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Flexible pavement

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ABSTRACT

Flexible pavement is a type of pavement in which transmission of load takes place through grain to grain. In India flexible pavements are widely used. It can be constructed with low initial cost but maintenance cost is quite high due to occurrence defects throughout it design life. It consists of four layers and design code for the design of flexural pavement is done by IRC-37. Linear elastic theory is used for analysis of flexible pavement because the loading time on the highways is very short and provides almost an elastic behavior.

Keywords— *Subgrade, Optimum Moisture Content, Flexural Strength, Filler, Maximum Dry Density*

1. INTRODUCTION

The surface of the pavement should be designed so that it offers least possible rolling resistance to the moving traffic. The main objective of a well designed and constructed pavement is to keep elastic deformation of the pavement within permissible limits so that the pavement can sustain a large number of repeated loadings during the design life. Earthwork and pavement constitute a significant part of the cost of a road; hence it is desirable that thorough investigations be done about the availability of soil and other road materials of good quality at economical distance. Generally, the main materials used in highway construction are soil, aggregate and bitumen. These materials together determine the properties of the resultant pavement.

2. TYPES OF PAVEMENT

Pavements are generally classified into two categories on the basis of structural behavior;

2.1 Rigid Pavement

These pavements possess flexural strength and the load transformation takes place by slab action from one layer to another. These are made of Portland cement concrete. Joints are also provided in the construction of rigid pavement and has high completion cost but low maintenance cost. The design code for designing of rigid pavement is done by IRC-58.

2.2 Flexible Pavement

The pavements that have generally very less flexural strength are called flexible pavements. This type of pavements transmits the load to the lower layer by grain to grain contact. A flexible pavement consists of four components as mentioned below-

(a) Soil subgrade
(b) Sub base course
(c) Base course
(d) Surface course

3. HIGHWAY MATERIALS

3.1 Subgrade

It is a layer of soil and the loads on pavement are ultimately received by the soil subgrade. At least 50cm top layer of the subgrade soil is well compacted at optimum moisture content. It helps in providing support to the pavement from beneath. Strength of the soil is dependent on type of soil, moisture content, dry density, internal structure of soil, type of mode of stress application. In order to determine the strength of the soil, shear test (like direct shear test, triaxial test and unconfined compression test), bearing test and penetration test (California bearing ratio test and cone penetration test) are performed.

3.2 Aggregates

They form the major portion of the pavement. They bear stresses due to the wheel loads and also have to resists wear due to abrasion on the surface course. They are used with other binding materials like lime, cement to form compound materials.

3.2.1 Desirable properties of aggregates:

(a) Strength: Aggregate should be strong enough to resist the stresses developed due to traffic load. The aggregates should also have enough crushing strength.

(b) Hardness: The aggregates are subjected to wear due to abrasive action of traffic, therefore it should be hard enough to resist the wear and tear.

(c) Toughness: Since the pavement is subjected to impact loading due to wheel loads, therefore should be tough enough to resist the action of impact loading.

(d) Soundness: The property of aggregate to withstand the adverse actions of weather is known as soundness. Since these are subjected to different weather conditions like rain, high temperature in summers, therefore it is desirable that the aggregates should be sound enough to withstand the weathering actions.

(e) Shape of aggregates: Aggregates can be cubical angular, flaky, elongated. Flaky and elongated shaped particles have relatively less strength and durability in comparison to other shapes of particles. Therefore, it is avoided to use too flaky and too elongated aggregates in the pavements.

In order to decide the suitability of aggregates, different test is conducted like crushing test, impact test, abrasion test, soundness test, shape test, water absorption test and specific gravity test.

(a) Bitumen: Bitumen is a petroleum product obtained by distillation of petroleum crude oil and is it is hydrocarbon material found in gaseous, liquid, semisolid, or solid form. Bitumen is soluble in carbon disulphide (CS_2). The bituminous should not be highly temperature susceptible and in presence of water it should strip off from aggregate. Cutback bitumen is a type of bitumen, obtained when viscosity of bitumen is reduced by volatile diluents while bitumen emulsion is a condition I which bitumen is suspended in an aqueous medium.

Grading of bitumen by VG (Viscosity Gradient):

- **VG-40 (3200 Poise)**
- **VG-30 (2400 Poise)**
- **VG-20(1600 Poise)**
- **VG-10(800 Poise)**

The various test which are used while ascertaining the nature of quality of bitumen are penetration test (hardness of bitumen), ductility test, float test (consistency of bitumen) viscosity test, solubility test (to measure the quantity of impurity present in the bitumen), specific gravity test, softening point test, flash and fire point test, spot test, loss on heating test, water content test.

(b) Tar: it is also a bituminous material but is obtained by the destructive distillation of coal and is soluble in toluene. Tar is less resistant to water and more temperature susceptible. Tar is graded by RT (Road Tar):

- **RT-1** (Used for surface dressing in very cold weather condition)
- **RT-2** (Used for surface dressing under normal climate condition
- **RT-3** (Used for surface dressing and renewal coat)
- **RT-4** (Used for premix tar macadam)
- **RT-5** (Used for grouting)

(c) Mix design: The objectives of mix design are to provide sufficient amount of bitumen to ensure a durable pavement with proper workability for easy placement and provide sufficient voids in the compacted bitumen so that additional compaction can be done by traffic. Constituent of a mix: The mix consists of coarse aggregate, fine aggregate, filler aggregate, filler and binder.

- **Coarse aggregate:** It provides compressive &, shear strength and shows good interlocking properties.
- **Fine aggregate:** They are used to fill up the void created by the coarse aggregate and helps in stiffening the mix.
- **Filler:** It fills the voids in the fine aggregates & provides stiffness.
- **Binder:** It helps in adhesion of the particles together and fills up the mix.

Marshall method, Hubbard- field method, Hveem method, Smith triaxial method are the four methods used for mix designing. But most popularly used method in India is Marshall method.

Steps in mix design:

Step 1: Selection of aggregate
Step 2: Determination of specific gravity
Step 3: Proportioning of aggregate
Step 4: Preparation of specimen
Step 5: Determination of specific gravity on compacted specimen
Step 6: Stability test
Step 7: Selection of optimum binder content

4. PAVEMENT CONSTRUCTION

4.1 Construction of subgrade

Soil/ moorum/ gravel/ mixture of these material is used for preparation of subgrade. The materials should be free from the organic matter as they will decompose with passage of time. Requirements of soil properties for subgrade:

(a) Liquid limit should be less than 50%
(b) Plasticity index should be less than 25%
(c) The soil should be non-expansive

4.2 Construction procedure

Subgrade acts as a foundation to the pavement. The soil is spread evenly and additional water is sprayed in order to obtain optimum moisture content. The water can be sprayed with the help of water tanks. Then the soil is compacted with the help of a Pneumatic tire roller or sheep foot roller. This whole process is repeated until the desired range of compaction is achieved. As per IRC the specified compaction requirement of highway subgrade is 97% in terms of maximum dry density.

4.3 Construction of sub-base course

This layer acts as drainage layer. GSB (Granular sub base) or cement treated soil can be used in one or more layer. GSB is made by crushed stones or gravels or coarse sand or moorum. Requirements of material used for GSB:

(a) The liquid limit should be less than 25%
(b) Plasticity index should be less than 6%

4.4 Construction procedure:

The GSB is spread over the subgrade and followed by compaction with vibratory roller. This process is reported until it reaches 98% of maximum density.

4.5 Construction of Base course

The main function of Base course is to provide load distribution. The preparation of Base course can be done by WMM (Wet mix macadam) or by WBM (Water bound macadam). WMM consists of a well graded hard crushed aggregates and an adequate proportion of water mixed

thoroughly in a mixing plant. The prepared WMM is spread over the sub-base course and is then compacted by vibratory roller.

WBM consists of coarse aggregates, screenings and binding materials. WBM is prepared, the coarse aggregates are spread and compacted by vibratory roller. The dry screening is done in order to fill the voids and water is then sprinkled over the surface accompanied by rolling again.

4.6 Bituminous course

(a) Prime coat: It is the first application of low viscous liquid bituminous material over an existing porous pavement surface. The main objective of priming is to plug the capillary void of porous surface and to bond the loose mineral particles on existing surface Since it has to penetrate into capillary voids, therefore only low viscous binders should be used. Tar, MC/SC cutbacks, low viscous bitumen tar is used.

(b) Tack coat: It is the application of bituminous material over existing pavement surface which is relatively impervious like an existing bituminous surface. This coating provides bond between two layers.

(c) Seal coat: It is used as a top coat over bituminous pavement and can also be provided over worn out existing bituminous pavement. Seal coat serves two main purposes, firstly it seals the surface against action of water and second it helps in providing skid resistance texture.

(d) Surface dressing: It is provided over an existing pavement to serve as thin wearing coat. The single coat surface dressing consists of single application of binder material followed by spreading of aggregate and rolling. Surface dressing helps in protecting the base course and makes the pavement dust free.

(e) Penetration macadam: in this the coarse aggregates are first spread and compacted well in dry state and then hot bituminous binders of relatively high viscosity is sprayed in fairly large quantity at top. The bitumen penetrates into voids from the surface of compacted aggregate and fill up a part of void and binds aggregate together.

(f) Premixed method: in this method the aggregate and bituminous binders are mixes thoroughly before spreading and compacting. It is possible to coat each particle of aggregate with binder but still quantity of bitumen used less than penetration macadam.

5. DEFECTS IN PAVEMENT

Various types of failure in pavement ranging from minor and localized failure to major and general failure do take place. By early detection and repair of defects at initial stages, the rapid deterioration of the pavement can be prevented and preventive maintenance measures. Some of defects are mentioned below along with their symptoms and causes:

5.1 Surface defects

(a) Fatty surface

Symptoms: Bitumen binder moves upward and collected as a film of bitumen.

Causes: Presence of excessive binder in premix or excessively heavy axle load.

(b) Smooth surface

Symptoms: the pavement becomes slippery and offer very low skid resistance.

Causes: The main cause of smooth surface is excessive binder.

(c) Hungry surface

Symptoms: Loss of aggregate takes place and fine cracks are developed.

Causes: less amount of bitumen must have been used in surfacing.

5.2 Cracks

(a) Alligator crack

Symptoms: inter-connected cracking forming a series of small blocks.

Causes: excessive deflection of surface and brittleness of binder.

(b) Longitudinal crack

Symptoms: development of crack in a line between two lanes or at the edges.

Causes: it may occur due to lack of lateral support and poor drainage.

(c) Reflection cracks

Symptoms: cracks over joints and cracks in the pavement underneath.

Causes: due to joints and cracks in the pavement layer underneath.

5.3 Deformation

(a) Slippage

Symptoms: It is due to the relative movement between the surface layers.

Causes: inadequate prime coat or coat tack coat.

(b) Shoving

Symptoms: localized bulging of pavement surface

Causes: Due to lack of stability in the mix.

5.4 Disintegration

(a) Stripping

Symptoms: Separation of bitumen adhering to the surface of aggregate.

Causes: Inadequate mix composition and continuous contact with water.

(b) Raveling

Symptoms: failure of binder to hold the aggregates.

Causes: it occurs due to inadequate compaction, construction during cold weather and insufficient binder in the pavement.

(c) Pot holes

Symptoms: Bowl shaped holes are formed on the pavement surface.

Causes: Water into the pavement through the surface course.

6. CONCLUSION

Construction of flexible pavement requires a thorough study of the materials which are to be used. Since it consists of four layers and each layer requires different material properties. Selection of materials and proper compaction at optimum moisture content is required, otherwise it may lead to different types of defects and will ultimately increase the maintenance cost.

Proper analysis of the causes of defects should be kept in mind in order to make a high quality pavement with a higher service span.

7. REFERENCES

[1] Hofstra, A.,and Klomp, A.J.P. Permanent Deformation of Flexible pavement under simulated Road traffic conditions, Proceedings, Third International Conference on the structural design of Asphalt pavements, Vol-I, London, 613-621. 1972 .

[2] Sousa, J.B., Craus, J. and Monismith, C. L., (1991). Summary report on permanen Deformation in Washington, University of California.

[3] P. Sikdar, S. Jain, S. Bose, P. Kumar, "Premature Cracking of Flexible Pavements," Journal of Indian Roads Congress, 1999, 355 – 398.

[4] W. Woods, A. Adcox, "A GeneraCharacterization of Pavement System Failures, with Emphasis On a method for selecting a repair process" Journal of Construction Education, 2004, 58 – 62.

[5] A. Ahmed, "Pavement Distresses Study: Identification and Maintenance (case study)," M.Sc. thesis, University of Sudan, 2008.

[6] Mr. Etikala Nagaraju 2015. "Pavement Rehabilitation and Maintenance", International Journal of Civil Engineering (SSRJ – IJCE), Volume 21, Issue 6, PP. 38 – 40.

[7] Magdi M.E. Zumravi 2015. "Survey and Evaluation of Flexible Pavement Failures", International Journal of Science and Research (IJSR), Volume 4, Issue 1, PP. 1602-1607.

[8] Sharad S. Adlinge, A.K. Gupta (2013). "Pavement Deterioration and its Causes", International Journal of Innovative Research and Development (IJIRD). Volume 2, Issue 4, PP. 9 – 15.

[9] Caltrans 2001. "Flexible Pavement Rehabilitation Manual", California Department of Transportation, Sacramento, CA.

