE ROAD AND BITUMINIOUS ROAD

Per metre cost of road for 9.0 metre top width

Flexible Pavement :

SL	ITEMS	QTY	RATE (RS)	AMOUNT (RS)	Thickness (MM)
1.0	Granular sub base	2.60 cumtr	697	1812.2	200
2.0	Wet Mix Macadam	2.325 cumtr	1364	3171.3	250
3.0	Dense bitumen mix	0.9 cumtr	13100	11790	100
4.0	Wearing course (BC)	0.45 cumtr	14300	6435	50
5.0	Tack coat	9 sq. metre	30	270	
			Total cost	23478.5	
			Per metre cost	Rs 23479.00	

SL	ITEMS	QTY	RATE (RS)	AMOUNT(RS)	THICKNESS(MM)
1.0	Granular sub base	2.60 cu metre	697	1812.20	200
2.0	Dry lean concrete	0.92 cu metre	2030	1827	100
3.0	Cement concrete road	2.70 cu metre	6500	17550	3000
			Total cost	21189.20	
			Per metre cost	RS 21190.00	

Hence, there is cost saving in adopting the rigid pavement roads, but for bigger project only

Chapter: NO 6

Mix design of Pavement Quality Concrete

Balance work of Four Laning of Obedullaganj to Itarsi Section of NH-69 from Km.2.800 to 8.300 And from Km. 20.700 to 63.000 (Design Length 46.30Km.) Excluding Km.8.300 to Km. 20.700 Wild Life Area (Entrusted with State Authority) in the State of Madhya Pradesh . Package-I/NH-69) on EPC Mode.

AUTHORITY	**: NATIONAL HIGHWAY AUTHORITY OF INDIA**
AUTHORITY ENGINEER	**: LION ENGINEERING CONSULTANT**
EPC CONTRACTOR	**: NKC-CDS (JV)**

TEST SUMMARY OF PQC (M-40)

SL. No.	Property		Results	Specifications
1	**Gradation**		Report Attached	As per MORT&H table No.600-3
2	**AIV of Mix Material**		18.42%	Max.30%
3	**FI & EI of Mix Material(Combined)**		27.92%	Max.35%
4	**Compressive Strength**			
	7 Days (N/mm^2)		43.70	-
	28 Days (N/mm^2)		55.04	-
5	**Flexural Strength**			
	7 Days (N/mm^2)		5.25	-
	28 Days (N/mm^2)		6.95	4.5+1.65s
6	**Specific Gravity**			
	a	Cement	3.15 gm/cc	-
	b	FlyAsh	2.13 gm/cc	-
	c	31.5 mm Aggregate	2.718 gm/cc	-
	d	20 mm Aggregate	2.714 gm/cc	
	e	10 mm Aggregate	2.708 gm/cc	-
	f	Natural Sand	2.628 gm/cc	-
7	**Water Absorption**			
	a	31.5 mm Aggregate	0.75%	Max.2%
	b	20 mm Aggregate	0.80%	Max.2%
	c	10 mm Aggregate	0.84%	Max.2%

	d	Natural Sand	1.01%	Max.2%
8	**Cement Test Result**			
	a	Fineness Of Flyash	2.75	Max. 34%
	b	Fineness Of Cement	2.16	Max. 10 %
	c	Normal Consistency	25.5	-
	d	Initial Setting Time	190	Min.30 Min.
	e	Final Setting Time	275	Max. 600 Min.
	f	Soundness	2.75	Max.10 mm.
	g	3 days	26.64	23 N/mm^2
	h	7 days	36.41	33 N/mm^2
	I	28 days	46.99	43 N/mm^2

Balance work of Four Laning of Obedullaganj to Itarsi Section of NH-69 from Km.2.800 to 8.300 And from Km. 20.700 to 63.000 (Design Length 46.30Km.) Excluding Km.8.300 to Km. 20.700 Wild Life Area (Entrusted with State Authority) in the State of Madhya Pradesh . Package-I/NH-69) on EPC Mode.

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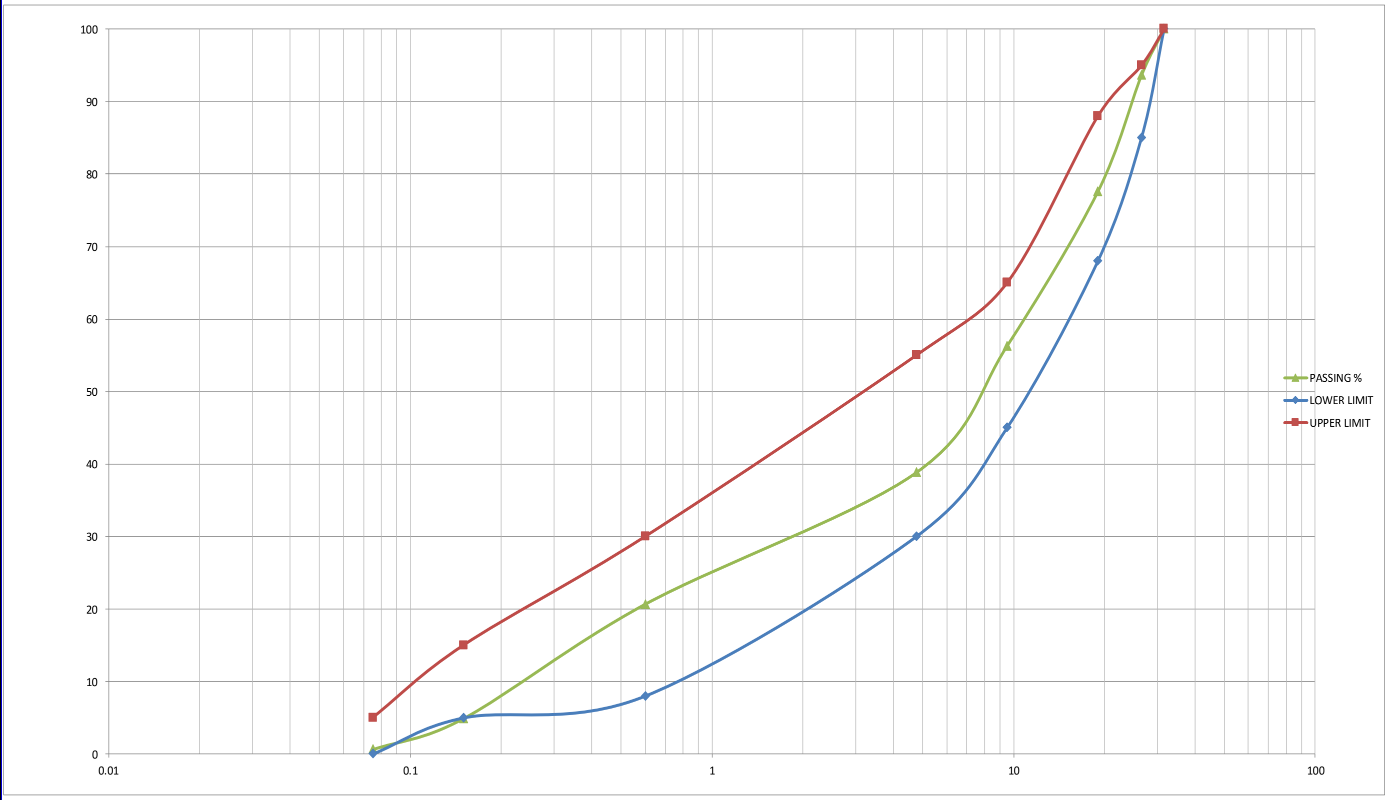
EPC CONTRACTOR : NKC -CDS (JV)

BLENDING OF PQC

SIEVE SIZE (MM)	AVG PASSING %				31.5 MM	20 MM	10 MM	SAND	PASSING %	MID LIMIT	LOWER LIMIT	UPPER LIMIT
	31.5 MM	20 MM	10 MM	SAND	22%	20%	20%	38%				
31.5	100	100	100	100	22	20	20	38	100	100	100	100
26.5	70.97	100	100	100	15.61	20	20	38	93.61	90	85	95
19	6	91.26	100	100	1.32	18.25	20	38	77.57	78	68	88
9.5	0.45	0.87	90.02	100	0.10	0.17	18.004	38	56.28	55	45	65
4.75		0.33	6.8	98.4	0	0.07	1.36	37.39	38.82	42.5	30	55
0.600			1.09	53.78	0	0	0.22	20.44	20.65	19	8	30
0.150				12.83	0	0	0	4.88	4.88	10	5	15
0.075				1.57	0	0	0	0.60	0.60	2.5	0	5
PAN												



Individual gradation of 31.5 mm for PQC MIX DESIGN				
Date of sampling -	09-08-2018	Source of Aggregate -	KHANDWAD	
Date of testing -	13-08-2018	weight of sample -	25998 gm	
Sample no -01				
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.5	0	0	0	100
26.5	7765	7765	29.87	70.13
19	16885	24650	94.81	5.19
9.5	1086	25736	98.99	1.01
4.75				
0.600				
0.150				
0.075				
Sample no -02				
weight of sample - 25550 gm			25600	
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.5	0	0	0	100
26.5	7384	7384	28.84	71.16
19	16658	24042	93.91	6.09
9.5	1406	25448	99.41	0.59
4.75				
0.600				
0.150				
0.075				
Sample no -03				
weight of sample - 24480 gm			24462	
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.5	**0**	**0**	0.00	100.00
26.5	6940	6940	28.37	71.63
19	15876	22816	93.27	6.73
9.5	1603	24419	99.82	0.18
4.75				
0.600				
0.150				
0.075				

Individual gradation of 20 mm for PQC MIX DESIGN

Date of sampling	09-08-2018	ource of Aggregate	KHANDWAD	
Date of testing	13-08-2018	weight of sample -	22205	

Sample no -01

SIEVE SIZE (MM)	weight retained (gm)	Cumulative Weight retained (gm)	Cumulative Retained %	Cumulative Passing %
31.5	0	0	0	100
26.5	0	0	0	100
19	1966	1966	8.85	91.15
9.5	20042	22008	99.11	0.89
4.75	95	22103	99.54	0.46
0.600				
0.150				
0.075				

Sample no -02

weight of sample - gm 23820

SIEVE SIZE (MM)	weight retained (gm)	Cumulative Weight retained (gm)	Cumulative Retained %	Cumulative Passing %
31.5	0	0	0	100
26.5	0	0	0	100
19	2188	2188	9.19	90.81
9.5	21568	23756	99.73	0.27
4.75	60	23816	99.98	0.02
0.600				
0.150				
0.075				

Sample no -03

weight of sample 22520

SIEVE SIZE (MM)	weight retained (gm)	Cumulative Weight retained (gm)	Cumulative Retained %	Cumulative Passing %
31.5	**0**	**0**	0	100
26.5	0	0	0	100
19	1840	1840	8.17	91.83
9.5	20354	22194	98.55	1.45
4.75	144	22338	99.19	0.81
0.600				
0.150				
0.075				

EPC CONTRACTOR AUTHORITY / AUTHORITY ENGINEER

individual gradation of 10 mm for PQC MIX DESIGN				
Date of sampling	09-08-2018	Source of Aggregate -	KHANDWAD	
Date of testing	13-08-2018	weight of sample -	19480 gm	
Sample no -01				
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.5	0	0	0	100
26.5	0	0	0	100
19	0	0	0	100
9.5	1964	1964	10.08	89.92
4.75	16390	18354	94.22	5.85
0.600	998	19352	99.34	0.62
0.150				
0.075				
Sample no -02				
weight of sample -	gm		18980	
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.5	0	0	0	100
26.5	0	0	0	100
19	0	0	0	100
9.5	1824	1824	9.61	90.39
4.75	15784	17608	92.77	7.23
0.600	1102	18710	98.58	1.42
0.150				
0.075				
Sample no -03				
weight of sample -	gm		16998	
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.5	**0**	**0**	0	100
26.5	0	0	0	100
19	0	0	0	100
9.5	1786	1786	10.51	89.49
4.75	14338	16124	94.86	5.14
0.600	850	16974	99.86	0.14
0.150				
0.075				
EPC CONTRACTOR			**THORITY / AUTHORITY ENGINE**	

individual gradation of sand for PQC MIX DESIGN					
Date of sampling	09-08-2018	Source of Aggregate -	TAWA RIVER		
Date of testing	13-08-2018	weight of sample -	11205	gm	

Sample no -01

SIEVE SIZE (MM)	weight retained (gm)	Cumulative Weight retained (gm)	Cumulative Retained %	Cumulative Passing %
31.5	0	0	0	100
26.5	0	0	0	100
19	0	0	0	100
9.5	0	0	0	100
4.75	158	158	1.41	98.59
0.600	4852	5010	44.71	55.29
0.150	5002	10012	89.35	10.65
0.075	1090	11102	99.08	0.92

Sample no -02

weight of sample - 9660 gm

SIEVE SIZE (MM)	weight retained (gm)	Cumulative Weight retained (gm)	Cumulative Retained %	Cumulative Passing %
31.500	0	0	0.00	100.00
26.500	0	0	0.00	100.00
19.000	0	0	0.00	100.00
9.500	0	0	0.00	100.00
4.750	198	198	2.05	97.95
0.600	4298	4496	46.54	53.46
0.150	3912	8408	87.04	12.96
0.075	1128	9536	98.72	1.28

Sample no -03

weight of sample - gm			8852	
SIEVE SIZE (MM)	**weight retained (gm)**	**Cumulative Weight retained (gm)**	**Cumulative Retained %**	**Cumulative Passing %**
31.500	0	0	0.00	100.00
26.500	0	0	0.00	100.00
19.000	0	0	0.00	100.00
9.500	0	0	0.00	100.00
4.750	118	118	1.33	98.67
0.600	4080	4198	47.42	52.58
0.150	3336	7534	85.11	14.89
0.075	1096	8630	97.49	2.51

EPC CONTRACTOR **AUTHORITY / AUTHORITY ENGINEER**

Balance work of Four Laning of Obedullaganj to Itarsi Section of NH-69 from Km.2.800 to 8.300 And from Km. 20.700 to 63.000 (Design Length 46.30Km.) Excluding Km.8.300 to Km. 20.700 Wild Life Area (Entrusted with State Authority) in the State of Madhya Pradesh . Package-I/NH-69) on EPC Mode.

NKC-CDS (JV)

COMPRESSIVE STRENGTH OF CONCRETE

(As per IS:516)

Location	40+800 RHS	Grade of Mix	M-40 PQC
Date of Casting	21-09-2018	source of material	khandwad
Date of Testing	19-10-2018	Age of Cubes	28 days
volume of cube	3375 cc	Size of cube	150*150*150 (mm)

Sl. No.	ID NO.	Weight of Cube (gm)	Density of Cube (gm/cc)	Load KN	Compressive Strength N/mm^2	AVERAGE Compressive Strength (N/mm2)
1	7	8350	2.474	1235	54.89	54.56
2	8	8342	2.472	1220	54.22	
3	9	8402	2.489	1240	55.11	55.22
4	10	8335	2.470	1245	55.33	
5	11	8406	2.491	1222	54.31	54.22
6	12	8366	2.479	1218	54.13	
7	13	8420	2.495	1214	53.96	54.67
8	14	8374	2.481	1246	55.38	
9	15	8433	2.499	1255	55.78	54.78
10	16	8396	2.488	1210	53.78	
11	17	8377	2.482	1220	54.22	54.07
12	18	8389	2.486	1213	53.91	
13	19	8415	2.493	1238	55.02	54.80
14	20	8408	2.491	1228	54.58	
15	21	8360	2.477	1244	55.29	55.51
16	22	8420	2.495	1254	55.73	
17	23	8371	2.480	1250	55.56	55.33
18	24	8355	2.476	1240	55.11	
19	25	8418	2.494	1251	55.60	55.76
20	26	8444	2.502	1258	55.91	
21	27	8349	2.474	1248	55.47	55.00
22	28	8324	2.466	1227	54.53	
23	29	8436	2.500	1240	55.11	55.56
24	30	8434	2.499	1260	56.00	
25	31	8390	2.486	1224	54.40	54.67
26	32	8376	2.482	1236	54.93	
27	33	8435	2.499	1256	55.82	56.02
28	34	8345	2.473	1265	56.22	
29	35	8413	2.493	1253	55.69	55.38
30	36	8369	2.480	1239	55.07	

Average Compressive Strength of 30 Cubes at 28 Days = 55.04 (N/mm2)

Remark:-

EPC CONTRACTOR AUTHORTITY /AUTHORITY ENGINEER

Balance work of Four Laning of Obedullaganj to Itarsi Section of NH-69 from Km.2.800 to 8.300 And from Km. 20.700 to 63.000 (Design Length 46.30Km.) Excluding Km.8.300 to Km. 20.700 Wild Life Area (Entrusted with State Authority) in the State of Madhya Pradesh . Package-I/NH-69) on EPC Mode.

NKC-CDS (JV)

FLEXURAL STRENGTH OF CONCRETE

(As per IS:516)

Location	40+800 RHS	Grade of Mix	M-40 PQC
Date of Casting	21-09-2018	source of material	khandwad
Date of Testing	19-10-2018	Age of beams	28 days
volume of beam	15750 cc	Size of beam	700*150*150 (mm)

ID. No.	Weight of beam (gm)	Density of beam (gm/cc)	fracture distance "a"(cm)	Load (KN)	flexural Strength N/mm^2	AVERAGE flexural Strength
7	39355	2.499	26.5	38	6.76	6.84
8	39400	2.502	27.0	39	6.93	
9	39296	2.495	28.0	39	6.93	7.02
10	39354	2.499	28.5	40	7.11	
11	39330	2.497	29.4	40	7.11	6.93
12	39411	2.502	25.5	38	6.76	
13	39330	2.497	26.9	40	7.11	7.02
14	39256	2.492	28.6	39	6.93	
15	39241	2.491	29.2	38	6.76	7.02
16	39310	2.496	27.6	41	7.29	
17	39336	2.498	28.9	40	7.11	6.84
18	39402	2.502	24.9	37	6.58	
19	39285	2.494	26.7	39	6.93	6.76
20	39246	2.492	27.4	37	6.58	
21	39313	2.496	25.8	41	7.29	7.20
22	39374	2.500	28.6	40	7.11	
23	39396	2.501	25.4	40	7.11	6.93
24	39425	2.503	26.9	38	6.76	
25	39359	2.499	28.4	39	6.93	6.93
26	39386	2.501	27.2	39	6.93	
27	39391	2.501	26.4	40	7.11	6.84
28	39288	2.494	28.8	37	6.58	
29	39415	2.503	25.6	40	7.11	6.93
30	39426	2.503	26.8	38	6.76	
31	39456	2.505	27.0	39	6.93	7.02
32	39390	2.501	28.3	40	7.11	
33	39444	2.504	26.5	39	6.93	7.11
34	39475	2.506	25.5	41	7.29	
35	39510	2.509	24.9	40	7.11	6.84
36	39419	2.503	26.0	37	6.58	
Average Flexural Strength of 30 beam at 28 Days				**=**	**6.95**	**(N/mm2)**
Standard daviation of beam				=	0.21	

Remark:-

EPC CONTRACTOR AUTHORTITY /AUTHORITY ENGINEER

Balance work of Four Laning of Obedullaganj to Itarsi Section of NH-69 from Km.2.800 to 8.300 And from Km. 20.700 to 63.000 (Design Length 46.30Km.) Excluding Km.8.300 to Km. 20.700 Wild Life Area (Entrusted with State Authority) in the State of Madhya Pradesh . Package-I/ NH-69) on EPC Mode.

NKC-CDS (JV

CALCULATION OF STANDARD DEVIATION

Sl.No.	Average Flexural Strength (28 Days)	$(x-\bar{x})^2$	Calculation			Remarks
1	6.76	0.04				
2	6.93	0.00	$\bar{x}$	=	∑x	
3	6.93	0.00			n	
4	7.11	0.03		=	208.53	
5	7.11	0.03			30	
6	6.76	0.04	$\bar{x}$	0	6.95	
7	7.11	0.03				
8	6.93	0.00				
9	6.76	0.04	Standard deviation	=	$\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$	
10	7.29	0.12				
11	7.11	0.03		=	$\sqrt{\frac{1.33}{29}}$	
12	6.58	0.14				
13	6.93	0.00				
14	6.58	0.14				
15	7.29	0.12				
16	7.11	0.03				
17	7.11	0.03				
18	6.76	0.04				
19	6.93	0.00				
20	6.93	0.00				
21	7.11	0.03				
22	6.58	0.14			**0.21**	
23	7.11	0.03				
24	6.76	0.04				
25	6.93	0.00				
26	7.11	0.03				
27	6.93	0.00				
28	7.29	0.12				
29	7.11	0.03				
30	6.58	0.14				
n = 30	**∑x = 208.53**	**$\sum(x-\bar{x})^2$=1.33**				

Remarks:

EPC CONTRACTOR **AUTHORITY / AUTHORITY ENGINEER**

Balance work of Four Laning of Obedullaganj to Itarsi Section of NH-69 from Km.2.800 to 8.300 And from Km. 20.700 to 63.000 (Design Length 46.30Km.) Excluding Km.8.300 to Km. 20.700 Wild Life Area (Entrusted with State Authority) in the State of Madhya Pradesh . Package-I/ NH-69) on EPC Mode. NKC-CDS (JV)

AUTHORITY	: NATIONAL HIGHWAY AUTHORITY OF INDIA
AUTHORITY ENGINEER	: LION ENGINEERING CONSULTANTS
EPC CONTRACTOR	: NKC-CDS (JV)

Testing Laboratry: Central Laboratory Hosangabad @ 40+800 RHS

PAVEMENT QUALITY CONCRETE (PQC)

MIX DESIGN FOR PQC(M-40)

A) Design Parameters / stipulations:

1. Compressive Strength in 28 Days (Grade of Concrete)	=	40	Mpa
2. Characteristic Flexural Strength	=	4.5	Mpa
3. Target Mean Flexural Strength	=	4.85	Mpa
4 Maximum size of Aggregate (Not more than 31.5mm)	=	31.5	mm
5. Deegree of Workability (Slump) as per Mort&h 602.3.4.2)	=	25+/-15	
6. Maximum Water Cement Ratio	=	0.45	
7. Deegree of Quality Control (Exposure)	=	Moderate	
8. Type of Exposure	=	Mild	
9. Shape of Aggregate	=	Angular	
10.Coarse Aggregate Quarry	=	Khandwad Quarry	
11.Fine Aggregate Quarry	=	Tawa River	
12 Cement Source /Grade	=	Ultratech OPC 43 Grade	
13. Flyash Source / Grade	=	Sarni / Grade I	
14. Admixture used (Rheoplast PQC PC)	=	Rheoplast	

B) Test Data of Materials

1. Cement Used	=	Ultratech OPC 43 Grade
2. Specific Gravity of Cement	=	3.15
3. Specific Gravity of Flyash	=	2.13
4. Specific Gravity of Aggregate (31.5 mm)	=	2.718
5. Specific Gravity of Aggregate (20mm)	=	2.714
6. Specific Gravity of Aggregate (10mm)	=	2.708
7. Specific Gravity of Coarse sand	=	2.628
8. Water absorption of Coarse aggregate (31.5mm)	=	0.75
9. Water absorption of Coarse Aggregate (20mm)	=	0.80
10.Water absorption of Coarse Aggregate (10mm)	=	0.84
11.Water absorption of Coarse Sand	=	1.01
12.Aggregate Impact Value	=	18.42
13.Flakiness Index of (31.5 mm)	=	9.46
14.Flakiness Index of (20mm)	=	10.49
15.Flakiness Index of (10mm)	=	11.37
16.Elongation Index of (31.5 mm)	=	10.63
17.Elongation Index of (20 mm)	=	11.02
18.Elongation Index of (10mm)	=	7.30

C) Strength of Concrete Mix

As per Clause 602.3.3.1 of "MORT&H" the mix shall be based on the flexural strength be based on the Flexural Strength of Concrete.
As per Clause 602.3.3.1 of Technical Specification the mix shall have 28 Days Compressive Strength of 40 Mpa & 28 Days Flexural Strength of 4.5 Mpa.

W/C Ratio shall be limited within =0.45 When Only OPC cement is Used
W/C Ratio shall be limited within =0.50 When Blended Cement is used.
As per Clause 602.3.2 of "MORT&H" Specification, Cement Content Shall not be less than 360 Kg. Per Cubic meter of Concrete and incase flyash Grade I (as per IS 3812) blendiing 20% by weigt of Cementitious material allowed. Such case quantity of OPC shall not be less than 310 Kg/Cum.

D) Detail of Calculation.

Detail Calculations of the mix which satisfied all the Criterion of the Specifications is as given below.

Cement	=	315	Kg.
Fly Ash	=	75	Kg.
W/C RATIO	=	0.31	
Water	=	120.9	Kg.
Admixture 0.6 *390/100	=	2.34	Kg.

E) % of Aggregate as per Blending observed for mix.

Coarse Sand	=	38	%
31.5 mm Aggregate	=	22	%
20 mm Aggregate	=	20	%
10 mm Aggregate	=	20	%

F) Absolute Volume of fine and Coarse Aggregate.

$$1 - \left(\frac{315}{3150} + \frac{75}{2130} + \frac{120.9}{1000} + \frac{2.34}{1090} \right) = 0.742 \text{ Cum.}$$

Weight of Coarse Sand
0.38 × 2628 × 0.742 = 740.991 KG/Cum.
Weight of Coarse Aggregate (31.5mm)
0.22 × 2718 × 0.742 = 443.686 KG/Cum.
Weight of Coarse Aggregate (20mm)
0.20 × 2714 × 0.742 = 402.758 KG/Cum.
Weight of Coarse Aggregate (10mm)
0.20 × 2708 × 0.742 = 401.867 KG/Cum.

G) For One Cum. Concrete mix Material Required for SSD Condition

Cement	=	315	KG.
Flyash	=	75	KG.
Coarse Sand	=	740.991	KG.
31.5 mm Aggregate	=	443.686	KG.
20 mm Aggregate	=	402.758	KG.
10 mm Aggregate	=	401.867	KG.
water	=	120.9	KG.
Admixture	=	2.34	KG.

H) Water Required for One Cum Concrete After Moisture correction

Water Cement Ratio of	0.31	390	=	120.9	KG
Water absorption of Coarse Sand	0.0101	740.991	=	7.484	KG
Water absorption of Coarse Aggregate (31.5mm)	0.0075	443.686	=	3.328	KG
Water absorption of Coarse Aggregate (20mm)	0.008	402.758	=	3.222	KG.
Water absorption of Coarse Aggregate (10mm)	0.0084	401.867	=	3.376	KG.
	Total Weight of water			138.309	KG.

Actual Qty. OF Material for 1 cum after moisture Correction (On Dry Condition)

cement			=	315	KG.
Flyash			=	75	KG.
Admixture			=	2.34	KG.
Water			=	138.301	KG.
Actual Qty. of Coarse Aggregate 31.5mm	443.686	3.328	=	440.359	KG.
Actual Qty. of Coarse Aggregate 20mm	402.758	3.222	=	399.536	KG.
Actual Qty. of Coarse Aggregate 10mm	401.867	3.376	=	398.492	KG.
Actual Qty. of Coarse Sand	740.991	7.484	=	733.507	KG.

I) Admixture dosages as worked out from trial

Rheoplast PQC PC - 0.60% By weight of Cementitious
This dosage produced required Slump at 1 Hour(60 Minutes) from mixing i.e all the time of Pour.

Slump

Trial No.	Slump Observed					Remarks
	Initial	After 15 Min.	After 30 Min.	After 45 Min.	After 60 Min.	
18.0	70mm	60mm	50mm	40mm	30mm	

J) Compressive & Flexural Strength

Correction Factor:= 1.0

7 Days Result on dated. 30.08.2018				28 Days Result dated. 20.09.2018			
batch no	Date of Casting	Compressive Strength (N/mm²)	Flexural Strength in Mpa	batch no	Date of Casting	Compressive Strength (N/mm²)	Flexural Strength in Mpa
1	23.08.2018	43.56	5.33	1	23.08.2018	54.67	7.11
		44.09	5.51			53.96	6.93
2		43.11	5.16	2		55.02	6.76
		44.36	4.98			54.44	7.29
3		44.80	5.33	3		55.33	7.47
		44.98	4.98			54.22	6.76
4		43.78	5.16	4		53.78	6.93
		45.33	5.33			55.11	6.76
5		43.2	5.51	5		55.56	7.11
		44.44	4.98			53.69	6.76
6		43.91	5.16	6		54.76	6.93
		45.78	5.51			53.96	6.93
	AVG.	44.28	5.25		AVG.	54.54	6.98

CALCULATION FOR "R" VALUE

"R" VALUE	Average of flexural strength for 7 days / Average of flexural strength for 28 days	0.75
"R" VALUE	Average of compressive strength for 7 days / Average of compressive strength for 28 days	0.81

7 Days Result on dated. 28.09.2018				28 Days Result dated. 19.10.2007			
Identification on mark	Date of Casting	Compressive Strength (N/mm²)	Flexural Strength in Mpa	Identification on mark	Date of Casting	Compressive Strength (N/mm²)	Flexural Strength in Mpa
Cube /Beam No.01	21.09.2018	43.56	5.33			Correction Factor:= 1.0	
Cube /Beam No.02	"	43.11	4.98	Cube /Beam No.07	21.09.2018	54.89	6.76
Cube /Beam No.03	"	42.89	5.16	Cube /Beam No.08	"	54.22	6.93
Cube /Beam No.04	"	43.91	5.33	Cube /Beam No.09	"	55.11	6.93
Cube /Beam No.05	"	44.53	5.16	Cube /Beam No.10	"	55.33	7.11
Cube /Beam No.06	"	44.22	5.51	Cube /Beam No.11	"	54.31	7.11
	AVG.	43.70	5.25	Cube /Beam No.12	"	54.13	6.76
				Cube /Beam No.13	"	53.96	7.11
				Cube /Beam No.14	"	55.38	6.93
				Cube /Beam No.15	"	55.78	6.76
				Cube /Beam No.16	"	53.78	7.29
				Cube /Beam No.17	"	54.22	7.11
				Cube /Beam No.18	"	53.91	6.58
				Cube /Beam No.19	"	55.02	6.93
				Cube /Beam No.20	"	54.58	6.58
				Cube /Beam No.21	"	55.29	7.29
				Cube /Beam No.22	"	55.73	7.11
				Cube /Beam No.23	"	55.56	7.11
				Cube /Beam No.24	"	55.11	6.76
				Cube /Beam No.25	"	55.6	6.93
				Cube /Beam No.26	"	55.91	6.93
				Cube /Beam No.27	"	55.47	7.11
				Cube /Beam No.28	"	54.53	6.58
				Cube /Beam No.29	"	55.11	7.11
				Cube /Beam No.30	"	56	6.76
				Cube /Beam No.31	"	54.4	6.93
				Cube /Beam No.32	"	54.93	7.11
				Cube /Beam No.33	"	55.82	6.93
				Cube /Beam No.34	"	56.22	7.29
				Cube /Beam No.35	"	55.69	7.11
				Cube /Beam No.36	"	55.07	6.58
					AVG.	55.04	6.95

Standard Deviation from Trial Beams for Flexural Strength

CHAPTER NO 7

Test On Cement Concrete Pavement

- **Aggregate Impact Value as per IS: 2386 (Part 4)**
- **Gradation and combined elongation and flakiness test**
- **Soundness Test as per IS: 2386 (Part 5)**
- **Alkali Aggregate Reactivity IS: 2386 (Part 7)**
- **Strength of Concrete (Tests on Cubes and beams) as per IS:516**
- **Workability of fresh Concrete - Slump Test IS: 1199**
- **Core strength of hardened concrete as per IS: 516**
- **Workability of fresh concrete- Slump test as per IS: 1199**
- **Thickness determination**
- **Thickness measurement for trial strength**
- **Flexural test**
- **sand patch test for texture depth**
- **Riding quality test by NSV OR BUMP INDICATOR**

CHAPTER NO 8

REFRENCES :

1.0 MOR&TH REV 5
2.0 IRC 15 - 2011