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DESIGN OF FLEXIBLE AND RIGID PAVEMENTS BY VARIOUS METHODS

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Abstract: Pavements are required for the smooth, safe and systematic passage of traffic. Pavements are generally classified as flexible and rigid pavements. Flexible pavements are those which have low flexural strength and are flexible in their structural action under loads. Rigid pavements are those which possess noteworthy flexural strength and flexural rigidity.

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 are carried out for the design pavement of a section by using the result obtain by design method and their corresponding component layer thickness.

In our project we are calculating thickness of flexible pavement by comparing various design methods such as, Group Index method (GI), California Bearing Ratio method (CBR), California Resistance Value Method, Tri axial method is done and rigid pavement was done by Indian Road Congress method (IRC). From this design method maximum thickness is adopted for the construction of flexible pavement.

I INTRODUCTION

For economic and efficient construction of highways, correct design of the thickness of pavements for different conditions of traffic and sub-grades is essential. The science of pavement design is relatively new.

In India, previously road crust was designed on some rational data but more on the experience of the road engineer. Some arbitrary thicknesses of the pavements were used which lead to costly failures and wastage as in some cases, the thickness of pavements was insufficient and in the other cases expensive. As there are no proper design criteria, the construction of roads was more or less uneconomical in almost all cases.

Hence judicious method of designing and calculating the crust thickness on the basis of estimation of traffic loads and bearing capacity of sub-grade etc.., will lead to economical construction of roads.

Types of pavements:

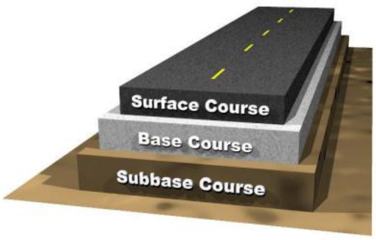
Based on the structural behavior, pavements are generally classified into the following three categories:

1. Flexible pavement
2. Rigid pavement
3. Semi-rigid pavement.

Flexible pavements

Flexible pavements are those which are flexible in their structural action under the loads. Some important features of these pavements are:

1. It has no flexural strength,
2. It reflects the deformation of lower layers,
3. It will transmit the vertical compressive stress to bottom layers by grain to grain transfer,
4. The lower layer have to take up only lesser magnitudes of stress and there is no direct wearing action due to traffic loads, therefore inferior materials with low cost can be used in the lower layers.

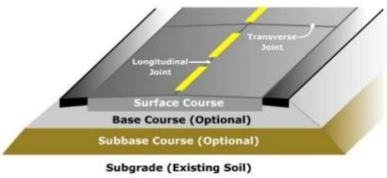


Flexible pavement

Rigid pavement

Rigid pavements are those which possess note worthy flexural rigidity. It possesses flexural strength. Load transfer is by the way of slab action and it distributes the wheel load to a wider area below

1. Flexural stresses will be developed due to wheel load temperature changes
2. Tensile stresses will be developed due to bending action of the slab under the wheel load
3. It does not deform to the shape of lower layer, but it bridges the minor variations of the lower layer.



Rigid pavement

Semi - rigid pavement:

When bonded materials like pozzolanic concrete, lean concrete or soil cement are used, then the pavement layer has considerably high flexural strength than the common flexible pavement is called a semi-rigid pavement. These materials have low resistance to impact and abrasion and are therefore used with flexible pavement surface course.

2. LITERATURE SURVEY

Panchadi Manoj Kumar[1], B.Praveen babu[2] et al,. (2016) The country has witnessed tremendous increase in the vehicle population and increased axle loading pattern during the last decade, leaving its road network overstressed and leading to premature failure. The type of deterioration present in the pavement should be considered for determining whether it has a functional or structural deficiency, so that appropriate overlay type and design can be developed. Structural failure arises from the conditions that adversely affect the load carrying capability of the pavement structure. Inadequate thickness, cracking, distortion and disintegration cause structural deficiency

Ganesh Borude[1], Vijaykumar Bhusare[2], Yogesh Surywanshi[3] et al,. (2017)

In this project work represent that behavior of the flexible and rigid pavement under static pressure and transient loading by using finite element analysis. After that assigning the suitable material properties and support condition analysis is done.

From the study we concluded that the Static pressure applied on flexible and rigid pavement The deformation in flexible pavement is 50- 60% more than rigid pavement due to applied pressure. When pressure is applied on both the pavement i.e rigid and flexible pavement it has been observed that the stresses generated in rigid pavement is 30-35% greater than flexible pavement. rigid pavement under transient loading.

3. METHODS USED FOR DESIGNING OF PAVEMENTS

I. 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

Here,

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

b=that portion of material passing 0.074mm sieve, greater than 15

And not exceeding 35%

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

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

II. 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

3. Design Of Flexible Pavement By California Bearing Ratio Method

The following sub sections describe the various variables and parameters involved in design of flexible pavement of road as per IRC 37 - 2001.

Traffic- CV/Day Annual traffic census 24 X 7

For structural design, commercial vehicles are considered. Thus vehicle of gross weight more than 8 tonnes 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.

$$\sqrt{\left(\frac{3P}{2\Delta\pi E}\right)2 - a2}$$

Here

T=Pavement thickness, cm

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

A=radius of contact area, cm

Δ=design deflection (0.25 cm)

4. DESIGN OF PAVEMENTS

a) Group index method

GI = (F-35)0.2+0.05(WL -40)+0.01(F-15)(IP-10) =17.35

So Pavement Thickness =700mm

Thickness of Surface Course =35mm

Thickness of DBM =145mm

Thickness of Base Course=200mm

Thickness of Sub Base=320mm.

b) California Resistance Value Method

Pavements thickness is given by the empirical equation:-

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

Calculation:

TI = 1.35(EWL)0.11

TI=1.35(32729750)0.11

TI=9.66

T=K(TI)(90-RC)/C1/5

T=0.166(9.66)(90-44)611/5

T=730 mm

So Pavement Thickness =730mm

Thickness Of Surface Course =35mm

Thickness Of DBM =145mm

Thickness Of Base Course=210mm

Thickness Of Sub Base=340mm

c) Design of flexible pavement by cbr

1. Initial Traffic in the Year of Completion of Construction

   A = P x (1 +r) x

   Where:

   A = Traffic in the year of completion of construction CV/ Day

   P = Traffic at last Count April 2013

   r = Annual growth rate of traffic

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x = Number of years between the last census and the year of completion of construction

A =1001 x (1 + 0.075) x1 1076 CV / Day

(As per Clause 3.3.4.4 Table 1 of IRC -37 -2001)

2. Vehicle Damage Factor =3.5Standard Axle per CV
3. Design Calculation

Initial traffic in design lane = Initial traffic x Distribution factor

= 1076 x 0.75 = 807.05 CVPD

N = [365 x {(1+r) x - 1} x A x F] / r

=365 x [{(807(1 +0.075)^10-1}x3.5]/0.075 = 14.58 msa

Say 15.00 msa

4. Total Pavement Thickness for design C.B.R. = 660 mm

(As per Plate - 2 of IRC-37-2001)

The thickness of individual component layers of flexible pavement by CBR method is given below:

So pavement thickness =660mm

Thickness of surface course =40mm

Thickness of DBM =70mm

Thickness of base course=250mm

Thickness of sub base=300mm.

d) Tri axial method

The thickness of pavement.

$$\sqrt{(\frac{3P}{2\Delta\pi E})2 - a2}$$

Here

T=Pavement thickness, cm

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

A=radius of contact area, cm

∆=design deflection (0.25 cm)

DATA :

Wheel load=4100Kg

Radius of contact area=15cm

Traffic coefficient=1.5

Rainfall coefficient=1.0

Design deflection=.25cm

E-value of sub grade soil Es=100 Kg/cm2

E-value of base course material Eb =400kg/cm2

CALCULATIONS:

T= √(3*4100/2*100)2-152

T=740 mm

So Pavement thickness=740mm

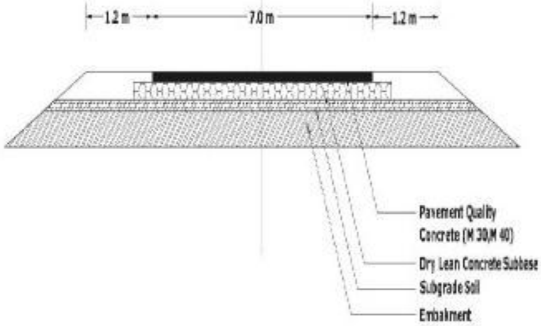
Thickness of surface course =35mm

Thickness of DBM =145mm

Thickness of base course=210mm

Thickness of sub base=350mm

e) Design of Rigid Pavement Data:



Width of expansion joint gap=2.5cm

Maximum variation in temperature between summer and winter=13.10c

Thermal coefficient of concrete=10*100C

Allowable tensile stress in CC during curing=0.8Kg/cm2

Coefficient of friction=1.5

Unit weight of CC=2400kg/cm3

Design wheel load=5100Kg

Radius of contact area=15Cm

Modulus of reaction of sub base course=14.5Kg/cm3

Flexural strength of concrete =45Kg/cm2+

E value of concrete=3*105Kg/cm2

∆ Value =0.15

Design load transfer through dowel system=40%

Permissible flexural stress in dowel bar=1400Kg/cm2

Permissible shear stress in dowel bar=1000Kg/cm2

Permissible bearing stress in concrete =100Kg/cm2

Permissible tensile stress in steel=1400Kg/cm2

Permissible bond stress in deformed tie bars=24.6Kg/cm2

Present traffic intensity=4100 commercial vehicles/day (Data collected by traffic survey)

(Note: The data assumed based on IRC-58:2002)

SLAB THICKNESS

Assume trial thickness of slab=20cm

Radius of relative stiffness,

I=[$Eh^3/12K(1-\mu^2$]1/4

=[3*105*203/12*14.5(1-0.152)]1/4

L=61.28
Lx/I=445/95.41 =4.66
Ly/I = 350/95.41 =3.66(according to I.R.C.Chart)
Adjustment for traffic intensity
Ad =P' (1+r)(n+30)
Assuming growth rate =75 %
Number of year after the last count before new pavement is opened to traffic n =3
Ad =4100 (1+ (7.5/100))(3+30)
=44592.6 CV/day
So traffic intensity being in the range >4500,
Fall in group and the adjustment factor =+2cm
So revised design thickness of the slab =20+2 =22 cm.

Cost comparison

Flexible pavements

S. No	Method Used	Cost for construction of 3Km road in Rs
1	Group Index	1394451.45
2	California Resistance Value method	1442136.15
3	California Bearing Ratio method	1412085.15
4	Tri axial method	1449648.9

Rigid pavements

S. No	Method Used	Cost for construction of 3Km road in Rs
1	Group Index	1444406.04

5. CONCLUSIONS

1. In this project work, an attempt is made to incorporate latest techniques of geometric design, pavement design for a road for an existing colony which 2 km away from Car Shed Junction, P.M.Palem. The IRC specifications are based on rational thinking, the proposed road is safe in both geometrics as well as pavement design.
2. It is also proposed to design a flexible pavement by Group Index method and CBR method. Some more methods are available in the design of flexible pavement, which are much advanced like California resisting value method, Mc leod method, Triaxial method and Burnister method. Because of the limitations of time and scope, only GI method and CBR method are adopted.
3. To have a practical concept of estimation analysis, an attempt is made to estimate the quantities of earth work of flexible pavement

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