Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 7, No. 3, July : 2023

A FLEXIBLE PAVEMENT DESIGN FOR AN EXISTING COLONY

Pritam Prakash Research Scholar, Department of Civil Engineering, SOET, K.K. University, Bihar
Prof. **Deepak Kumar** Assistant Professor, Department of Civil Engineering, SOET, K.K. University, Bihar

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 note worthy flexural strength and flexural rigidity. The profound development in the automobile technology has resulted heavy moving loads on the existing highways for optimization of the transport cost. The existing roads which are designed based on the thumb rules are not able to cater to the heavy wheel loads resulting in the deterioration of the existing roads. In the paper, an attempt is made to design a road at Biharsarif, based on the principles of pavement design. On the existing alignment of the road, soil samples are collected for the determination of soil characteristics like consistency limits, sieve analysis, C.B.R. values etc.., Based on this the thickness of the pavement (flexible) is designed. The alignment of the road is also designed and fixed by surveying and leveling. The total road length being 497 metersof which, one section is 247m, other is 200m and the third section is 50m.

Keywords— *Flexible Pavement, Design Existing Colony, Systematic Passage of Traffic, Flexural Strength.*

INTRODUCTION OF PAVEMENTS

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 pavementdesign is relatively new. In India, previously road crust was designed on some rational data but more on theexperience 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. The surface of a pavement should be stable and non-yielding, to allow the heavy wheel loads of the road traffic to move with least possible rolling resistance. The road should be even along the longitudinal profile to enable the fast vehicles to movesafely and comfortably at the design speed. A pavement layer is considered more effective or superior, if it is able to distribute the wheel load stress through a larger area per unit depth of the layer. The elastic deformation of the pavement should be within the permissible limits, so that the pavement can sustain a large number of repeated load applications during the design life. It is always desirable to construct the pavement well above the maximum level of the ground water to keep the sub-grade relatively dry even during monsoons. At high moisture contents, the soil becomes weaker and soft and starts yielding under heavy wheel loads, thus increasing the tractive resistance.

LITERATURE REVIEW

Flexible pavements are preferred over cement concrete roads as they have a greatadvantage 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 results obtained by design method and their corresponding component layer thickness.

Saurabh Jain, Dr. Y. P. Joshi, S. S. Goliya- This paper discusses about the designmethods that are traditionally being followed and examines the “Design of rigid and flexible pavements by various methods & their cost analysis by each method”

D. S. V. Prasad and G. V. R. Prasada Raju - This paper investigates the performance of flexible pavement on expansive soil sub grade using gravel/flyash as sub base course with waste tyre rubber as a reinforcing material. It was observed that from the laboratory test results of direct shear and CBR, the gravel sub base shows better performance as compared to flyash sub base with different percentages of waste tyre rubber as reinforcing material. Cyclic load tests are also carried out in the laboratory by placing a circular metal plate on the model flexible pavements. It was observed that the maximum load carrying capacity associated with less value of rebound deflection is obtained for gravel reinforced sub base compared to flyash reinforced sub base.

A "Proposal of alignment and pavement design for a newly built up colony"- by J.B.S. Bharathi et al In this project an attempt is made to design a model road for a newly built up colony based on the modern principles of pavement design. On the existing alignment of the road, soil samples are collected for the determination of soil characteristics like consistency limits, sieve analysis, C.B.R values, etc. Based on this, the thickness of the pavement(flexible) is designed. The alignment of the road is also designed and fixed by surveying and levelling.

TYPES OF PAVEMENTS

(i) Flexible Pavement- Pavements that are flexible in their structural response under loads are known as flexible pavements. Some important features of these pavements are:

- It has no flexural strength,
- It exhibits lower layers' distortion.,
- Grain to grain transfer will be used to convey the vertical compressive stress to the bottom layers.
- Since the lower layers only need to withstand smaller stresses and are not directly subjected to wear from traffic loads, poorer and less expensive materials can be utilized there.Flexible pavements consist of the following components:
  a. The Soil Subgrade
  b. The Sub-Base course
  c. The Base course
  d. The Surface Course

Flexible pavements are frequently made of bituminous concrete, granular materials with or without bituminous binders, WBM, soil aggregate mixes, etc. Equations or empirical charts are frequently used in the design of flexible pavements. For the design of flexible pavements, there are theoretical and semi-empirical approaches as well.

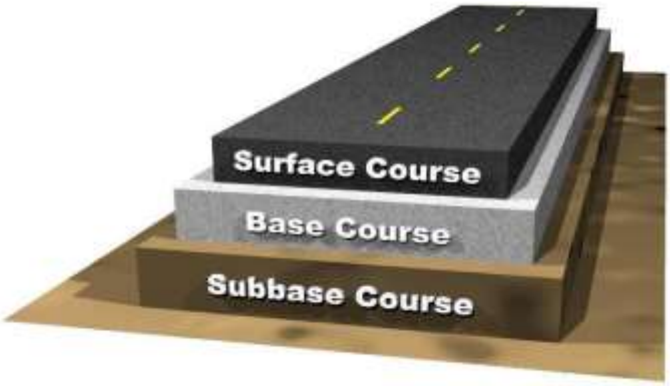

Figure 1- Flexible Pavement Typical Cross-section

(ii) Rigid Pavement- Pavements That Exhibit Flexural Rigidity That Is Noteworthy Are Considered Rigid.

- It Has Flexural Strength
- The Load Is Transferred Via Slab Action, Which Disperses The Wheel Load Over A Larger Area Below.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 7, No. 3, July : 2023

- Wheel Load Temperature Fluctuations Will Result In Flexural Stresses.
- The Bending Of The Slab Beneath The Weight Of The Wheel Will Cause Tensile Stresses To Occur.
- It Bridges The Slight Deviations Of The Lower Layer But Does Not Conform To The Contour Of The Bottom Layer.

There Are The Following Elements In Rigid Pavement:

a. The Cement Concrete Slab
b. The Base Course
c. The Soil Sub Grade

Portland Cement Concrete, Either Plain, Reinforced, Or Prestressed, Is Used To Create Rigid Pavements. About 40 Kg/Cm2 Of Flexural Stress Is Anticipated To Be Absorbed By The Ordinary Cement Concrete. With The Pavement Acting As An Elastic Plate Lying On Top Of An Elastic Or Viscous Foundation, These Were Created Utilizing The Elastic Principle.

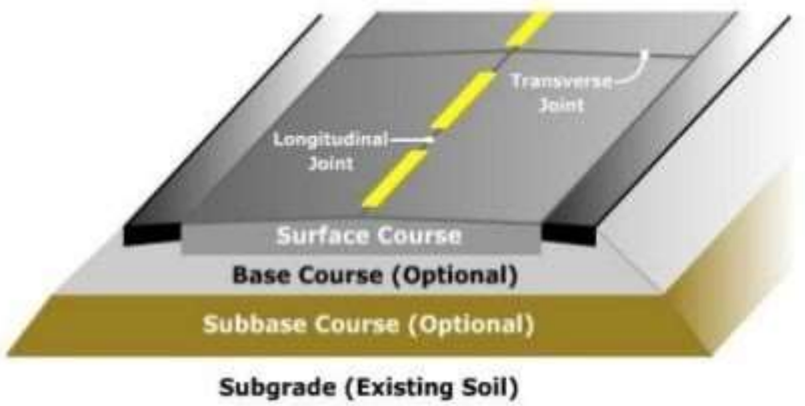

Figure 2- Rigid Pavement Typical Cross-section

(iii) Semi Rigid Pavement- The term "semi-rigid pavement" refers to a pavement layer that has a significantly higher flexural strength than the typical flexible pavement when bonded materials such as pozzolanic concrete, lean concrete, or soil cement are utilized. These materials are employed with flexible pavement surface courses because they have poor impact and abrasion resistance.

DESIGN OF FLEXIBLE PAVEMENT

Different methods for designing flexible pavements can be categorized into three major categories.:

(i) Empirical methods-

- These are based on physical properties and strength parameters of soil sub grade
- The group index method, CBR method, Stabilometer method and Mc leod method etc…, are empirical methods.

(ii) Semi empirical methods or semi theoretical methods- These methods are based on stress strain function and experience.

E.g.: Triaxial test method

(iii) Theoretical methods- These are based on mathematical computations. For example, Burmister method is based on elastic two layer theory.

(iv) Group Index Method- In 1945, D.J. Steel proposed the thickness specifications using a Highway Research Board method based on group index values. In mathematical formulae based on the percent fines, liquid limit, and plasticity index, the term "group index value" refers to an arbitrary index given to the various soil types. The GI values of soil range from 0 to 20. For a constant value of traffic volume, the soil subgrade is weaker the higher the GI value, and the greater the thickness need of the pavement. The traffic volume in this method is classified into three groups:

Traffic Volume (Commercial vehicles)	No. of vehicles/day
Light	Less than 50
Medium	50 to 300
Heavy	Over 300

Design Steps- Initially, the group index value is calculated for the soil sub grade based on thefollowing formula: GI = 0.2a + 0.005ac + 0.01bd

Where,

a = percentage of material passing through IS 200 (0.075mm) sieve, is more than 35and less than 75 (0 to 40)

b = percentage of material passing through IS 200 (0.075mm) sieve, is more than 15and less than 55 (0 to 40)

c = liquid limit more than 40 and less than 60 (0 to 20)

d = plasticity index more than 10 and less than 30 (0 to 20)

SURVEY AND ESTIMATION

Survey Data- In the design of a pavement, the earthwork estimation plays a major role.

Station	Distance(m)	Back Sight (m)	Intermediate Sight (m)	Fore Sight (m)	Height Of Instrument (m)	Reduced Level (m)	Remarks
	15.2	0.91			100.91	100	BM =100
1	5		1.14			99.77	
	10		1.09			99.82	
	15		1.02			99.89	
	20		0.95			99.96	
	25		0.815			100.095	
	30		0.69			100.22	
	35		0.55			100.36	
	40		0.549			100.361	
	45		0.49			100.42	
2	50	1.43		0.395	101.945	100.515	
	55		1.215			100.73	
	60		1.09			100.855	
	65		0.97			100.975	
	70		0.86			101.085	
	75		0.77			101.175	
	80		0.67			101.275	
	85		0.60			101.345	
3	90	1.25		0.45	103.645	102.395	
	95		1.00			102.645	
	100		1.01			102.635	
	105		0.80			102.845	
	110		0.59			103.055	
	115		0.42			103.225	

4	120	1.380		0.249	104.776	103.396	
	125		1.10				
	130		1.115				
	135		1.005				
	140		0.90				
	145		0.75				
	150		0.7				
	155		0.6				
5	160	1.4		0.45	105.726	104.326	
	165		1.09			104.636	
	170		1.07			104.656	
	175		1.1			104.626	
	180		0.85			104.876	
	185		0.61			105.116	
	190		0.47			105.256	
	195		0.42			105.306	
6	200	1.13		0.12	106.736	105.606	
	205		1.1			105.636	
	210		1.11			105.626	
	215		0.96			105.776	
	220		0.755			105.981	
7	225	1.59		0.37	107.956	106.366	
	230		1.11			106.846	
	235		1.09			106.866	
	240		0.84			107.116	
	245		0.61			107.346	
	247		0.50			107.456	

In order to obtain the total quantity of earthwork estimation, the longitudinal profile of the proposed road section is determined. For this purpose, the reduced levels along the center-line of the pavement are initially obtained and are tabulated as follows: Table 1. RL's along the centre line of longitudinal profile of the proposed pavement of Road I:

(ii) Earthwork Estimation- Table 2. Earthwork for filling of Road I.

		EARTHWORK FOR FILLING OF ROAD SECTION 1				
S.NO	TOP WIDTH (m)	HEIGHT (m)	BOTTOM WIDTH (m)	AREA (m^2)	INTERVAL (m)	QUANTITY OF EARTHWORK (m^3)
1	5	0.4	5.8	2.16	2.5	5.4
2	5	0.35	5.7	1.8725	5	9.3625
3	5	0.45	5.9	2.4525	5	12.2625
4	5	0.4	5.8	2.16	5	10.8
5	5	0.4	5.8	2.16	5	10.8
6	5	0.25	5.5	1.3125	5	6.5625
7	5	0.25	5.5	12.2625	5	61.3125

8	5	0.3	5.6	1.59	5	7.95
9	5	0.3	5.6	1.59	5	7.95
10	5	0.25	5.5	1.3125	5	6.5625
11	5	0.1	5.2	0.51	5	2.55
12	5	0.1	5.2	0.51	5	2.55
13	5	0.1	5.2	0.51	5	2.55
14	5	0.1	5.2	0.51	5	2.55
15	5	0.2	5.4	1.04	5	5.2
16	5	0.3	5.6	1.59	5	7.95
17	5	0.1	5.2	0.51	2.5	1.275
18	5	0.15	5.3	0.7725	5	3.8625
						167.45

DESIGN OF PAVEMENT THICKNESSS BY CBR METHOD

1. The soil samples are taken and their optimum moisture content is determined byProctor's density test for light compaction.
2. The soil sample is then compacted in CBR mould for optimum density and the mould issoaked for 3 days.
3. The CBR test is then performed to obtain the CBR values for the soil sub grade.

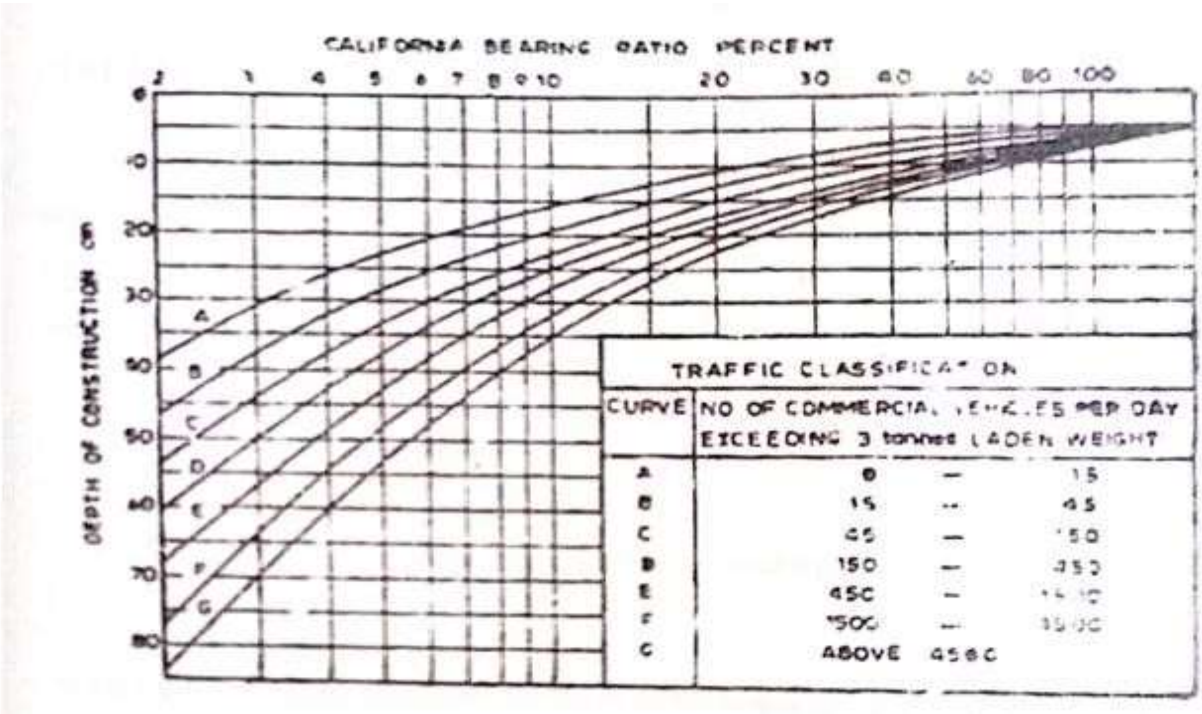

Figure 3- CBR design chart

Sample 1-

CBR corresponding to 2.5mm penetration = $\left(\frac{74.4}{1370}\right) \times 100$ = 5.4% Assume,

Average Daily Traffic (ADT) = 300

Annual rate of growth of traffic (r) = 8%

Time taken for pavement construction (n) = 1 yearNo.

of vehicles for design (A) = P (1 + r)$^{(n + 10)}$

$$= 300(1 + \frac{8}{100})^{(1+10)}$$

=699.49 vehicles/day

= 700 vehicles/day

Therefore, Design Curve E is to be used for design as the design traffic volume is in the range 450 to 1500 vehicles/day. Using the design chart, the total pavement thickness over subgrade having CBR of 5.4% isobtained as 40cm for curve E. Thus 40cm of pavement materials is required to cover the natural soil subgrade having 5.4%CBR value. Therefore, the thickness of base and sub base courses are 12.5cm and 22cm having CBR value55% and 25% using the design chart. The CBR values for the gravel and road metal are assumed as follows:

Type of material	Suggested CBR values(%)
Gravel	25
Road metal	55

CONCLUSION

Provide the greater of the two values obtained in each case for safety. Hence, provide a sub base of 25 cm thickness, base course of 15 cm thickness and wearing course of 7 cm thickness (as obtained from the curves recommended by IRC). 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, Biharsharif. The IRC specifications are based on rational thinking, the proposed road issafe in both geometrics as well as pavement design. 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 Burnistermethod. Because of the limitations of time and scope, only GI method and CBR method are adopted.

REFERENCES

[1]. “ Highway Engineering” by S.K.Khanna and C.E.G.Justo.
[2]. “ Highway Engineering” by T.D.Ahuja.
[3]. “Estimation and costing in civil engineering” by B.N.Dutta.
[4]. “Soil mechanics and foundation engineering” by K.R.Arora.
[5]. “Surveying” by K.R.Arora.
[6]. “Surveying” by B.C.Punmia.
[7]. **“**IRC 37-2001” : Guidelines for the design of flexible pavements.