**REVIEW PAPER ON FLEXIBLE AND RIGID PAVEMENT**

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***ABSTRACT***

Transportation contributes to the economic, industrial, social and cultural development of any country. Transportation is vital for the economic development of any region since every commodity produced whether it is food, clothing, industrial products or medicine needs transport at all stages from production to distribution. It provides movement of passengers and goods from one place to another place. Main modes of transportation in our country are Roadways. Railways, Waterways, and Airways. Out of these, roadways allow movement of about 85% of passengers and 70% of goods because it is nearest to the people and also provides flexibility for movement of vehicles.

Pavements are generally classified into two categories based on the structural behavior:
- Flexible Pavement

- Rigid Pavement

***Keywords:-*** *industrial development, flexible pavement, rigid pavement, California bearing ratio, village road*

**INTRODUCTION**

The literature review is a summary of previous research on a topic. The literature review surveys scholarly articles, books, and other sources relevant to a particular area of research or interest. Within the review the author provides a description, summary and critical evaluation of each source, i.e, the strengths and weaknesses. The literature review may also identify gaps or controversies in the literature and topics needing further research. Also, literature reviews are important because they help you learn important authors and ideas in your field. This is useful for your coursework and your writing. Knowing key authors also helps you become acquainted with other researchers in your field.

 **LITERATURE REVIEW**

Khan (1998) describes the Group Index Method and California Bearing Ratio Method for design of flexible pavements. In Group Index Method the thickness is obtained by first determining the Group Index value of the soil. The curves are plotted between Group Index of subgrade and thickness of the pavement for various traffic conditions. In California Bearing Ratio Method, the curves are plotted between California Bearing Ratio percent and depth of construction.
Hadi and Arfiadi (2001) state that the design of rigid pavements involves assuming a pavement structure then using a number of tables and figures to calculate the two governing design criteria, the flexural fatigue of the concrete base and the erosion of the sub-grade/sub- base. Each of these two criteria needs to be less than 100%. The designer needs to ensure that both criteria are near 100% so that safe and economical designs are achieved. This paper presents a formulation for the problem of optimum rigid road pavement design by defining the objective function, which is the total cost of pavement materials, and all the constraints that influence the design. A genetic algorithm is used to find the optimum design. The results obtained from the genetic algorithm are compared with results obtained from a Newton-Raphson based optimization solver.

Arora (2003) has reported that the Westergaard's analysis is used for design of rigid pavements. The stresses in the concrete slab are determined using Westergaard's theory. Westergaard considered the rigid pavement as a thin elastic plate resting on soil subgrade. The upward reaction at any point is assumed to be proportional to the deflection at that point. The slab deflection depends upon the stiffness of the subgrade and the flexural strength of the slab. Thus the pressure-deformation characteristics of a rigid pavement depend upon the relative stiffness of the slab and the subgrade.

MORTH Standard Data Book (2003) for Analysis of Rates for Road and Bridge Works published by Indian Roads Congress (IRC), was first brought out by MORTH in 1994 and the revised in June 2003, reprinted in September 2003 and September 2004. The rates have been analyzed using mechanical means. Manual means for certain items have also been provided which can be used for areas inaccessible to machines and for small jobs. The rates of all items include element of setting out and carrying out the work in narrow or part width of road, where directed, Mode of measurements shall be as per provisions contained in the relevant clauses of the specifications unless specified otherwise. The rates include the element of hire and running charges of all types of plant, machinery and equipment required to complete the work unless specified otherwise. Royalty, duty and all other taxes are included in the rates.

Darestani [et.al](http://et.al/) (2006) state that the 2004 edition of Austroads rigid pavement design guide has been based on the work of Packard and Tayabji which is known as the PCA method. In this method, a number of input parameters are needed to calculate the required concrete base thickness based on the cumulative damage process due to fatigue of concrete and erosion of sub base or subgrade materials. This paper reviews the 2004 design guide, introduces design software specially developed to study the guide and highlights some important points. Results of the current study show the complex interdependence of the many parameters.

**GENERAL**

The IRC: 37-2001 was based on a Mechanistic Empirical approach, which considered the design life of pavement to last till the fatigue cracking in bituminous surface extended to 20 per cent of the pavement surface area or rutting in the pavement reached the terminal rutting of 20 mm, whichever happened earlier. The same approach and the criteria are followed in these guidelines as well, except that the cracking and rutting have been restricted to 10 per cent of the area for design traffic exceeding 30 msa. These guidelines aim at pavement design by including alternate materials like cement and reclaimed asphalt materials, and subjecting them to analysis using the software IITPAVE, a modified version of FPAVE.

The Guidelines recommend that the following aspects should be given consideration while designing to achieve better performing pavements:

i. Incorporation of design period of more than fifteen years.

ii. Computation of effective CBR of subgrade for pavement design.

iii. Use of rut resistant surface layer.

iv. Use of fatigue resistant bottom bituminous layer.

v. Selection of surface layer to prevent top down cracking.

vi. Use of bitumen emulsion/foamed bitumen treated Reclaimed Asphalt Pavements in base course.

vii. Design of drainage layer.

viii. Design of drainage layer.

ix. Computation of equivalent single axle load considering (a) single axle with single wheel (b) single axle with dual wheels (c) tandem axle and (d) Iridem axles.

x. Design of perpetual pavements with deep strength bituminous layer

 Traffic

 General

* The recommended method considers design traffic in terms of the cumulative number of standard axles (80 kN) to be carried by the pavement during the design life. Axle load spectrum data are required where cement bases are used for evaluating the fatigue damage of such bases for heavy traffic. Following information is needed for estimating design traffic:
1. Initial traffic after construction in terms of number of Commercial Vehicles per day (CVPD).

 2. Traffic growth rate during the design life in percentage.

 3. Design life in number of year.

 4. Spectrum of axle load.

 5. Vehicle Damage Factor (VDF).

 6. Distribution of commercial traffic over the carriageway.

* Only the number of commercial vehicles having weight of 30 KN or more and their axle- loading is considered for the purpose of design of pavement.
* Assessment of the present day average traffic should be used on seven-day-24-hour count made in accordance with IRC: 9-1972, "Traffic Census on Non-Urban Roads".

 Traffic Growth rate

* The present day traffic has to be projected for the end of design life at growth rates ('r') estimated by studying and analyzing the following data:
1. The past trends of traffic growth; and
2. Demand elasticity of traffic with respect to macro-economic parameters (like GDP or SDP) and expected demand due to specific developments and land use changes to take place during design life.
* If the data for the annual growth rate of commercial vehicles is not available or if it is less than 5 per cent, a growth rate of 5 per cent should be used (IRC SP:84-2009).

 Design Life

* The design life is the defined in terms of the cumulative number of standard axles in misa that can be carried before a major strengthening, rehabilitation or capacity augmentation of the pavement is necessary.
* It is recommended that pavement for National Highways and State Highways should be designed for a minimum life of 15 years. Expressways and Urban Roads may be designed for a longer life of 20 years or higher using innovative design adopting high fatigue bituminous mixes. In the light experience in India and abroad, high volume roads with design traffic greater than 200 msa and perpetual pavement can also be designed using the principles stated in guidelines. For other categories, a design life of 10-15 years may be adopted.
* If stage construction is adopted, thickness of granular layer should be provided for the full design period. In the case of cemented bases and sub-bases, stage construction may lead to early failure because of high flexural stresses in the cemented layer and therefore, not recommended.

 Vehicle Damage Factor

* The guidelines use Vehicle Damage Factor (VDF) in estimation of cumulative msa for thickness design of pavement.
* The vehicle damage factor is a multiplier to convert the number of commercial vehicle of different axle loads and axle configuration into the number of repetitions of standard axle load of magnitude 80 kN. It is defined as equivalent number of standard axle per commercial vehicle. The VDF varies with the vehicle axle configuration and axle loading.
* The equations for computing equivalency factor for single, tandem and tridem axles given below should be used for converting different axle load repetitions into equivalent standard load repetitions. Since the VDF values in AASHO Road Test for flexible and rigid pavements are not much different, for heavy duty pavements, the computed VDF values are assumed to be same for bituminous with cemented and granular bases.

Single axle with single wheel on either side =(axle load in kN/65)4

Single axle with dual wheels on either side =(axle load in kN/80)4

Tandem axle with dual wheels on either side =(axle load in kN/148)4

Tridem axles with dual wheels on either side =(axle load in kN/224)4

Distribution of Commercial Traffic Over the Carriageway

Distribution of commercial traffic in cach direction and in cach lane is required for determining the total equivalent standard axle load applications to be considered in the design. In the absence of adequate and conclusive data, the following distribution may be assumed until more reliable dala on placement of commercial vehicles on the carriageway lanes are available:

A. Single-lane roads

 Traffic tends to be more channelized on the single-lane roads than two-lane roads and to allow for this concentration of wheel load repetitions, the design should be based on total number of commercial vehicles in both directions.

B. Two-lane single carriageway roads

 The design should be based on 50 per cent of the total number of commercial vehicles in both directions. If vehicle damage factor in one direction is higher the traffic in the direction of higher VDF is recommended for design.

C. Four-lane Single carriageway roads

 The design should be based on 40 per cent of the total number of commercial vehicles in both directions.

D. Dual carriageway roads

 The design of dual two-lane carriageway roads should be based on 75 per cent of the number of commercial vehicles in each direction. For dual three-lane carriageway and dual four lane carriageway, the distribution factor will be 60 per cent and 45 per cent respectively.

* Where there is no significant difference between traffic in each of the two directions, design traffic for each direction may be taken as half of the sum of traffic in both directions. Where significant difference between the two streams exists, pavement thickness in each direction can be different and designed accordingly.
* For two way two lane roads, pavement thickness should be same for both the lanes even if VDF values are different in different directions and designed for higher VDF. For divided carriageways, each direction may have different thickness of pavement if the axle load patterns are significantly different.

 **CONCLUSIONS**

The dissertation entitled "Economy of Flexible and Rigid Pavements with variation in Subgrade strength and Traffic" has been taken up with the view to study the effect of CBR and design traffic on the cost of flexible and rigid pavements. The pavements have been designed for a two lane carriageway of width 7.5m assumed to be located in Kurukshetra, Haryana. The CBR of existing ground has been varied from 4% to 10% and design traffic on the road has been varied from 2msa to 150msa to determine its effects on the thickness of the pavement and ultimately on the cost of the pavement.

The main conclusions drawn from the study are:

The thickness of Flexible Pavement decreases gradually with increase in the value of CBR from 4% to 10%.

There is no significant variation in the thickness of Rigid Pavement with increase in Subgrade strength from 4% to 10%.

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