

## **A STUDY ON THE RIGID PAVEMENT CONSTRUCTION, JOINT AND CRACK FORMATION**

**Shagun Chaddha<sup>1</sup>, Ajay Singh Chauhan<sup>2</sup> and Bhavika Chawla<sup>3</sup>**

<sup>1,2</sup> PG student, Department of Civil Engineering, Chandigarh University, Gharraun Punjab, India

<sup>3</sup> Student, Department of Civil Engineering, baddi university

**Abstract**–Rigid pavement is a technical term that is used where road are made up of concrete instead of asphalt. These roads are providing excellent pleasing appearance. Rigid pavement does not allow any flexibility as comparison of flexible pavement. The rigid pavement is basically formed of cement concrete or reinforced concrete slab that is of either plan, reinforced or prestressed concrete. The characteristics of rigid pavement are generally associated with flexural strength and rigidity which result that the load is distributed over a wide area of sub-grade. This paper is a study about the construction of a rigid pavement, what are the different types of joint as well as the different design factor that we considered while constructing the rigid pavement. The different types of cracks formed on rigid pavement and how these cracks to be occurred on rigid pavement. Recommendation has been given for design as per IRC 15 2011 and IRC 62 2014 and also for joints.

**Keywords**–pavement, rigid pavement, flexible pavement, flexural strength.

### **I. INTRODUCTION**

The rigid pavement are associated with flexural strength or slab action or rigidity due to which the load has been distributed over a wide range area of sub-grade soil and as we all know that rigid pavement in slabs has been laid with steel reinforcement [2]. Fewer amounts of cracks have been formed on rigid pavement. Its life period is also long as comparison to flexible pavement. Less maintenance cost and continues traffic flow. There is no damage due to oil and greases which result in accidents on highways as result thermal stresses has the ability to expand very less in concrete. These are some parameter that has been considered in this paper which tells us that why we use rigid pavement instead of flexible pavement. The basic reason of using rigid pavement for aeroplane road is to prevent the super heated air over the runway surface of aeroplane because higher temperature near the surface has an effect on aircraft wing. It is light in colour as comparison to flexible pavement. The path is easily visible to the pilot which reduced the accident rate during landing. The concrete pavement is also provides necessary fraction between the pavement and tire which reduce the potential of hydro-planing and skidding. The main reason of using concrete pavement is its hardness and durability. In IRC 62 2014 the life span of rigid pavement is 20 years.

- Elements used in construction of rigid pavement.
- Design factor.

#### **1.1 The general elements which are used in constructing rigid pavement are**

##### **1.1.1 Pavement slab construction**

Pavement slab construction involves in cement concrete pavements i.e.

- Cement grouted layer.
- Rolled concrete layer.
- Cement concrete slab.

##### **1.1.2 Joints construction**

Joint construction involves construction of joints i.e. expansion, Contraction, warping and construction joints. Joints are provided in cement concrete roads because these roads are comes in contact with atmospheric temperature and allow expansion, contraction, warping of slab. However, the problem of joints has not been fully solved some of the issues are-

- The subsequent maintenance and Careless practices the initial sealing of joints.
- The lack of a suitable sealing and joint filler.
- The inaccuracy of present subbase construction practices to provide continuous and uniform support for the slabs.

## **1.2 Design factors.**

### **Main design factors which are considered for design of pavement.**

#### **1.2.1 Factors related with traffic.**

1.2.1.1 Traffic factors involves wheel load, contact pressure, moving load, repetitions of load.

**1.2.1.1.1 Wheel load-** This factor is also considered while design the pavement because it define weather the sub-grade soil is failed or not by determining the depth of the pavement [3] [2].

**1.2.1.1.2 Contact pressure-** it is also an important factor, as a result of this we determine the contact pressure and contact area between the pavement surface and wheel [3].

**1.2.1.1.3 Moving load and repetition of load-** these two factors are also important factor because design of pavement is not done only on the magnitude of load but it also depend on the frequency of load application.

#### **1.2.2 Material to be used in pavement component layers.**

Material to be used in pavement component layers helps to describe the stress distribution characteristics. This factor involves the fatigue behaviour and durability of materials under adverse conditions.

#### **1.2.3 Sub grade soil factors.**

For deciding thickness requirement of pavement, properties of soil Sub grade are important. Soil is homogeneous in nature but large amount of variations may be occurring in its properties. For calculating the behaviour of soil large amount of tests are carry out. It varies with moisture content of soil, permeability of soil, internal structure of soil, application of load on soil, type of soil. To determining the power of Sub grade following properties are determined;

- Shear strength of soil
- Bearing power of soil
- Penetration resistance of the soil.

#### **1.2.4 Environmental factors**

This affects the pavement (its design and materials) and creates various damages. Temperature and precipitation are two environmental factors which affects the pavement.

Failures occur due to two factors:

(a) Deficiency of the pavement materials.

(b) Structural in-adequacy of the pavement system.

Deficiency of the Pavement Materials:

- Soft aggregates
- Poor workmanship in joint construction
- Poor joint filler or sealer material
- Poor surface finish
- Improper and insufficient curing

Here are the various defects that creep in due to the causes above:

- Dis-integration of the cement concrete
- Formation of cracking
- Spalling of joints.
- Poor riding surface
- Slippery surface
- Formation of shrinkage cracks
- Ingress of surface water and further progressive failures.

Structural in-adequacy of Pavement System:

Inadequate sub-grade support, less pavement thickness would be major cause of developing the structural cracking in pavements. Following are the causes and types of failure which develop:

- Inadequate pavement thickness
- In-adequate sub-grade support and poor sub-grade soil
- Incorrect spacing of joints.

Above would give rise to the failures of the following types:

- Cracking of the slab corners
- Cracking of the pavement longitudinally
- Settlement of slabs
- Widening of joints
- Mud Pumping.

These are the failure that leads to the formation of above mentioned cracks.

## **II. CONSTRUCTION OF RIGID PAVEMENT**

The construction of the rigid pavement is very unique. The material and equipment are used has been described. These are also helpful in using rigid pavement for the construction of rigid pavement.

### **2.1 MATERIAL**

Cement, coarse aggregate, fine aggregate and water are main materials which are necessary for designing rigid pavement.

Cement, ordinary Portland cement is used. Coarse aggregate, the size of coarse aggregate should not exceed  $1/4^{\text{th}}$  the slab thickness. This should be free from harmful materials such as coal, mica, clay etc. Aggregate used should be as per IS: 383. Recycled concrete aggregate can be used for the construction of base and subbase of concrete rigid pavement [5].

### **2.2 PLANT AND EQUIPMENT**

- Concrete mixture
- Batching device
- Internal vibrators
- Edging tools
- Vibrating screed.

### **2.3 CONSTRUCTION PROCEDURE**

- Preparation of sub grade.
- Placing of forms.
- Batching of materials and mixing
- Transportation and placing of concrete.
- Compaction and finishing
- Curing of cement concrete

## **III. JOINTS AND JOINTING ARRANGEMENT**

Joints are designed to control cracks, prevent entry of unwanted materials in to joints, to afford load which are transfer across the joints. Joints helps to release stresses due to temperature variation, shrinkage of cracks etc. without joints most concrete pavement would be comes in contact with cracks within 1 or 2 years after placement. The various joints provided in rigid pavement are:

- Expansion joint.
- Contraction joint.
- Warping joint.
- Longitudinal joint.

### **3.1 EXPANSION JOINTS**

These are provided along traverse direction. These are provided to allow free expansion of slabs due temperature and moisture variations. These are provided in concrete pavement and other airfield structures. They are also required at in intersection of runway. In India expansion joints are provided in interval of 50 to 60 m [1]. Dowel bar is also provided in expansion joint in order to provide strength at corners.

### **3.2 CONTRACTION JOINT**

To permit the contraction of the slab contraction joints are provided which are caused by shrinkage and temperature fluctuations. These joints are spaced closely. Before paving of contraction joints dowel bar assembly is placed. This assembly are large and helps to transfer a large vehicular load from one slab to another. These are of surface groove type which control cracking and permit accurate shaping of joint. These are used at the end of the paving operation each day. The spacing should be provided in between 2.5-4 m [4].

### **3.3 WARPING JOINTS**

It is also known as hinged joint. These joints are provided to mitigate stresses which occur due to warping. Warping of cement concrete pavement occurs by two conditions, one is warping up and other is warping down. Warping up condition occur in mid night when the bottom slab temperature is more than top slab. Warping down condition occur in mid day when top slab pavement temperature is more than bottom slab. Hence to minimize these stresses this joint is provided.

### **3.4 LONGITUDINAL JOINT**

These joints are provided to prevent longitudinal cracking in the cement concrete pavement. These are helps to maintain the two slab together because this type of joint act as hinge. For hold the adjacent slab together tie bars are provided.

## **IV. CRACKS IN RIGID PAVEMENT**

As concrete is a good and strong material, but it enrooting many cracks due to shrinkage, temperature and creep etc. The main reason of cracks is

- Improper concrete mix
- Improper curing
- Poor joint filler material
- Unequal spacing of joints
- Poor Sub-grade soil
- Pavement thickness is imperfect.
- Use of soft aggregate

But these can be removed easily at the time of their preparation which cannot lead these types of crack to be developed after the construction of pavement. Joints problem can be removed by placing it with help of IRC code 15 2004 and IRC 62 2014. It results in increasing the life span of rigid pavement.

### **4.1 TYPES OF FAILURES**

Increase in vehicular traffic, quality of pavement material and other environmental changes will reduce the utility of pavement which result in the failure and to increase the utility and service life of pavement we should know about the types of crack, its repair techniques and programs.

#### **4.1.1 FATIGUE CRACKING**

Fatigue is a crumble of a material which is done by repeatedly applied load [6]. There are number of factors which devote to fatigue damage of pavement. These factors include heat of hydration, creep, shrinkage etc. At initial stage of concrete, micro cracks are formed and after that it take shape of micro voids when large amount of water dynamically extend under the effect of

loading. Drainage condition is not there which result in cracking while raining because of loading the minor cracks will expand.

#### **4.2.2SHRINKAGE CRACKING**

During setting and hardening of pavement of concrete at places away from joints leads to the formation of hair line cracks which are called as shrinkage cracks. The development of shrinkage cracks normally occur during curing operations. Cracks are formed in longitudinal and transverse direction. Causes of shrinkage cracks are late curtailed of contraction joint, improper design of reinforcement.

#### **4.3.3PUMPING**

Elimination of water and sub grade material through joints and cracks is called pumping. When free water gathers beneath the slab, deflection of pavement slab occur due to which development of cracks take place. This failure does not occur in flexible pavement because this pavement does not create void space under them.

#### **4.4.4SPALLING**

Spalling is defined as breaking or crumbling of the edges of cracks and pavement. Spalling occur when large amount of stresses occur on pavement. This occurs due to poor alignment of dowel bar and also due to poor workmanship.

#### **4.5.5PUNCH OUT**

Crumbling of small section of concrete slab in to several pieces is called punch out. This causes roughness problem and it also allow infiltration of moisture which leads erosion of sub base. Punch out also occur when compaction is not done properly and it also create corrosion problem in steel.The repairing process and method used are very simple and of low cost. This also leads us to use rigid pavement.

#### **4.2.1 REPAIR MATERILS FOR CRACKS**

The material used in crack repair is

- Fibre reinforced concrete.
- Elastomeric concrete.
- Epoxy modified mortar.
- Low viscosity epoxy material.

#### **4.2.2REPAIR METHOD**

##### **4.2.2.1CRACK FILLING**

It is the process of refilling cracks filler in to non active cracks to reduce the trespass of incompressible materials. Low viscosity epoxy materials are used in crack filling.

##### **4.2.2.2CRACK SEALING**

It is the process of refilling cracks filler in to active cracks which helps to reduce the trespass of incompressible material. Crack is sealed by epoxy resin mortar.

##### **4.2.2.3 STITCHING**

This is a repair technique mostly used for longitudinal cracks. The main purpose of stitching is to maintain aggregate interlock. Tie bars are also used in stitching which prevent the cracks. This technique binds the cracked portion of slab together and reduces chances of cracks to grow further. Cross stitching, u-bar stitching, slot stitching are used.

##### **4.2.2.4DIAMOND GRINDING**

It is the removal of thin layer filler of hardened concrete pavement by using closely dispersed diamond blades. It is used to improve the durability of pavement and also used to remove bumps in the newly placed concrete pavement.

## V. CONCLUSION

We come to the point that while designing the rigid pavement it is important to design it as per IRC procedure. It will not only make the construction of the pavement accurate but also reducing the crack of the pavement that have been formed after 6 month or 1 year. It will also affect the life span of the pavement. It will reduce the accident rate that will happen due to oil and grease that has been sometime formed on the road of the flexible pavement. We can reduce the accident by inspecting the pavement at regular interval of time. We can also reduce the cracks that are generated on the road by repairing them. This can be done by inspecting the road at a regular interval of time.

## REFERENCES

- [1] Matti Huhtala, "The effect of wheel loads on pavement," Technical research centre of Finland, 1995, pp. 235-241.
- [2] S. K. Khanna and C. E. G. Justo, "Highway engineering," Ninth edition. Vol. 3, Nem chand and brothers, 2011, pp. 107-145.
- [3] William Van Breement and E. A. Finney, "Design and construction of joint in concrete pavement," Journal of the american concrete, 1950, pp.46-59.
- [4] Taesoon Park, "Application of construction and building debris as base and subbase materials in rigid pavement" Journal of transportation engineering, 2003, pp. 558-563.
- [5] Matti Huhtala, Jari Pihlajamaki and Markku Pienimaki, "Effects of tires and tire pressure on road pavements" transportation research board, 1989, pp. 107-114.
- [6] IRC 62 2014 and IRC 15 2011.