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# Designing of Flexible Pavement for IET Lucknow, Using Group Index Method

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A B S T R A C T

The GI method for constructing flexible pavement comprises measuring the several levels of pavement, such as the surface course, base course, sub base, and sub grade. This work proposes the use of the GI method to build flexible pavements, with the practical approach of defining liquid limit, plasticity index, and water content. Certain materials in the form of admixtures are added to improve the index qualities. As a result, the inclusion of admixtures will increase the flexibility of the pavement. Transportation is critical to human civilization's advancement. The root by which we can readily connect two areas is the road. India has the second-longest road network in the world, with a total length of 4,320,899 kilometers. National highways, expressways, state highways, and other district roads are included..

Keywords:Flexible pavement, Group index, Liquid limit, Plasticity index, Plastic limit, Water content, Surface layer, Base coarse, Subbase, Selected layer, Subgrade

## 1INTRODUCTION

The only method to provide maximum services to all resources is to use road transportation. It offers door-to-door delivery. Flexible Pavement has a number of advantages, including cost, ease of repair, resistance to deformation induced by freezing and thawing, and the ability to detect flaws quickly. From top to bottom, flexible pavement is made up of four layers: surface course, base course, sub-base, and sub grade. Sub-grade can be continued indefinitely. Flexible pavement is made up of a wearing surface that sits on top of the base course and is supported by sub-grade. The load transmission method in this pavement is grain to grain load transfer. Asphalt concrete-based surface courses are utilized all over the world.
Different approaches for designing flexible pavement include the Group Index (GI) method, California Bearing Ratio (CBR) method, and Triaxial method.

Fig1. This Photois of Flexible pavement IET Lucknow.

The few techniques of arranging system for adaptable asphalt GI approach are Burminster's style system, connection method, ND strategy, and American State bearing quantity. Burminster's design process is based on the concept of a two-layer system. In flexible pavement, the Burminster approach allows for a 5mm deflection.
Since 1947, the Missouri State Highway Department has employed a design method based mostly on group index and heavy traffic to estimate total thickness to suggest for flexible pavements.

## 2.LITERATURE REVIEW

For the design of flexible pavements, Khan (1998)[1] explains the Group Index Method and the California Bearing Ratio Method. The thickness is determined using the Group Index Method by first determining the soil's Group Index. For varied traffic situations, the curves between Group Index of Subgrade and thickness are plotted.

Various approaches for designing flexible pavements have been presented by Arora (2003)[2]. The Group Index Method, CBR Method, California Resistance Value Method, and McLeod Method are among the different ways. The thickness of the base and surface is connected to the volume of traffic in the Group Index Method.

Stresses in homogenous mass, elastic deformation under circular load, and Burmister analysis for flexible pavement have all been published by Punmia et al (2005)[3]. Vertical deflection charts have been created. The design curves were created using the Group Index Method and the California Bearing Ratio Method. The curves between Group Index and thickness are plotted in the Group Index Method. Curves between thickness of building and California Bearing Ratio are plotted in the California Bearing Ratio Method.

A case study for multilayer pavement structural analysis utilizing equivalent thickness methods is discussed by Subagio et al. (2005)[4]. By converting the structure into an analogous one-layer system with equivalent thicknesses of one elastic modulus, an approximate approach for calculating stresses and strains in multilayer pavement systems has been established. The approach of equivalent thickness presupposes that the stresses and strains beneath a layer are determined by the stiffness of that layer.

Das (2008)[5] uses a mechanisticempirical-approach to examine dependability challenges in bituminous pavement design. Variabilities in pavement design input parameters are considered, and the reliability of a specific pavement is calculated using both simulation and analytical methods for several proposed failure definitions. By using a mechanistic empirical pavement design approach, a methodology for designing bituminous pavements for a specific degree of overall reliability has been proposed.

(2015)[8] Sudan-Friendly Flexible Pavement Design The goal of this study is to produce a viable road pavement design approach for Sudan based on international and regional (Kenya) standards. A review of international and regional codes of practice literature was conducted. The recommended design method was designed based on the benefits and drawbacks of these codes. A software was also created in Visual Basic to improve the method's efficiency. A study case of particular highways in Khartoum state was designed utilizing this new method of design to validate the correctness of this new method of design.
According to the findings, this proposed approach is more suited to Sudanese conditions. Finally, conclusions and suggestions for the practical use of the new method were drawn.

[9] Flexible Pavements and Climate Change: An Overview and Implications (2019)
Climate and flexible pavements are inextricably linked. Pavements are climate-sensitive infrastructure, as the rate of deterioration, subsequent maintenance, and life-cycle costs are all affected by the weather. Meanwhile, climate mitigation measures are urgently needed to lessen the macroclimate and microclimate impacts of pavements and related mobility. To adapt to changing climates and lessen environmental consequences, current pavement design and life cycle management procedures may need to be updated. This paper presents the results of a comprehensive review of recent qualitative and quantitative pavement research on climate change. Climate stressors, pavement performance susceptibility to climatic elements, climate change impacts on pavement systems, and, most critically, issues of climate change adaptation, mitigation, and interconnections are all included. This document is valuable for people who want to learn more about or conduct research on flexible pavements' climate resilience.

## METHODOLOGY[6]

Before we design a flexible pavement using the Group Index Method, it's important to understand what we're doing. What is the definition of flexible pavement? A real flexible pavement responds to traffic loading "elastically." It is built atop one or more unbound foundation courses lying on a subgrade with a bituminous-treated surface or a relatively thin layer of hot-mix asphalt (HMA). Flexible pavement design using the Group Index approach is an empirical method based on the physical features of the soil sub-grade.

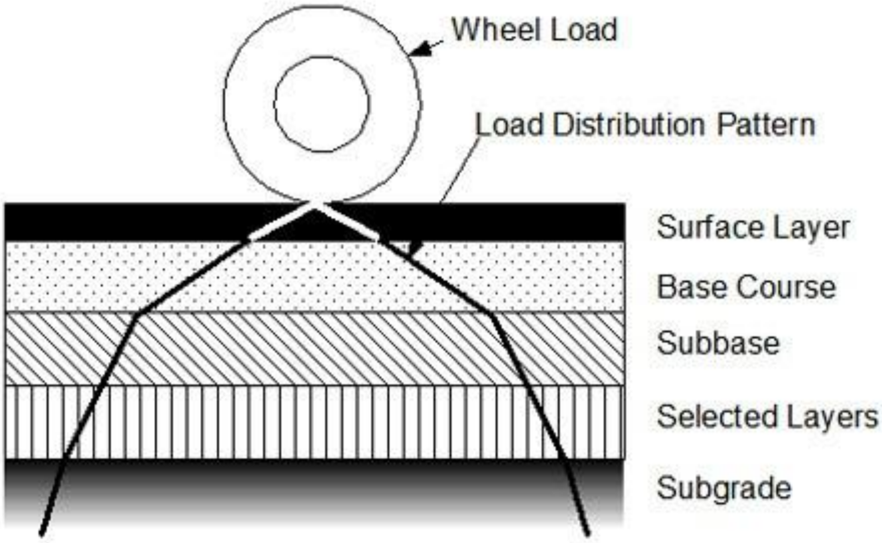


Fig.2 Cross section of flexible pavement with wheel load

**Determination of Group Index Value of Soil Subgrade**[7]

The Group Index of a soil is determined by its physical qualities such as particle size, liquid limit, and plastic limit. It ranges from 0 to 20, with a lower number indicating higher sub-grade quality and a larger value indicating inferior sub-grade quality. From the equation below, we may determine the Group index value of the soil subgrade using a sieve analysis test.

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

Where, a= percentage of soil passing 0.074 mm sieve in excess of 35 per cent, not exceeding 75. b= percentage of soil passing 0.074 mm sieve in excess of 15 per cent, not exceeding 55. c= Liquid limit in per cent in excess of 40. d= Plasticity index in excess of 10.

## Group Index Method of Flexible Pavement Design

***Data Required for Flexible Pavement Design***

*1. Group index of soil subgrade* Group index value range of different soils is given below

- For good soil – 0 to 1
- For fair soil – 2 to 4
- For poor soil – 5 to 9
- For very poor soil – 10 to 20

*2. Traffic volume* It is the measure of Annual average daily traffic, peak-hour traffic. It is denominated by commercial vehicles/day or CVPD. It is classified in three categories. Based on number of vehicles per day. If no. of vehicles per days is

- <50 - light traffic
- 50-300 - medium traffic
- >300 - Heavy traffic

***Flexible Pavement Design Procedure:***

Before going to design the pavement we must know the structure of flexible pavement

*Calculation total thickness (T):* From the below chart for given group index of soil subgrade and traffic volume value select appropriate thick curve value of "combined thickness of surface, base and sub-base line" which will give the total thickness of pavement.

(Note: thick line indicates the total thickness value and the dotted line indicates thickness of surface and base)

*Calculation thickness of sub-base course ($t_{sb}$):* From the below chart for given group index of soil subgrade select appropriate curve value of "thickness of sub base only" which will give the thickness of the sub-base course. The curve highlighted in below diagram

*Calculation of thickness of base and surface course ($t_b$ &$t_s$):* Thickness of surface and base course = total thickness – sub-base thickness

$$= T - t_{sb} \qquad \text{EQUATION 1}$$

The combined value of thickness of base and surface course can be found out from above chart form dotted curve with the help of group index value and traffic volume. Or otherwise assume the thickness of surface course ($t_s$) = 5 cm Then we can easily calculate the value of thickness of the base course,

$$T_b = T - t_{sb} - t_s \qquad \text{EQUATION 2}$$

*Cross section of flexible pavement:*The group index method is essentially an empirical method based on the physical properties of the subgrade soil and it does not consider the strength characteristics of soil and is therefore open to question regarding its reliability.

***EXAMPLE:***

The Indian Road Congress is in charge of the country's transportation sector (IRC).

Under similar traffic and design conditions, several grades of concrete have been proven to be more suited than bituminous roads. Since the total life cycle cost is lower by 30% to 50%, the difference between the total life costs of both roads is relatively small for roads with traffic less than 400cv/day and in good condition. The initial cost of a concrete overlay is 15% to 60% higher than the cost of a flexible overlay.

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

The primary goal of this research is to devise a strategy for selecting the most cost-effective pavement design approach for a portion of a highway network, as well as to determine the cost analysis of various pavement design methods. Prioritization based on subjective judgment vs. economic analysis Develop a strategy for selecting the best appropriate method for highway network planning. Data analysis and interpretation for a highway network challenge in order to demonstrate the proposed method.

## TRAFFIC DATA (MAX WHEEL LOAD, TRAFFIC VOLUME DAILY&HOURLY)

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 = 45%
Plastic limit = 20%
Plasticity index (PI) = 25%
O.M.C = 25%
Standard proctor density (gm/cc) = 1.61 gm/cc

**DESIGN AND COST ANALYSIS OF FLEXIBLE AND RIGID PAVEMENTS**

The combined action of the multiple layers of the Pavement achieves the structural capability of flexible pavements. The load is given directly to the wearing course, and it is spread with depth in the base, sub-base, and sub-grade layers, eventually reaching the earth. Because the tension caused by traffic load is greatest at the top, the top and upper layer materials are of higher grade. The sub-grade layer is in charge of transferring load from the upper layers to the ground. Flexible pavements are built so that the load transmitted to the sub-grade does not exceed the bearing capability of the sub-grade. As a result, the thickness of the layers would vary depending on the CBR of the soil, affecting the cost of the pavement.

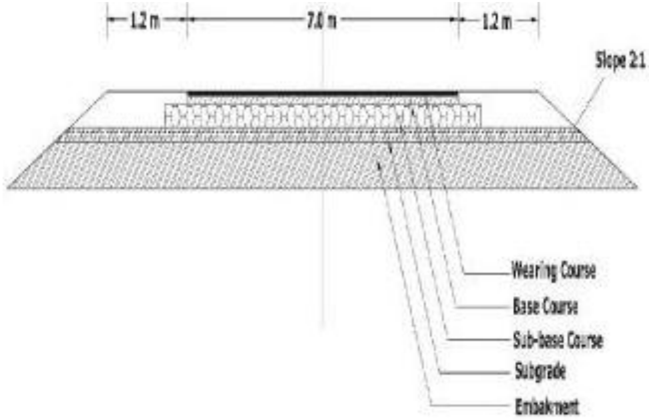


Fig.3.Typical Cross-section of a flexible pavement

The thickness of a flexible pavement fluctuates depending on the amount of traffic it receives. The range of variation in commercial vehicle volume on different roadways has a direct impact on traffic load repeats. Various axle loads have different detrimental effects. The Indian Roads Congress technique of flexible pavement design employs the notion of ESAL for the purpose of flexible pavement design, and this study does as well.

***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

Or

GI= (F-35) 0.2+0.005(WL -40) (F-35) + 0.01(F-15) (IP-10) …………EQUATION 3

**DATA:**

F =60%

WL=45%

IP =25%

GI = (F-35)0.2+0.005(WL -40) (F-35) + 0.01(F-15) (IP-10)

=12.375

Finally,

Pavement Thickness =670mm

Thickness of Surface Course =35mm

Thickness of DBM =150mm

Thickness of Base Course=280mm

Thickness of Sub Base=205mm

## CONCLUSION

1. Our observation shows that designing of flexible pavements are more economical than rigid pavement for lesser volume of traffic.
2. The repair of the flexible pavements are much easier as compared to rigid pavements.
3. Rutting and other faults can be easily detected and thus accidents due to these failures can be reduced.
4. Lesser use of machineries because of which requirement of manpower increases which generates more employment.
5. The design period of flexible pavement is generally 15 years and it requires time to time maintenance.
6. The construction cost is low but the maintenance cost is quite high.
7. Flexible pavement needs no joint unlike rigid pavement, hence reducing the bumps in the pavement, which is advantageous for vehicles.
8. The cracks developing due to freezing and thawing are minimized.
9. Load bearing capacity is high due to grain-to-grain transfer of load, thus it can be used to carry heavy load vehicles resulting in its use at Airports.
10. During the construction period of flexible pavement, the diversions of route is for lesser duration as compared to rigid pavement.
11. In case of emergency, we can allow the traffic to move the under-construction road but we can not allow the movement of vehicles for under construction road of rigid pavement.
12. The thickness of rigid pavement is less than the flexible pavement.
13. The heat generation in tyres at rigid pavement is so high, but the heat generation in flexible pavement is low. For example the rate of accidents at Yamuna expressway is much higher due to bursting of tyres.

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