International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

Construction of Rigid Pavement

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***Abstract*—The rigid pavements which are made up of concrete shows some detrimental structural characteristics such as a very low tensile strength, limited ductility, little resistance to cracking, brittle failure mechanism in tension etc. Due to these undesirable characteristics of concrete, generally the reinforcement is provided in the form of continuous steel bars placed in the concrete structure in the appropriate positions to withstand the imposed tensile and shear stresses. Rigid pavement are those which contains sufficient beam strength bridge over the localized sub-grade failures and areas of in adequate support.**

Keywords—Rigid Pavement, Reinforcement, Concrete:

INTRODUCTION

Rigid pavements are those which posses note worthy flexural strength or flexural rigidity. In rigid pavement the stresses are not transferred from the grain to grain to the lower layers. The rigid pavements are made of Portland cement concrete either plain, reinforced or pre-stressed concrete. The plain cement concrete slabs are expected to take up about 45kg/cm2 flexural stress. The rigid pavement has a slab action and is capable of transmitting the wheel load stresses through a wider area below. The rigid pavement slab as tensile strength , tensile stresses are developed due to the bending of the slab under the wheel load temperature variations Providing a good base at sub base course layer under the cement concrete slab increase the pavement life considerably and there for workout more economical in the long run The rigid pavements are usually designed and the stress are analysed using the elastic theory EASE OF USE

A. COMPONENTS OF RIGID PAVEMENT AND THERE FUNCTIONS:

1. Prepared soil subgrade.
2. Granular sub-base (GSB) or drainage layer.
3. Base course/ (DLC-Dry lean concrete).
4. CC pavement slab using PQC (paving quality concrete).

1. Prepared soil subgrade:

- The soil subgrade of rigid pavement consist of natural or selected soil from identified borrow pits fulfilling the specified requirements.
- The soil subgrade is well compacted to the desired density and to the required thickness.
- The soil subgrade is the lower most layer of the pavement structure which ultimately supports all other pavement layer and traffic loads.
- A good soil subgrade / well compacted and prepared soil subgrade gives long service life to the pavement.

2. Granular sub-base (GSB) or drainage layer:

- The GSB course has to serve as an effective drainage layer of the rigid pavement to prevent early failures due to excessive moisture content in the subgrade soil.
- Crushed stone aggregate are preferred In the granular sub-base course as this material has high permeability and serves as a effective drainage layer.
- Coarse graded aggregates with low percent of fines (<5% finer than 75 micron sieve) will serve as good drainage layer.
- An effective drainage layer under the CC pavements have the following benefits:

  a. Increases in service life and improved performance of CC pavements.

  b. Prevention of early failures of the rigid pavements due to pumping and blowing.

  c. Protection of the subgrade against frost action in the frost suceptible areas**.**

3. Base course: (Dry lean concrete):

- The granular base course is generally provided under the CC pavement slab in low volume roads and also in roads with moderate traffic loads.
- On roads carrying heavy to very heavy traffic loads high quality base course materials such as dry lean concrete are preferred.
- In the base course of the CC pavement as they are designed for a life of 30 years or more with good maintenance. The CC pavement are expressed to provide a service life of 40 years or even more.
- The DLC layer provides a uniform support, high K value and excellent working platform for laying the PQC slab with a sensor paver.

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ISSN: 2278-0181
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- The suppression member is spread on the top of the DLC/ base course before laying the CC pavement slab**.**

4. CC pavement slab: (paving quality concrete (PQC)):

- M-40 cement concrete mix with a minimum flexural strength of 45 kg/cm^2 is recommended by the IRC for use in the CC-pavements of highways with heavy to very heavy traffic loads.
- The C pavement slab is extended to with stand the flexural stress caused by the heavy traffic loads and the warping effects in the CC pavements due to the temperature variations.
- The high quality CC mix with high flexural strength is used for the construction of PQC slab of the CC pavement.
- The CC pavement slab as considerable flexural strength and spreads the applied load/ wheel loads over a large area by slab action.
- The slab prevents the infiltration of excess surface water in to the sub-base.

B. CONSTRUCTION OF SUB-GRADE:

General:

The sub-grade can be defined as a native soil compacted to with stand the loads above it or highway subgrade are basement soil may be defined as the supporting on which pavement and its special under course rests.

Materials:

a. Soil.

b. Moorum.

c. Gravel.

d. Mixture of aggregates.

Requirements of materials:

- Material should be free from organic matter and soluble salts.
- Materials used is non expansive soil.
- The size of aggregate should be less than 50mm
- Liquid limit should be less than 50%
- Plasticity index should be less than 25%
- MDD should be grater than 1.75grm/cm^3
- Soluble sulphates should be less than 0.5%
- Maximum compacted dry density should not be less than 97%

Construction procedure:

- The site should be cleared off and the top soil consisting of grass ,roots ,rubbish and other organic matter are to be removed.
- After site has cleared the work should be set out .Before spreading the material batter pegs are marked on both sides of an embankment at regular intervals.
- The selected soil in the loose condition is spread to a uniform thickness using appropriate equipment over a prepared ground.
- Additional water as required is sprayed so as to obtain the OMC of the soil determine from the laboratory compaction test.
- The soil with the added water is mixed thoroughly using appropriate equipment so that the water gets distributed in the soil layers uniformly. The mixed soil is spread again to the uniform layer thickness by using graders.
- The soil layer is compacted by a rolling, by vibratory roller of 80 to 100KN static weight or heavy pneumatic tiered roller.
- The soil layer is compacted by rolling using the selected equipment so as to obtain the specify density.
- Bring the proper camber profile of the compacted surface.
- the soil is spread over the already compacted layer, water added mixed and compacted as mentioned above.
- The process is repeated until the desired height of the sugrade is archived.

Quality control tests:

1. Sand test: 2 tests per 3000m^3
2. Plasticity test: 2 tests per 3000m^3
3. Density test: 2 tests per 3000m^3
4. Moisture content test : 1 test per 250m^3
5. CBR test : 1 test per 3000m^3

C. CONSTRUCTION OF GRANULAR SUB-BASE OR DRAINAGE LAYER:

General:

The GSB course have to serve as an effective drainage layer of the rigid pavement to prevent early failures due to excessive moisture content in the subgrade soil. It also supports the other pavement layers.

Materials:

a. Crushed stone aggregates

b. Gravel.

c. Coarse sand.

d. Crushed slag.

e. Crushed bricks.

f. Crushed concrete.

g. Natural sand

h. Moorum.

Requirements of materials:

- A material should not contain organic matter or other deleterious constituents.
- The aggregate size should be less then 75mm.

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- Water absorption of the aggregates should be less then 2%
- Aggregate impact value should less than 40%
- Liquid limit should be less then 25%
- Plasticity index should be less then 6%.
- CBR value should be grater then 30%. a. For high volume roads CBR should be minimum 30% b. For low volume roads CBR should be less then 20%.
- Gradation: (% passing by weight).

Is sieves in mm	I	II	III	IV	V	VI
75	100	-	-	-	100	-
53	80-100	100	100	100	80-100	100
26.5	55-90	70-100	55-75	50-80	55-90	75-100
9.5	35-65	50-80	-	-	35-65	55-75
4.75	25-55	40-65	10-30	15-35	25-50	30-55
2.36	20-40	30-50	-	-	10-20	10-25
0.85	-	-	-	-	2-10	-
0.425	10-15	10-15	-	-	0-5	0-8
0.075	<5	<5	<5	<5	-	0-3

Construction procedure:

The GSB layer is constructed on the top of the prepared subgrade therefore first the surface of the subgrade is checked and grass and vegetation if any are removed. The grade and the cross slope of the top surface of the subgrade are corrected as required. The construction steps are give below:

- The subbase material is spread to the uniform thicknes and specified cross slope using a mortar grader by adjusting the blade of the grader.
- The moisture content of the material is checked and the additional quantity of water required to bring up to the optimum moisture content is sprinkled at an uniform rate using a truck mounted sprinkler.
- The water material is mixed properly using machinery such as disc harrows and rotavators.
- The mixed material is spread to the desired thickness, grade and camber using a mortar grader with hydraulic controls of the blade.
- The loose GSB layer is compacted by rolling if the compacted thickness of the layer is 100mm or lesser an ordinary smooth wheeled roller may be used. For compacted thickness exceeding 100mm and up to 225mm compaction is don by vibratory rollers of static weight 10 tons or more.
- Rolling is done starting from the lower edge and proceeded towards the centre of the un divided carriage way or towards the upper edge of the divided carriage way with a minimum 1/3 rd overlap between each run of the roller. The rolling speed is limited to less than 5kmph.
- Rolling is continued till at least 98% of maximum density of the material is archived.
- The surface level tolerance will be (+ or -) 6 mm.

Quality control tests:

- Gradation test : 1 tests per 400m^3
- Altarburge limits: 1 tests per 400m^3
- Moisture content test before compaction : 1 test per 400m^3 .
- CBR test : as required.
- Deleterious constituents : as required.

D. CONSTRUCTION OF DRY LEAN CONCRETE (DLC) SUB-BASE:

General:

The granular base course is generally provided under the CC pavement slabs in low volume roads and also roads with moderate traffic loads. An roads carrying heavy to very heavy traffic loads high quality base course materials such as DLC are preferred.

Materials:

a. *Cement:* OPC 43, Portland slag cement, Portland Pozzolana cement. If the subgrade is found to consist sulphates more than 0.5% cement shall be sulphate resistance.

b. *Aggregates:*

a. *Coarse aggregate:*

- Loss angeles abrasion value should be less than 35 %
- Combined elongation and flaky index should be less than 35%
- Water absorption should be less than 2%
- Soundness for 5 cycles : sodium sulphate should be less than 12% and magnesium sulphate should be less than 18%

b. *Fine aggregate :* natural sand/ crushed stone sand. Gradation:

Is sieves	% passing by weight
26.50mm	100
19mm	75-95
9.50mm	50-70
4.75mm	30-55
2.36mm	17-42
600 micron	8-22
300 micron	7-17
150 micron	2-12
75 micron	0-10

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c. *Water:* It should be free from oil ,salts, acids, and vegitable matter.

d. *Storage of materials:* Place the material with slope such that rain water should be drained off .

e. *Proportioning of the material for the mix:* Aggregate and cementitious material ratio of 15:1

f. *Moisture content:* The moisture content should be +2% keeping in view effectiveness of compaction archived.

g. *Cement content:* The cement content should not be less than 150kg/m^3 .

h. *Concrete strength :* The average compressive strength of 5 cubes shall not be less than 10Mpa at 7 days. Single cube compressive strength should be minimum 7.5Mpa at 7 days.

Construction procedure:

Batching and mixing: The batching plant shall be capable of proportioning the material by weight. The plant should have higher capacity by 25% than the proposed laying arrangements.

Transporting : A plant mix lean concrete shall be discharged immediately from the mixer. The concrete shall be transported by tipping trucks. And they should be a continues supply of the material. To feed the laying equipment to work at a uniform speed and in an uninterrupted manner.

Placing: Dry lean concrete shall be placed by a paver with electronic sensor on the drainage layer. The equipment shall be capable of laying the material in one layer in an even manner with out segregation. Dry lean concrete shall be placed and compacted across a full width.

Compaction:

- The compaction should be carried out immediately after the material is lied and levelled, rolling shall be continued on the full width.
- The minimum dry density obtained shall not be less than 98%.
- Spreading compacting and finishing not to exceed 90min when temperature is 25^0c to 30^0c. And 120 min if less than 25^0c.
- It is desirable to stop concreting when the temperature is above 35^0 c .
- Double drum smooth wheeled vibratory rollers of minimum 80-100KN static weight are suitable for rolling dry lean concrete.

Joints: Construction and longitudinal joints shall be provided.

Curing: Curing may be done by covering the surface by gunny bags which shall be kept wet continuously for 7 days by sprinkling water. Surface level tolerance should be (+ or -) 5mm.

Quality control test:

- Quality of cement : 1 test per 5 tonnes
- Compressive strength : as required
- Water content : 2 test per 500m^2
- Density of compacted layer : 2 test per 500 m^2
- Deleterious constituents : as required.

E. CONSTRUCTION OF CEMENT CONCRETE (CC) PAVEMENT (PQC):

General:

The work shall consist of construction of unreinforced ,dowel bars,plain cement concrete pavement in accordance with the requirements.

materials:

a. *Cement:* Ordinary Portland cement 43 & 53 grade, Portland slag cement, Portland pozzolana cement.

b. *Chemical admixtures:* Chemical admixtures are permitted to improve workability of concrete and setting time.

c. *Silica fumes:* Silica fumes are used as an admixture in the proportion of 3 to 10 percent of cement.

d. *Fibres:* Fibres are used to reduce the shrinkage cracking and post cracking. The fibres may be steel fibres or polymer synthetic fibre. With a diameter of 10 micron to 100 micron ad length 6 to 48 mm and suggested dosage should be 0.6 to 2kg/cm^3.

e. *Aggregates:*

➢ *Coarse aggregate:*

- It should contain clean, hard, strong, dense, non porous and durable pieces of crushed stone or crushed gravel. Requirments:
- Abrasion value should be less than 35%
- Combined EI and FI should be less than 35%
- Water absorption should be less than 2%
- Soundness for 5 cycles sodium sulphate should be less than 12%, and magnesium sulphate should be less than 18%.

➢ *Fine aggregates:*

- fine aggregates shall consist of clean natural sand or crushed stone sand or a combination of two. It should be free from soft, clay, organic and other matters.

Gradation:

Is sieves	% by weight passing the sieve
31.5mm	100
26.5mm	85-95
19mm	68-88
9.5mm	45-65
4.75mm	30-55
600 micron	8-30
150micron	5-15
75 micron	0-5

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f. *Water:* It should be clean, free from oil, salts, acid and vegitable matter.

g. *Steel:*

- Dowel bars:- mild steel bars
- Tie bars :- HYSD bars. h. Joint fillers: Joint filler board for expansion joints up to 20 to 25 mm thickness.

i. *Joint sealing compound:* The joint sealing compound shall be of hot poured, elastomeric type or cold poly sulphide, silicon.

j. *Storage of materials:* Materials should be placed with slope such that rain water should be drained off.

k. *Proportioning for concrete:* The mix design is based on IS:10262.

l. *Cement content:* The cement content should be 360 kg/m^3. And we should not be less than 310 kg/m^3 when blended with fly ash of 20%.

m. *Concrete strength:* The flexural strength of the concrete should not be less than 4.5Mpa.

n. *Preparation of base:* Clean DLC with mechanical broom or air compressor.

o. *Separation member:* A Separation member shall we used between the concrete slab and the subbase. Separation member with PVC sheet 125 micron thick is used.

p. *Form work:* Fixed form are side form type and slip form type.

q. *Joints:*

- Longitudinal joints: tie bars
- Transfers joints : dowel bars

Construction procedure:

Batching and mixing: Batching and mixing of the concrete shall be done at a central batching and mixing plants with automatic controllers. Plant should have higher capacity by 25% as the propelled laying arrangements.

Transporting: Transporting is done by transit mixer and dumper.

Hauling and placing of concrete: Spreading, compacting and finishing not to exceed 90 min when temperature is 20^0c to 30^0c . 120 min if les than 25^0c. and work shall not proceed and reject when temperature is high.

Compaction: Compaction is done by screed vibrators the compaction should be carried out immediately after the material is laid and levelled.

Finishing: Finishing is done by flat and finishers.

Texture: Texture is done by trimming and brushing.

Curing: Covering the surface by gunny bags, pounding, sprinkling water continuously for 28 days and the surface tolerance should be (+ or -) 5mm.

Quality control tests:

- Quality of cement 1 test per 5 tonnes.
- Aggregate gradation 2 test per day
- Water absorption 2 test per day
- Soundness test 1 test per each source
- Compressive strength for 2 cubes for 150 m^3
- Flexural strength for 2 beams for 150 m^3.
- Slump test 1 test per each load.
- Deleterious constituents as required.

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