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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.

1. 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 sped 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).

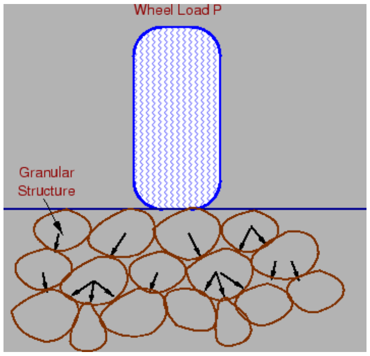
The main objective of this study is to develop a strategy to select the most cost efficient pavement design method to carried out for a sections of a highway network and also to identify the cost analysis of different pavement design methods. Prioritization based on Subjective Judgment, Prioritization based on Economic Analysis To develop a strategy for to select the most appropriate method to be carried out for design of a highway network. Analysis of data for a highway network problem to illustrate the proposed strategy and Interpretation of the results obtained..

Types of pavements

The pavements can be classified based on the structural performance into two, flexible pavements and rigid pavements. In flexible pavements, wheel loads are transferred by grain-to-grain contact of the aggregate through the granular structure. The flexible pavement, having less flexural strength, acts like a flexible sheet (e.g. bituminous road). On the contrary, in rigid pavements, wheel loads are transferred to sub-grade soil by flexural strength of the pavement and the pavement acts like a rigid plate (e.g. cement concrete roads). In addition to these, composite pavements are also available. A thin layer of flexible pavement over rigid pavement is an ideal pavement with most desirable characteristics. However, such pavements are rarely used in new construction because of high cost and complex analysis required.

Flexible pavements

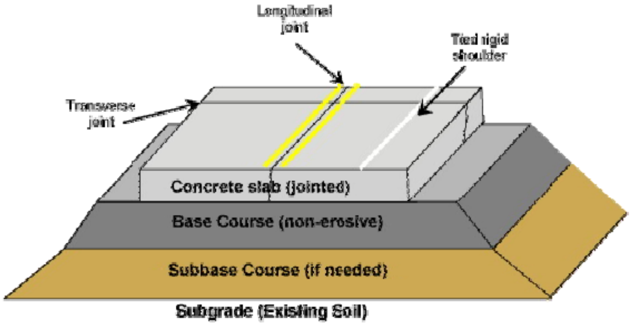
Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure.



Load transfer in granular structure

Rigid Pavement

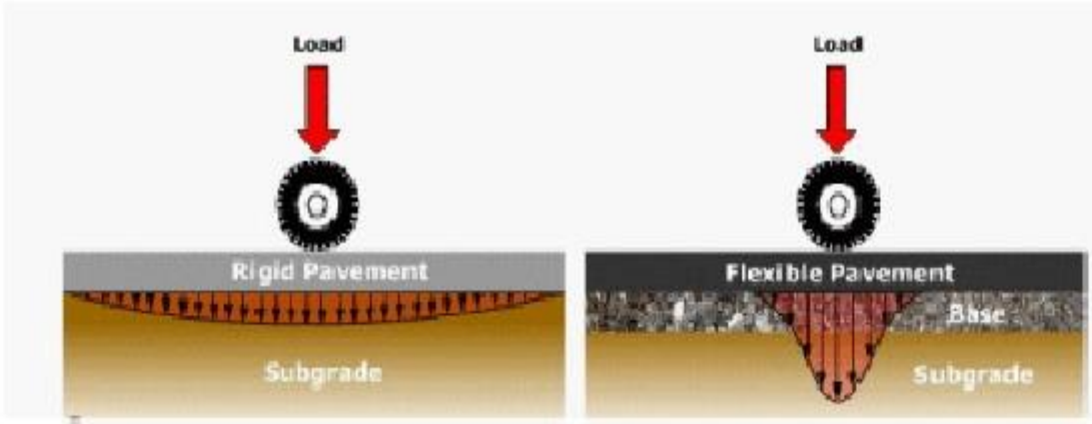
A rigid pavement structure is composed of a hydraulic cement concrete surface course and underlying base and sub base courses (if used). Another term commonly used is Portland cement concrete (PCC) pavement, although with today's pozzolanic additives, cements may no longer be technically classified as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

Design of flexible and rigid pavement

The structural capacity of flexible pavements is attained by combined action of the different layers of the Pavement. The load is directly applied on the wearing course and it gets dispersed with depth in the base, sub-base and sub-grade layers and then ultimately to the ground. Since the stress induced by traffic load is highest at the top, the quality of top and upper laye materials is better. The sub-grade layer is responsible for transferring the load from above layers to the ground. Flexible pavements are designed in such a way that the load transmitted to the sub-grade does not exceed its bearing capacity. Consequently, the thickness of layers Would vary with CBR of soil and it would affect the cost of the pavement.

Typical Cross-section of a flexible pavement

The thickness design of a flexible pavement also varies with the amount of traffic. The range of variation in Volume of commercial vehicles at different highways has direct effect on the repetitions of the traffic loads. The damaging effect of different axle loads is also different The Indian Roads Congress method of flexible pavement design uses the concept of ESAL for the purpose of flexible pavement design and the same has been used in this study also.

Design of flexible pavement

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.
Or
GI= (F-35) 0.2+0.05(WL -40) +0.01(F-15) (IP-10)
DATA:

F	=	66%
WL	=	55%
IP	=	31%
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

California Resistance Value Method

F.m Hakeem and R.M. Carmany in 1948 provided design method based on stabile meter Rvalue and cohesion meter 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=stabile meter resistance value
C = Cohesio meter value

The annual value of equivalent wheel load (EWL) here is the accumulated sum of the products of the constant and the number of axle loads .The various constant for the different number of axles in group are given below

Number of axles	EWL Constant(Yearly basis)
2	330
3	1070
4	2460
5	4620
6	3040

DATA
K =0.166, TI =9.66, R = 44, C =61
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.

Design Of Rigid Pavement

A rigid pavement is constructed from cement concrete or reinforced concrete slabs. Grouted concrete roads are in the category of semi-rigid pavements. The design of rigid pavement is based on providing a structural cement concrete slab of sufficient strength to resists the loads from traffic.

Layers in 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
Δ 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= [Eh3/12K(1- μ2])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

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.
4. It is observed that flexible pavements are more economical for lesser volume of traffic.
5. 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.
6. The life of rigid pavement is much more than the flexible pavement of about 40 years 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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