Principles, Procedures and Policies Adopted in Improvement and Widening of Roads (Sh-88)

Rami Reddy Madhuri, Gandham Prasanna, Venu Malagavelli, D. Prince Kamal Kiran

Abstract: Road widening is the solution for the problem of traffic density and road accidents, transportation infrastructure is the ever green problem facing all over the world, as day by day with the growth of economic status the people are switched to use four wheelers from two wheeler vehicles, the roads at present are mean for the capacity of the present situation, as the traffic density increases the improvements in road infrastructure and widening of roads are required. We concentrated on the different road widening problems and solutions carried out and mainly focused on the Mysore Bantwal Road (SH-88). The need of this research is to design Road transport model to ensure safe and effective moment of traffic. We even discussed different principles, policies and procedures of the design standards and guidelines. The major aim is to reduce economic losses and to improve capabilities for overlay design that are provided to meet today's highway traffic needs. Finally we used IIT PAVE software for calculating fatigue and rutting performance criteria.

Keywords: Widening, Transportation, Infrastructure, Roads, Traffic density.

I. INTRODUCTION

Transportation Infrastructure shows the economic growth and status of country's development. The designs and structures of Road Transport Infrastructure reduces the Road accidents and traffic Jams. The growths of four wheelers are increasing day by day, to face the present situations and estimation of feature, the solution is the Road Widening, for the improvement of traffic performance [1].

It is necessary to conduct the research and Analysis for road widening; the factors that effect on this concept are traffic density, present road wide, planned road wide, pros in the road design, and requirements for structure change. For the Road widening, the existing traffic volume study carried out and compared with design standard. The capacity, Jam density, Average daily traffic is calculated for the widening and strengthening of roads. The widened Portion is calculated based on the mechanistic flexible pavement design carried out as per IRC 37-2012 and design is intended with flexibility of the pavement, Pavement Evaluation and strengthening of pavement. Pavements are the key elements of infrastructure of a country, whose functions are to promote transportation. Flexible pavements undergo functional deterioration as well as structural deterioration simultaneously [2].

The rate of structural deterioration of flexible pavement depends on several factors such as

- The stability of the entity provident structure and the component layers.
- Efficiency functions of the pavement drainage system and sensitivity of the climate.

The unexpected enclosure development in the given region based on the traffic loads on the arterial roads. Fast growth in industries and urban areas has made to increase traffic and excessive usage of the roads. The weakening accumulates with the passage of time and results in failure of pavement structure. The failure is of structural type, if the pavement fails to carry design loads. It is of functional type, if it does not give a smooth riding surface, which in turn increases vehicle operation. The performance evaluation of a road can cover many aspects including evaluation of road surface condition. The maintenance engineering should therefore carryout structural evaluation studies periodically, based on the design period time, under given static and dynamic loads once the pavement is evaluated [3].

II. LITERATURE SURVEY

In 2010 Rokade *et.. al..,* studied on structural and functional evaluation of 4 national and 1 state high ways. The structural evaluation pavement is based on Benkelman Bean Technique to measure the residual & rebound deflections of the pavement structure. Benkelman beam deflection performance test can be done based on standard specification for high performance and standard functional structural evaluations [4]. In 2015 Betten Singh *et.. al..,* analyzed the traffic flow in Bangalore and Mysore cities of India are a mixed traffic characteristics. The traffic congestion is the common problem; most of the roads are congested and operate in low level of service[5]. To improve the performance operation of the urban road network by proposing the proper alternatives to enhance the traffic capacity a methodology is designed to achieve a complete methodology for analyzing the mixed traffic flow is analyzed. In 2013 Indrajit ghosh *et.. al.,* proposed methods related to Performance evaluation based on the capacity analysis for various highway facilities.

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The capacity analysis procedure, In general is expressed as performance of a highway in terms of level of service (LOS). Evaluating the performance of the two-lane roads is based on IRC: 64-1990 provides guidelines. The Highway Capacity Manuals (HCM) of other developed countries are used for reference, which summaries the evolution of research on determining the LOS of two-lane roads [6].

III. GEOMETRIC DESIGNS

A. Terrain Classification

The slope of the country classifies and specifies terrain across the specified area. The terrain is very important parameter for classification of terrain short isolated stretches of varying among these terrain should not be considered

Table 1: Terrain – Classification Cross Slope in %

Terrain	Classification Cross Slope in %
Plain	0 – 10
Rolling	10 – 25
Mountainous	25 – 60
Steep	>60

B. Design Speed

Design Speed is a primary criterion for formative all geometric features of horizontal and vertical alignment. The design speeds for the roads particularly designed and paying attention on village roads [8] should be taken as given in table below:

Table 2: Road Classification – Design Speed

Road Classification	Design Speed (Km/h)							
	Plain Terrain		Rolling Terrain		Mountainous Terrain		Steep Terrain	
	Ruling	Min.	Ruling	Min.	Ruling	Min.	Ruling	Min.
ODR	65	50	50	40	30	25	25	20

Ruling design speed should be the guiding criterion for the purpose of geometric design. **Minimum design speed** may, however, be adopted where site condition and cost does not permit a design based on "Ruling Design Speed" [9].

C. Carriage Width

The Width of the carriage way depends on the Predicated traffic volume and traffic capacity of each line.

Table 3: Classification of Carriage width of way.

Classification	Width of carriage way
Single lane	3.75 m
Two lanes without raised kerbs	7.0 m
Two lanes with raised Krebs	7.5 m
Intermediate carriage way	5.5 m
Multilane pavements	3.5 m per lane

D. Camber

The camber on straight of road should be as recommended in below table.

Table 4: Camber – Classification of surface type.

Surface type	Camber (in %)	
	Low Rainfall (Annual Rainfall<1000 mm)	High Rainfall (Annual Rainfall>1000 mm)
Earth Road	4.0	5.0
WBM and Gravel road	3.5	4.0
Thin Bituminous Pavement	3.0	3.5
Rigid Pavement	2.0	2.5

At super-elevated road is a primary section, the shoulder should normally have the slope of same magnitude and direction as the pavement slope subject to the minimum cross-fall allowable for shoulder. The camber for earth shoulder should be at least 0.5 % more than that for the pavement subject to the minimum of 4 %. However, 1 % more slope than the camber for pavement is desirable.

In general, Horizontal curve should consist of circular portion flanked by spiral transition at both ends, design speed, super elevation and coefficient of side friction affect the design of circular curves, length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of super elevation.

E. Super Elevation

Super elevation to be provided on curve is calculated from the following formula

$e = V^2/127R$

where, e = Super elevation in meter per meter.
V= Design speed in m/s
R= Radius of the curve in meters

Table 5: Super Elevation with parameters

Plain and rolling terrain	7 %
Snow bound area	7 %
Hilly area but not snow bound	8 – 10 %

IV. COMPONENTS OF FLEXIBLE PAVEMENT

This In this type of pavement, there would be grain to grain transfer of load. It consists of fore layers namely Sub-grade, Granular Sub base (GSB), Wet Mix Macadam (WMM), Dense Bitumen Macadam (DBM) and Bituminous Concrete (BC). By considering the traffic load for designed years, rutting criteria, fatigue criteria, we calculate the load acting on the pavement for designing. Rutting and fatigue are some of the failures which occur in the corresponding sub base and bituminous course. Failure may occur due to loads, unforeseen site conditions, improper material selection, inadequate layer dimensions etc. Hence to prevent failure, specifications are to be followed [10].
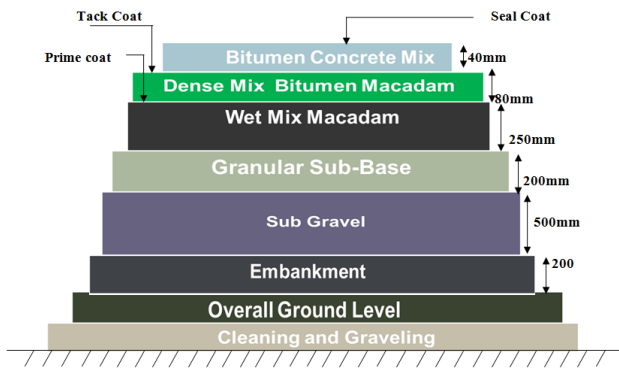
Figure 1: Different layers of flexible pavement

V. LAB TESTS

Tests on Sub-Grade\Soil

A. free swell index:

➢ Take 500g of sample and oven dry it at a temperature (100$°C$ -110$°C$) for 24 hours.

➢ Sieve the oven dried sample through IS Sieve 425µ.

➢ Take the sample passing through that sieve in two flakes of 100ml capacity, a quantity of 10g in each flask.

➢ Add 100ml of distilled water in first container and 100ml of kerosene in another container.

➢ Stir the sample well by stirrer to remove the entrapped air in it and allow the soil to swell and settle by keeping the flasks ideal for 24 hrs.

➢ Note the level of soil in both flasks after 24 hrs.

$$\text{Free swell index} = \frac{V_d - V_k}{V_K} \times 100$$

Where

V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

B. Casagrandes Test

This test is done to know the liquid limit of the soil sample. Procedure:

➢ The Casagrande's apparatus is set such that the number of shocks is '0' at the reading and is checked whether the instrument shows a unit for every one shock.

➢ The soil is mixed with unknown amount of water thoroughly using spatula uniformly. Using spatula, the soil is applied in the cap of the Casagrande's apparatus up to 1cm level. This 1cm level is checked with spatula.

➢ With the help of grooving tool, the paste in the brass cap is divided along the diameter of cup by holding the tool normal to the surface and drawing it firmly across the cup.

➢ The handle of Casagrande's apparatus is operated by turning it at the constant rate until the bottom of the grove (approx. 12mm). The numbers of bows or shocks are noted and the representative slice of soil is collected using spatula width wise from one edge to the other edge.

➢ The collected soil is kept in moisture container and weighed. Also, the empty weight of container is noted. Now the soil is put for drying.

➢ After drying, the container is weighed and noted. This process is done for different water contents of soil [12].

C. Plastic Limit Test

This test is conducted to find the plastic limit of soil sample.

➢ The soil sample is mixed with sufficient amount of distilled water on marble/glass plate to make it plastic enough to be shaped in to a ball.

➢ Some sample is taken and taken and made into a ball. That ball is rolled on a glass plate with hand by applying sufficient pressure. It is rolled into a thread of uniform diameter throughout its length.

➢ When the diameter of the thread has decreases to 3mm, the specimen is kneaded together and rolled again. The process is continued until the thread just crumbles at 3mm diameter.

➢ The crumbled soil thread is taken in to the moisture container and water content is determined.

➢ The test is repeated for different water contents in the soil [13].

This water content is noted as plastic limit for given soil sample.

D. California Bearing Ratio (Cbr) Test

➢ This test is used to find the CBR value represents the bearing strength of soil. It is based on the normalized values over a lot of experiments conducted on crushed aggregate powder by California Highway Department.

➢ Specimen, passing through 20mm sieve, in the mould is subjected to four days soaking. Load is applied in the cylindrical plunger of 5cm diameter so that the penetration rate is 1.25mm/minute.

➢ The loads for 0,0.5,1,2,2.5,3,4,5,7,10 and 12.5mm penetration are recorded.

➢ A graph is drawn between load and penetration values. The load values corresponding to 2.5mm (P2.5mm) and 5mm(P5mm) penetration values are noted.

➢ Normally the CBR value at 2.5mm penetration is higher than that at 5mm penetration and higher value is reported as CBR value of the soil [14].

$$CBR(\%) = \frac{P_{2.5\ or\ 5mm}}{P_{standard\ 2.5\ or\ 5mm}} \times 100$$

Where
Standard $P_{2.5mm}$= 1370kg   Standard P_{5mm}=2035kg

VI. EXPERIEMENTAL ANALYSIS

The overlay design and pavement thickness design are checked for performance criteria using IIT-PAVE software developed by IIT-Kharagpur which is given along with IRC: 37-2012 [15].

The software required input is like as Elastic Modulus of five layers in MPa, bituminous layer, granular layer (WBM, GSB …etc.) and Subgrade. Poisson's ratio of all the five layers & thickness in mm. The thickness of subgrade layer is not required it is considered infinite, all parameters given in below table with value to be used in design and analysis [16].

Table 5: Data to be used in analysis

Sr. No.	Layer	Modulus in Mpa	Poisson's ratio	Thickness in mm
1	Bituminous layer	3000	0.35	155
2	Base layer	171.0658	0.35	250
3	Sub base layer	130.2280	0.35	300
4	Sub grade	50	0.35	-

Wheel load is required to be input as standard load 40000N for single wheel assembly, for dual wheel set require 20000N same is adopted. The tyre pressure is considered 0.56 MPa. The Point of analysis has to be given to know strain developed at critical location as discussed in fatigue and rutting model [17].
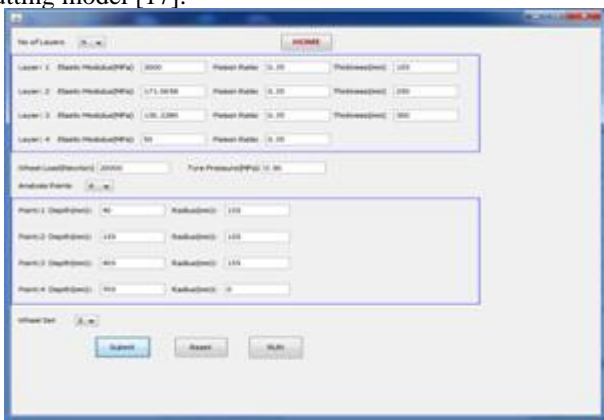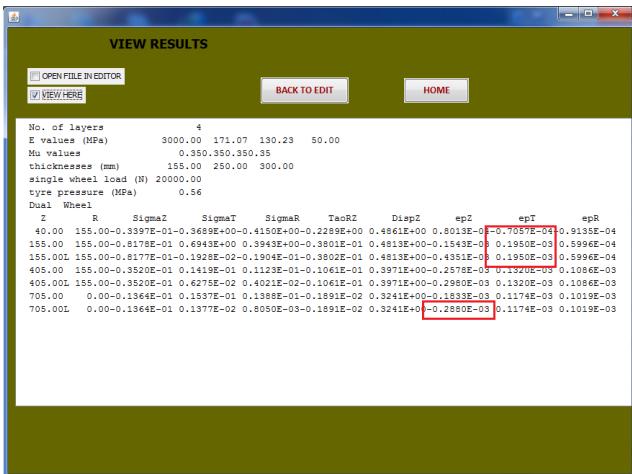

Figure2: IIT PAVE input screen

For the above input the output available in strain value at different location. Point of consideration is epT means tensile strain and epZ means vertical strain. Which shown as in below figure.

i) Allowable Horizontal Tensile Strain in Bituminous Layer is 155 x 10-6for VG 40 mixes based on fatiguemodel.
ii) Allowable Vertical Compressive Strain on Subgrade is 371 x 10-6 from the rutting-model.
From the IIT PAVE output screen result:
i) Horizontal tensile strain in bituminous layer is 195 x 10-6> 155 x10-6, This is not safe in horizontal tensile strain, so it need to increase thickness of bituminous layer than check.

ii) Vertical compressive strain on subgrade is 288 x 10-6< 371 x 10-6, this is safe. Increase bituminous layer thickness 195 mm from 155 mm, and base layer 250 mm, sub-base layer 300 mm and all other parameters are as it is. This design is checked below IIT PAVE software.

VII. CONCLUSION

It is observed from data that average daily traffic (ADT) in PCU/day is more than the IRC recommended for capacity per day of 2 lane for plain ruralroad.

Average daily traffic (ADT) on Mysore –Bantwal state highway 88is 25,843 PCU/day, it is more than 15,000 PCU/day of IRC recommended for capacity per day of 2 lane plain rural road from which it has been justified that widening is required on the selectedstretch.

Mechanistic pavement design for widening is also proposed which will be having 745 mm of overall depth with surface layer of 195 mm, base layer 250 mm and sub-base layer 300mm.

It has been found that 4 sections are having poor surfaces (1secton = 1 km) from the surface condition survey, and structural evaluation also has conducted using Benkelman beam deflection test at poor section within 4 km and found the characteristic deflection.

Overlay thickness at each section (total 4 kilometer) is calculated in 3 alternate designs like BC/DBM, DBM and BM are i) 35/40, 85, 120 ii) 35/40, 75,105 iii) 30/40, 70, 100 iv) 35/55, 90, 125respectively.

In mechanistic pavement design fatigue strain calculated as per multi-layer elastic theory using IIT PAVE software is 152 micro at bottom of bituminous layer, it is lower than 155 micro strain calculated as per performance model for 90% reliability so pavement design is safe in fatigue failure.

Rutting strain calculated as per multi-layer elastic theory using IIT PAVE software is 238 micro at top of sub grade, it is lower than 371 micro strain calculated as per performance model for 90% reliability so pavement design is safe in rutting failure.

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