PAVEMENT DESIGN

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ABSTRACT- ***Highway and pavement design plays an important role in the DPR projects. The satisfactory performance of the pavement will result in higher savings in terms of vehicle operating costs and travel time, which has a bearing on the overall economic feasibility of the project. This paper discusses about the design methods that are traditionally being followed and examines the "Design of rigid and flexible pavements by various methods & their cost analysis by each method".***

Flexible pavement are preferred over cement concrete roads as they have a great advantage that these can be strengthened and improved in stages with the growth of traffic and also their surfaces can be milled and recycled for rehabilitation. The flexible pavements are less expensive also with regard to initial investment and maintenance. Although rigid pavement is expensive but have less maintenance and having good design period. The economic part is carried out for the design pavement of a section by using the result obtains by design method and their corresponding component layer thickness. It can be done by drawing comparisons with the standard way and practical way. This total work includes collection of data analysis various flexible and rigid pavement designs and their estimation procedure are very much useful to engineer who deals with highways.

I.INTRODUCTION

The transportation by road is the only road which could give maximum service to one all. This mode has also the maximum flexibility for travel with reference to route, direction, time and speed of travel. It is possible to provide door to door service only by road transport .Concrete pavement a large number of advantages such as long life span negligible maintenance, user and environment friendly and lower cost. Keeping in this view the whole life cycle cost analysis for the black topping and white topping have been done based on various conditions such as type of lane as single lane, two lane, four lane different traffic categories deterioration of road three categories.

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub- grade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This gives an overview of pavement types, layers and their functions, cost analysis. In India transportation system mainly is governed by Indian road congress (IRC).

To design the road stretch as a flexible pavement by using different flexible methods like group index method, C.B.R. method as per IRC: 37-2001, tri axial method California resistance value method, and as a rigid pavement as per IRC: for the collected design upon a given black cotton soil sub grade and to estimates the construction cost of designed pavement by each method. To propose a suitable or best methods to a given condition or problem.

II.LITERATURE REVIEW

C.E.G. Justo et.al States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter (m^3) of BC mix. Modified Bitumen improves the stability or strength, life and other desirable properties of bituminous concrete mix.

Dr. R. Vasudevan states that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased Softening point and decreased Penetration value with a suitable ductility. When it used for road construction it can withstand higher temperature and load. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution and so on.

V.S. Punith et al (2001), some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction

Sabina et al (2001) studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by wt of bitumen) with conventional bituminous concrete mix (prepared with 60/70 penetration grade bitumen). Improvement in properties like Marshall Stability, retained stability, indirect tensile strength and rutting was observed in Plastic modified bituminous concrete mixes

III.PAVEMENT DESIGN PROCESS

Preliminary Pavement Design:

A preliminary pavement design needs to be performed during the early phase of project development. This step ensures that a viable design is generated, balancing risk while ensuring adequate funding rather than allowing the project cost to dictate the pavement design. Preliminary design considerations are then discussed at a district level Pavement Design Concept Conference.

Pavement Design Standard Operating Procedure (SOP):

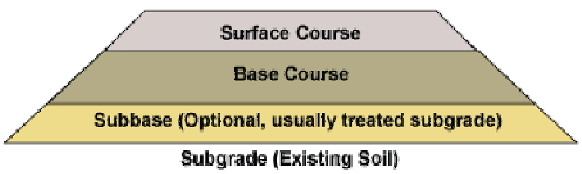
Communication between the district pavement engineer, planning staff, maintenance staff, construction staff and area engineers is key to designing, constructing, and maintaining quality pavements. District Engineers are responsible for ensuring this communication takes place and documenting communication channels in a district pavement design standard operating procedure

(SOP).this SOP should be reviewed and updated annually.

Types of pavements:

Flexible Pavements:

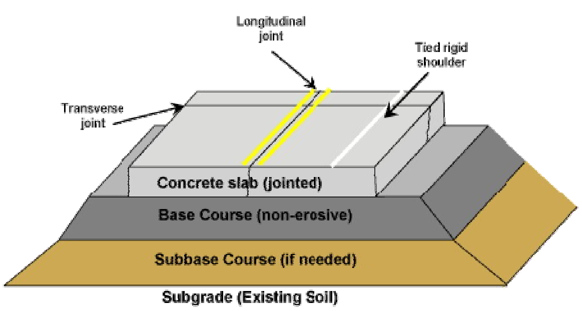
A flexible pavement structure is typically composed of several layers of material with better quality materials on top where the intensity of stress from traffic loads is high and lower quality materials at the bottom where the stress intensity is low. Flexible pavements can be analyzed as a multilayer system under loading.



Cross section for flexible pavements

Rigid Pavement

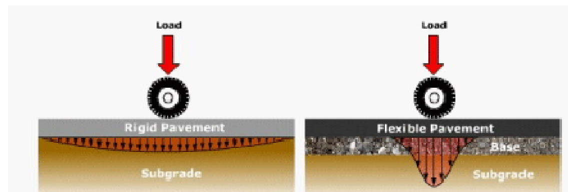
A rigid pavement structure is composed of a hydraulic cement concrete surface course and underlying base and sub base courses (if used). Another term commonly used is Portland cement concrete (PCC) pavement, although with today's pozzolanic additives, cements may no longer be technically classified as "Portland."



Cross section of rigid pavements

Rigid and Flexible Pavement Characteristics:

The primary structural difference between a rigid and flexible pavement is the manner in which each type of pavement distributes traffic loads over the sub-grade. A rigid pavement has a very high stiffness and distributes loads over a relatively wide area of sub-grade – a major portion of the structural capacity is contributed by the slab itself.



Typical stress distribution under a rigid and a flexible pavement

IV DESIGN AND COST ANALYSIS OF FLEXIBLE AND RIGID PAVEMENTS

Design Methods:

Design of Flexible Pavement by Group Index Method:

In order to classify the fine grained soils within one group and for judging their suitability as sub grade material, an indexing system has been introduced in HRB classification which is termed as Group Index. Group Index is function of percentage material passing 200 mesh sieve (0.074mm), liquid limit and plasticity index of soil and is given by equation: (0.074mm) . Liquid limit and plasticity index of soil and is given by equation:

$$GI=0.2a+0.005ac+0.01bd$$

a=portion of material passing 0.074mm sieve, greater than 35 and not exceeding 75%

b=portion of material passing 0.074mm sieve, greater than 15 and not exceeding 35%

c =value of liquid limit in excess of 40 and less than 60

d =value of plasticity index exceeding 10 and not more than 30

California Resistance Value Method:

F.m Hakeem and R.M.Carmany in 1948 provided design method based on stabilometer R-value and cohesiometer Computer- value. Based on performance data it was established by Hveem and Car many that pavements thickness varies directly with R value and logarithm of load repetitions. It varies inversely with fifth root of Computer value. The expression for pavement thickness is given by the empirical equation.

$$T = K\,(TI)\,(90-R)/C1/5$$

Here T=total thickness of pavement, cm

K=numerical constant=0.166

TI=traffic index

R=stabilometer resistance value

C =Cohesiometer value

Design of Flexible Pavement by California Bearing Ratio Method:

Traffic- CV/Day Annual traffic census 24 X 7:

For structural design, commercial vehicles are considered. Thus vehicle of gross weight more than 8 tones load are considered in design. This is arrived at from classified volume count.

Wheel loads:

Urban traffic is heterogeneous. There is a wide spectrum of axle loads plying on these roads. For design purpose it is simplified in terms of cumulative number of standard axle (8160 kg) to be carried by the pavement during the design life. This is expressed in terms of million standard axles or msa.

Design Traffic

Computation of design Traffic In terms of cumulative number of standard axle to be carried by the pavement during design life.

$$N = \frac{365\,A\,[(1+r)n-1]}{r} \times F \times D$$

Where

N = the cumulative number of standard axles to be catered for in design in terms of million standard axles msa.

A = Initial traffic in the year of completion of construction duly modified as shown below.

D = Lane distribution factor

F = Vehicle damage factor, VDF

n = Design life in years

r = Annual growth rate of commercial vehicles {this can be taken as 7.5% if no data is available}

Tri axial Method: L.A.Palmer and E.S.Barber in 1910 proposed the design method based on Boussinesq's displacement for homogeneous elastic single layer: The thickness of pavement.

$$T = \sqrt{(3P/2\Delta\pi Es)}.^{2}\,a^{-2}$$

Here

T=Pavement thickness, cm

Es=modulus of elasticity of sub grade from tri axial test result, Kg/cm2

A=radius of contact area, cm

Δ=design deflection (0.25 cm)

Cost comparision of rigid pavement:

The rigid pavement is designed as per IRC 58-2002. The CBR 3 % is considered for the design which corresponds to an effective k value of 8 kg/cm3 over 100 mm DLC as given in IRC58-2002. Cumulative Cost per Km (2-lane 7m wide) of 100 mm Dry Lean Concrete and 150 mm Drainage layer below the slab in rigid pavements are 32.00 lakhs.

Table: 1 Unit cost of new pavement alternatives

Sl. No	Pavement	t cm	Concrete Quantity /Km, m3	Rate per m3 of concrete, Rs	cost /Km, Rs, in lakhs
1	M1	32	2240	4353.00	129.50
2	M2	31	2170	3355.00	104.80

Note: inclusive of cost of 100 mm Dry Lean Concrete and 150mm Drainage layer below the slab in rigid pavements

V DATA COLLECTION AND ITS ANALYSIS:

Investigation of plastic waste materials aggregates and bitumen requires various field test and lab tests as explain in previous chapter. This chapter presents material which is collected from site given below for plastic coated aggregates in detail. The present chapter divided into three main sections. First section presents the physical requirement of aggregates and bitumen. Second section presents the properties of plastic. Third section presents the preparation plastic waste materials for shredding on aggregates.

Aggregates:

The aggregates are bound together either by bituminous materials or by cement. In a few cases, the rock dust itself when mixed with water forms slurry which acts as a binding medium. The aggregates may be classified into natural and artificial aggregates. The natural aggregates again are classified as coarse aggregates consisting of crushed rock aggregates or gravels and fine aggregates or sand.

Table 2: Physical requirements of coarse aggregates

Sl.No	Test	Permissible value
1	Abrasion Test a. Using Los Angeles machine (max) b. Aggregates impact test (max)	 35% 30%
2	Stripping test (max)	25%
3	Water absorption (except in the case of slag) max	1%
4	Soundness test: Loss with sodium sulphate 5 cycles (in case of slag only) max	12%
5	Weight unit or Bulk density (in slag only)	1120 per m^3

Aggregate: Aggregate of 20mm, 10 mm, Stone Dust and Lime as Filler

Bitumen: Bitumen is used as binders in pavements constructions. Bitumen may be derived from the residue left by the refinery from naturally occurring asphalt. As per definition given by the American Society of Testing Materials bitumen has been defined as “Mixtures of hydrocarbons of natural or pyrogenous origin, or combination of both, frequently accompanied by their non-metallic derivatives, which may be gaseous, liquid, semi-solid or solid, and which are completely soluble in carbon disulphide.”

Road Tar: This bituminous material is obtained by the destructive distillation of organic matters such as wood, coal shale etc. In the process of destructive distillation, the carbonation results in the production of crude tar which is further refined by distillation process.

Cut-back bitumen: The asphaltic bitumen is very often mixed with comparatively volatile solvents to improve the workability of the material. The solvent gets evaporated leaving behind the particles together. This cutback bitumen is classified into slow, medium and rapid curing depending upon the type of solvent used.

Emulsions: An emulsion is a mixture of normally two immiscible liquids. Asphalt gets broken up into minute globules in water in the presence of the emulsifiers. It improves the workability of bitumen or asphalt. As a result of emulsification, asphalt is available at normal temperature in the liquid form.

Bitumen: 60/70, 80/100 grade bitumen.

Test methods:

Bitumen:

1. Penetration test:

Penetration of a bituminous material is the distance in tenths of millimeter that standard needle will penetrate vertically into a sample under standard conditions of temperature, load and time.

2. Ductility of bitumen:

This test is done to determine the ductility of distillation residue of cutback bitumen, blown type bitumen and other bituminous products as per IS: 1208 – 1978.

3. Softening point:

Softening point is the temperature at which the substance attains a particular degree of softening under specified conditions of test.

4. Flash and fire point test:

This test method covers determination of the flash and fire point of all petroleum products except fuel oils and those having an open flash cup below 79 °C.

5. Viscosity test:

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress.

Aggregates:

1. Aggregate impact value:

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963.

2. Aggregate crushing value:

The aggregate crushing value gives a relative measure of the resistance of an aggregate crushing under gradually applied compressive load. With aggregate crushing value 30 or higher' the result may be anomalous and in such cases the ten percent fines value should be determined instead.

3. Los angels abrasion value:

The los angle (L.A.) abrasion test is a common test method used to indicate aggregate toughness and abrasion characteristics. Aggregate abrasion characteristics are important because the constituent aggregate in HMA must resist crushing, degradation and disintegration in order to produce a high quality HMA.

4. Specific gravity and water absorption test:

The specific gravity of an aggregate is considered to be a measure of strength or quality of material. The specific gravity test helps in the identification of stone.

Water absorption gives an idea of aggregate. Aggregate having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength impact and hardness tests.

VI RESULTS AND ANALYSIS

Results of Tests on Bitumen:

Table3: Observations for Tests on Bitumen

Test	Result	Ranges
Ductility Test	77.50 cm	Min 40
Penetration value	63 mm	60-70mm
Viscosity value	50.1 sec	-
Softening Point	48.25°C	45-600C
Flash Point Test	280°C	>65°-175°C
Fire Point Test	302°C	

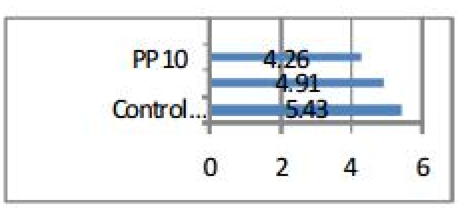
Results of tests on aggregates

Table 4: Observations for Tests on aggregates

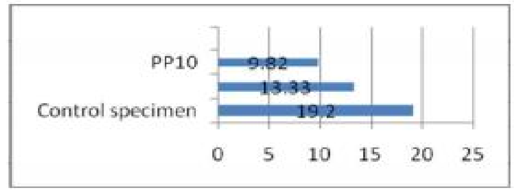
Percentage of Plastic	Moisture Absorption (%)	Aggregate Impact Value (%)	Aggregate Crushing Value (%)	Los Angeles Abrasion Value (%)	Specific Gravity	Stripping Value (%)
Control Specimen	1.7	5.43	19.2	13.42	2.45	8%
PP8	Nil	4.91	13.33	10.74	2.7	Nil
PP10	Nil	4.26	9.82	9.41	2.85	Nil

Comparison of Tests Results:

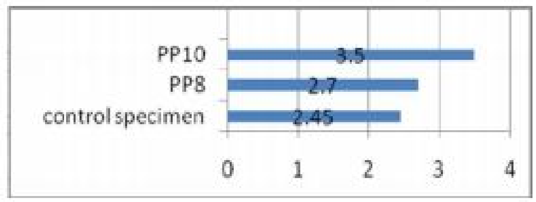
Graph 1:Comparison of Aggregate Impact Value Test Results



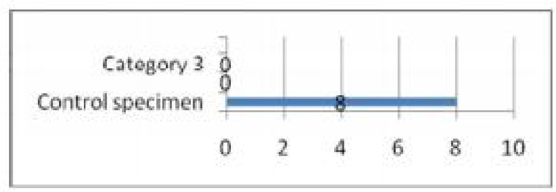
Graph 2: Comparison of Aggregate Crushing Value Test Results



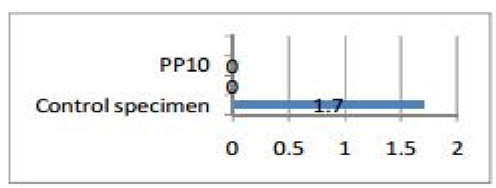
Graph 3:Comparison of Specific Gravity Test Results



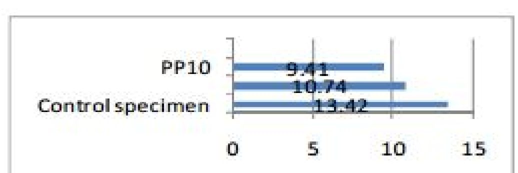
Graph 4: Comparison of Stripping Value Test Results



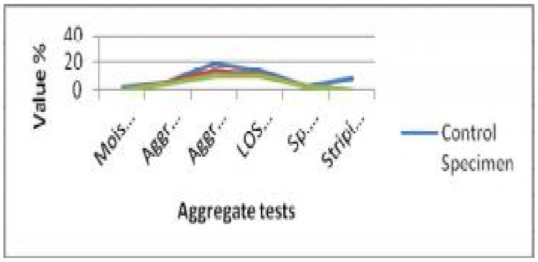
Graph 5 :Comparison of Water Absorption Test Results



Graph 6 : Comparison of Los Angeles Test Results



Graph 7:Comparison of Aggregate Test results



VII CONCLUSIONS

1. The pavement is designed as a flexible pavement upon a black cotton soil sub grade, the CBR method as per IRC 37-2001 is most appropriate method than available methods.

2. The pavement is designed as a flexible method from which each method is designed on the basis of their design thickness from which each method has different cost analysis of a section, from which CBR as per IRC is most appropriate in terms of cost analysis.

3. The pavement is designed as a rigid pavement; the method suggested by IRC is most suitable. It is observed that flexible pavements are more economical for lesser volume of traffic. The life of flexible pavement is near about 15 years whose initial cost is low needs a periodic maintenance after a certain period and maintenance costs very high.

4. The life of rigid pavement is much more than the flexible pavement of about 40 year's approx 2.5 times life of flexible pavement whose initial cost is much more then the flexible pavement but maintenance cost is very less.

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