A Study of Design and Methods of Rigid and Flexible Highway Pavements

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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.*

Keywords: Design Flexible Pavement, Design Rigid Pavement, Cost Analysis, Estimation.

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). Various grades of concrete under similar condition of traffic and design concrete road are found to more suitable than bituminous road. Since the whole life cycle cost comes out to be lower in the range of 30% to 50% but for roads having traffic less than 400cv/day and road is in good condition, the difference between whole life costs of both the road is very less. The initial cost of concrete overlay is 15% to 60% more than the flexible overlay. To design the road stretch as a flexible pavement by using different flexible methods like group index method, CBR method as per IRC: 37-2001, Triaxial 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. The main objective is to develop a strategy to select the most cost efficient pavement design method to carry out for 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. Transportation has been one of the essential components of the civil engineering profession since its early days. From time immemorial, the building of roads, bridges, pipelines, tunnels, canals, railroads, ports, and harbors has shaped the profession and defined much of its public image. As cities grew, civil engineers became involved in developing, building, and operating transit facilities, including street railways and elevated and underground systems. The role of civil engineers is to providing transportation infrastructure to accommodate a growing population. 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. Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load commuting upon it. Pavement grants friction for the vehicles thus providing comfort to the driver and transfers the traffic load from the upper surface to the natural soil. In earlier times before the vehicular traffic became most regular, cobblestone paths were much familiar for animal carts and on foot traffic load. Pavements are primarily to be used by vehicles and pedestrians. Storm water drainage and

environmental conditions are a major concern in the designing of a pavement. The first of the constructed roads date back to 4000 BC and consisted of stone paved streets or timber roads. 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. The roads of the earlier times depended solely on stone, gravel and sand for construction and water was used as a binding agent to level and give a finished look to the surface. All hard road pavements usually fall into two broad categories namely flexible Pavement. Flexible pavements are most commonly used for low to medium volume roads with significant usage also found in high volume interstate highways and airfield runways, taxiways and aprons subjected to heavy aircraft gear/wheel loads. As the demand for applied wheel loads and number of load applications increases, it becomes very important to properly characterize the behavior of sub grade soils and unbound aggregate layers as the foundations of the layered pavement structure. 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. The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth.

TRAFFIC DATA (WHEEL LOAD, TRAFFIC VOLUME):

An accurate estimate of the traffic that is likely to use the project road is very important as it forms the basic input in planning, design, operation and financing. A thorough knowledge of the travel characteristics of the traffic likely to use the project road as well as other major roads in the influence area of the study corridor is, therefore, essential for future traffic estimation. Hence, detailed traffic surveys were carried out to assess the present day traffic and its characteristics.

- **Temperature Data:** Generally temperature in this given region varies from 200 to 450 C.
- **Design Speed Data:** Pavement is designed for a speed of 100 km/hr as per IRC.
- **Soil Sub Grade Data for flexible pavement:**

C.B.R of soil sub grade	=	5%
Modulus of sub grade Reaction K value	=	2.94 Kg/cm2
Liquid limit	=	55%
Plastic limit	=	24%

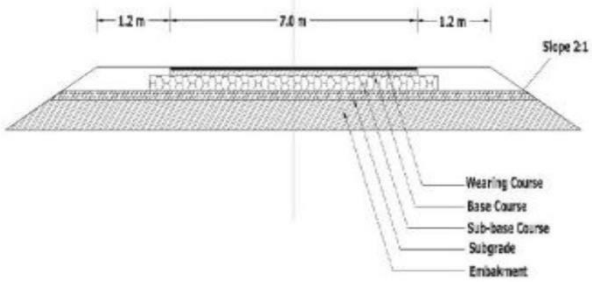
Plasticity index (PI)	=	31%
O.M.C	=	25%
Standard proctor density (gr. /cc)	=	1.61 gm/cc

- **Soil Sub Grade Data for rigid pavement:**

CBR of soil sub grade	=	5%
Modulus of sub grade Reaction K-DLC of sub-base	=	14.4Kg/cm2

DESIGN AND COST ANALYSIS:

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 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 STRATEGY AND 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

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.

- **California Resistance Value Method:** This design method based on stabilometer R-value and cohesiometer Computer value. Based on performance data it was established many 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

COST ANALYSIS:

The estimated costs of flexible pavement in different methods are given below:

S.No.	METHODS	ESTIMATED COST (Rs)
1.	Group Index Method	15822515.00
2.	CBR Method	14909074.00
3.	California Resistance Value Method	16134971.00
4.	Tri axial Method	16186485.00

By observing the above result of pavement by using different flexible and rigid methods, the difference in total thickness and individual component layers are not much. However by close observation the results of CBR method are slightly more because of poor CBR value of sub grade .But in the other method the CBR value of sub grade is not considered ,only soil properties like liquid limit ,plastic limit, shrinkage limit, grain size distribution of sub grade soil are considered GI method, modulus of sub grade from triaxial test are considered in

triaxial method, the resistance value of sub grade, expansion pressure, exudation pressure at different moisture content of sub grade soil are considered in California resistance value method. Similarly modulus of sub grade reaction is considered in rigid pavement design. The total pavement thickness required is determined using the design charts with the different value of msa (million std. axles).The IRC has also suggested the minimum thickness of the pavement component layers of sub base, base course and surfacing and the combination of various range of cumulative std. axles. So this method is more conviently and widely used in fields due to its relevant simplicity and the appropriate value of different component layers. Now days this method is more popular for design of flexible pavements. But the flexible pavements are design for period of 15 years so the periodical maintenance is much more when compared with rigid pavements. Another advantage of rigid pavements is it design for a period of 30 years which is doubled the life of flexible ,comparatively less maintenance and better quality of riding surface and other advantages. While looking into the economics, the flexible pavement methods there is not big difference in cost but in the CBR the cost is little bit low because of its low total thickness comparatively with other methods .Similarly in rigid pavement the cost is very high than the flexible pavement. But the rigid pavement is having long life, better riding surface visibility, less maintenance etc advantage. So the rigid pavements are widely used in the present road works. Also in flexible pavement always preference is given to CBR Method.

CONCLUSION:

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. 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. 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. 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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