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WIDENING AND STRENGTHENING OF FLEXIBLE PAVEMENT

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ABSTRACT

In India different types of pavement design have been observed, most of the highways are having the flexible pavement. Pavement is designed to support the wheel load imposed on it from traffic moving over it. Extra Load per unit area is also imposed with the change in climate. Pavement shall be strong enough to resist the stresses and to distribute an external load. The study highlights the need of pavement evaluation and pavement evaluation measures for the road pavements of Hanuman junction – Kalaparru Toll Plaza of NH-16 for the stretch of 10 km. The road plays an important role in connecting some of the main regions in Andhra Pradesh state of Vijayawada, Hanuman junction, Eluru. This corridor is expected to play a vital role in the economic development of the Andhra Pradesh. It is a great and well-maintained highway in Andhra Pradesh. We can achieve more than the design speed, The design speed would be around 85 to 100 km/h, one can travel by bike with safely. A distressed pavement should require the maintenance. This Maintenance can measure the constitute fresh investment on the existing road. The analysis and design of flexible pavement by using IITPAVE software with IRC 37 – 2018 guidelines.

Keywords: Widening, strengthening, flexible pavement.

1. INTRODUCTION

1.1 General

Transportation infrastructure plays a lead role in economic growth and development of country. The road transport is the ancient and perhaps the most widely adopted mode of transport of mankind. The road transport witnessed a tremendous growth rate after independence of our country. Pavements are the key elements of infrastructure of the country, whose functions are to promote transport activities, economic activities and to improve the standard of living. Flexible pavements undergo the functional deterioration as well as the structural deterioration simultaneously due to the combine effects of climate, environment and traffic loads. The functional deterioration is also indicated by the changes in surface condition of the pavement in the form of distress in the quality, which can be measured by simple methods; it is also possible to restore the surface to original condition of the pavement by providing a profile correction course and a re-surfacing the layer.

The existing roads in the States are generally flexible pavements and their capacity augmentation by way of widening and strengthening would therefore generally be by provision of flexible pavements only.

A common road design problem is the widening and repair of existing road surfaces. In this scenario we wish to fill in the road shoulder and possibly widen the road as well on both sides. To minimize the cost we don't want to change the existing pavement.

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2. LITERATURE REVIEW

Kunal P. Bhagat, Chetan P. Hadial, Ujjval J. Solanki (2015), "Mechanistic design of overlay based on Benkelman beam deflection technique," in this literature flexible pavement overlay design was carried out as per IRC: 81- 1997 -Guidelines for Flexible Road Pavement Strengthening using Benkelman beam deflection (BBD) technique. The design thickness as per evaluated of Benkelman beam deflection is 85 mm bituminous layer. They have done overlay design as per IRC 37 2012 base on fatigue and rutting failure criteria. The various inputs required for the design is computed through deflection & existing pavement layer thickness as per IRC guidelines. The computed fatigue & rutting strain is 0.0837 micron and 169 micron due to material which is lower than strain due to traffic so the overlay design found safe in both criteria.

Mahendrakar Kiran Kumar, D. Gouse Peea, Konge Praveen Kumar (2015), "A study on overlay designs of repeatedly deteriorating flexible pavement," in this research they have studied on a factor, in India there is very high and very low pavement temperature in some parts of the country. Under this condition, flexible pavement tends to become soft in summer and brittle in winter. Further increase in road traffic during the last one decade with an unduly low level of maintenance has contributed to accelerated deterioration of road surfacing. To prevent this deterioration process, several types of measures may be adopted effectively such as improved design use of high performance material and effective construction technology.

A.A. Patel, Dhaval V. Lad (2015)**,** "Pavement evaluation by Benkelman beam of state highway section (Waghodiya crossing to Limda)" In this structural evaluation of flexible pavement deflection by the Benkelman Beam is measured. Rebound deflection is used for overlay design. A detailed pavement condition survey is done on State Highway 158 (Waghodiya crossing to Limda) and the road condition is evaluated structurally. Their present study is evaluates the overlay thickness for State Highway 158 Waghodiya crossing to Limda.

3. OBJECTIVE OF THE STUDY

The objectives of the work would be:

(i) To study the existing traffic situation for the selected road stretch. Highway infrastructure projects would also require substantial up-scaling if the sector is to be developed for broader objective of achieving socio-economic development of the country and maintain the targeted growth trajectory.

(ii) To carry out traffic volume survey of stretch.

(iii) To study on need of road widening and justify the activities such as Road Safety, pilot schemes to test the efficacy of new / emerging technologies and materials, etc.

(iv) To evaluate the necessity of strengthening and overlay design.

(v) To know the impact of road widening on environment

(vi) To study the need of road widening and justify.

(vii) Development opportunities are to ensure that roadway improvement are committed.

(viii) To analyse the impact of road widening on local residents.

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4. STUDY AREA AND METHODOLOGY

4.1 Study area

The road pavements of Hanuman junction – Kalaparru Toll Plaza of NH-16 for the stretch of 10 km. The road plays an important role in connecting some of the main regions in Andhra pradesh state of Vijayawada, Hanuman junction, Eluru.

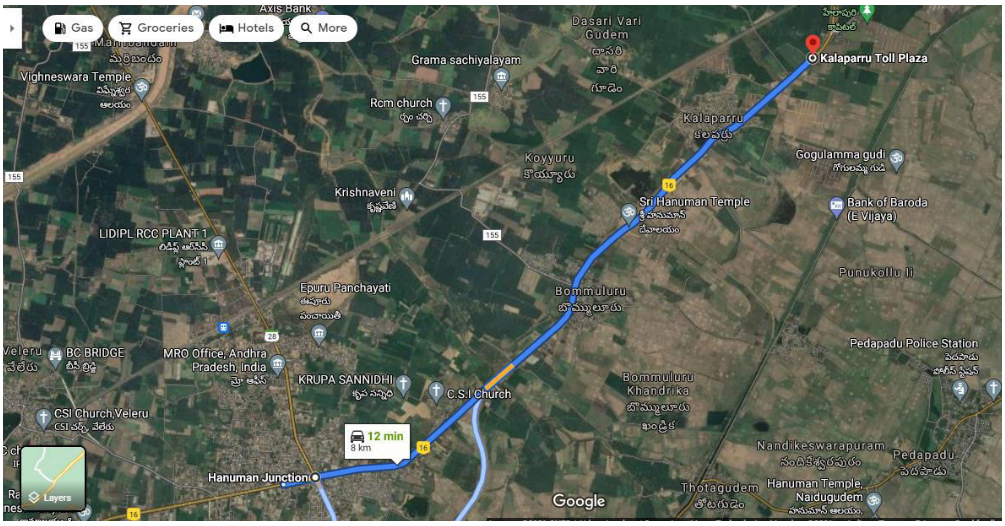

Fig. 1: Map area for selected area for widening.

4.2 Methodology

The Methodology involved for the study is as follows.

1) The detailed site investigation: in which road inventory data, traffic flow condition and identify the traffic circulation pattern in & around study area.

2) The traffic survey & Analysis: A Collected data has analysed to identify roadway segment capacity, based on the IRC Guidelines for the capacity of Urban Road in plain area IRC: 86-1983.

3) Preparation of a conceptual design : A Next step has to propose section specific inventions to be identified and prepare their of implementation plan. Based on the need of urgency.

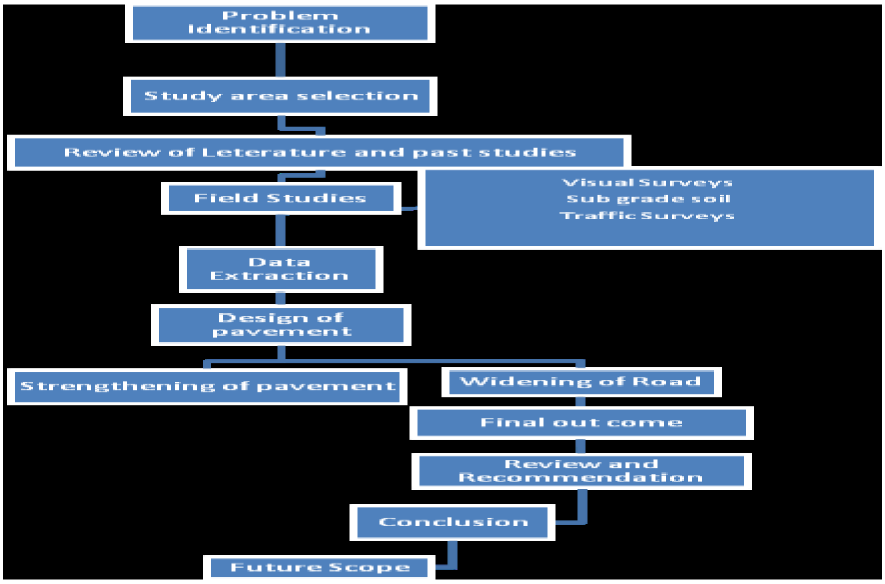

Fig. 2: Flow chart for methodology.

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5. EXPERIMENTAL WORK

5.1 Laboratory testing of soil

5.1.1 California Bearing Ratio Test

The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. It is also defined as the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

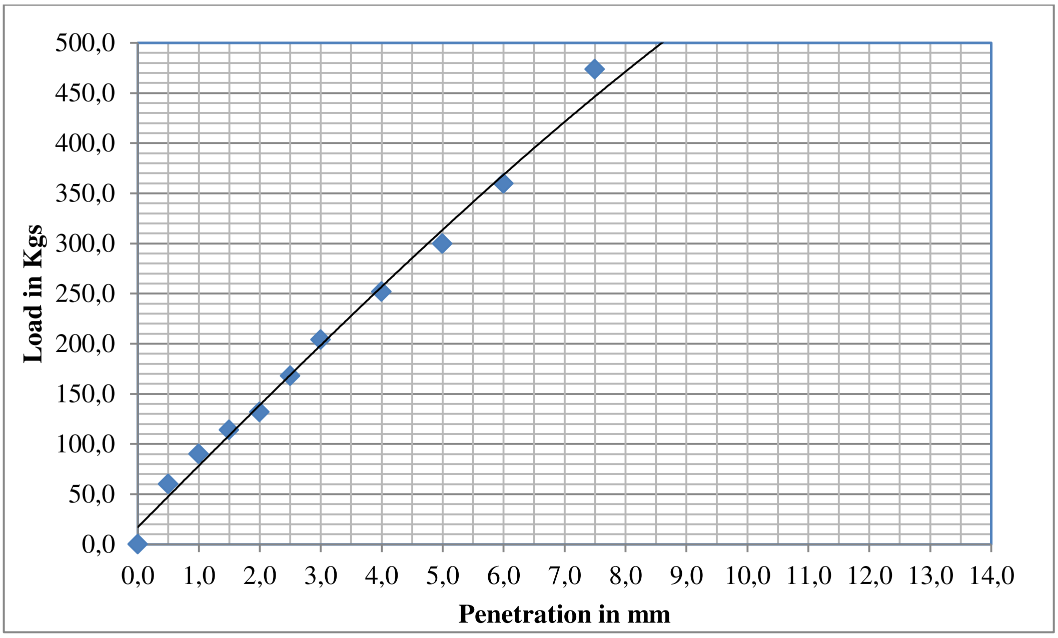

Fig. 3: Sample calculation graph of CBR.

- **Existed soil CBR values :** Collect existing / Embankment CBR Data as per SP 19 one sample for every one kilometer length. Compute 90th percentile CBR value for high volume roads and 80th percentile CBR value for low volume roads. For this study we considered 10km road. The test results of soaked CBR values given below;

Table. 1: Compute 90th percentile existing CBR value.

Chainage (km)	4 days soaked CBR	Count	Ascending order CBR	Percentile
0	4.5	10	4.5	100
1	5.8	9	4.6	90
2	6.9	8	5.6	80
3	9.2	7	5.7	70
4	12.4	6	5.8	60
5	5.6	5	6.4	50

6	6.4	4	6.9	40
7	4.6	3	9	30
8	9	2	9.2	20
9	5.7	1	12.4	10

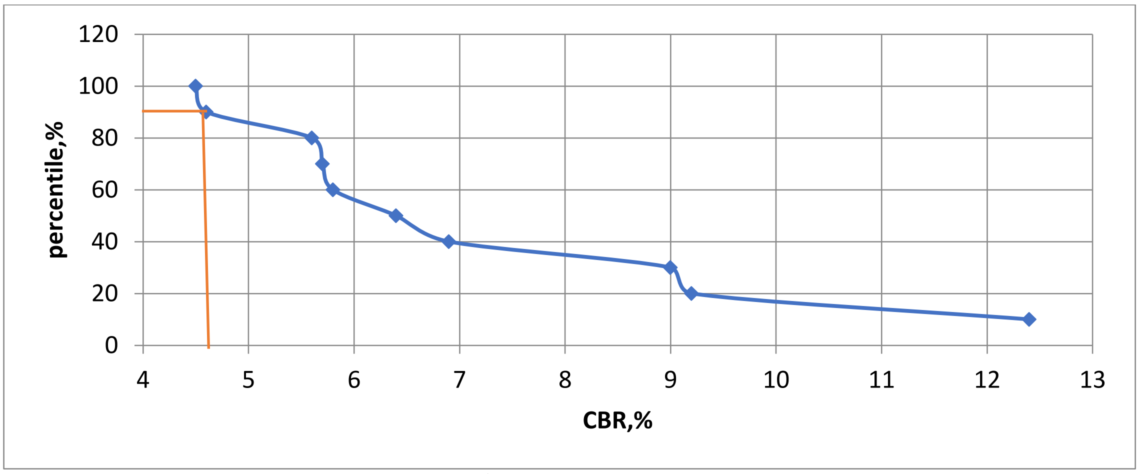

Fig. 4: 90th percentile CBR value.

Result: 90th percentile CBR value found as **4.6% &** CBR value of borrow soil is 8.5 %**.**

6. DESIGN OF WIDENING OF FLEXIBLE PAVEMENT

6.1 Design of Pavement (IRC 37: 2018 and IIT PAVE)

As discussed earlier the design of flexible pavements is done by using the guidelines of IRC 37: 2012 and applying the results to the IIT PAVE software.

In our design the pavement is divided into four layers i.e Bituminous course, DBM layer, WMM layer and Subgrade. So we need to analyse the properties of all these layers.

The design steps for pavement given below;

1. Compute subgrade effective resilient modulus (M_{RS})
2. Compute design traffic in terms of MSA (N_{DES})
3. Select layer combination
4. Compute permissible horizontal & vertical strain
5. Compute actual strain as per IITPAVE. (try combinations of different thicknesses)
6. Selection of Economic pavement composition

6.1.1 Resilient Modulus and Poisson Ratio of Subgrade

The relation between modulus and the effective CBR in IRC is given as (Annexure 1)

$$M_{RS}\text{ (MPa)} = 10 * CBR \text{ for } CBR <= 5$$
$$= 17.6 * (CBR)^{0.64} \text{ for } CBR > 5$$

M_{RS} = modulus of subgrade soil.

From the **5.3.1.5** in chapter 5 : 90th percentile CBR value found as **4.6% &** CBR value of borrow soil is **8.5 %.**

Existing soil M_{RS} (Mpa) = 10 * (CBR) = 10 * 4.6 = 46 Mpa

Borrow soil M_{RS} (Mpa) = $17.6 * (CBR)^{0.64}$ = $17.6 * (8.5)^{0.64}$ = 69.237 Mpa

Wheel load 40000Newtons & tyre pressure 0.56

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Then submit these inputs in IITPAVE, get the deflection for combined the layers:

$M_{RS} = [2(1 - \mu^2)\ pa\ ] / \delta$

Where,

p = contact pressure = 0.56 MPa

a = radius of circular contact area, which can be calculated using the load applied (40,000 N) and the contact pressure 'p' (0.56 MPa) = 150.8 mm

μ = Poisson's ratio

$M_{RS} = [2(1 - \mu^2)\ pa\ ] / \delta\ = [2(1-0.35^2\ ) \times 0.56 \times 150.8] / 2.333\ = 63.52$ Mpa

6.1.2 Design Traffic

Table. 2: MSA calculations.

Traffic Data 2020-2021	**Location**	**Direction**	**BUS**	**LMV/ LCV/ M. Bus**	**2-Axle Trucks**	**3-Axle Trucks**	**M-Axle Trucks**	**Total**
7-days	Hanuman junction at Chainage 350+500	To Vijayawada	48	67	240	54	232	**641.00**
		To Kalaparru	37	73	228	67	248	**653.00**
	Vehichles		85	140	468	121	480	1294

VDF	**Location**	**Direction**	**BUS**	**LMV/ LCV/ M. Bus**	**2-Axle Trucks**	**3-Axle Trucks**	**M-Axle Trucks**
Hanuman junction at Chainage 350+500	Hanuman junction at Chainage 350+500	To Vijayawada	2.35	1.98	3.72	4.60	6.42
		To Kalaparru	2.40	1.49	3.30	3.78	5.26
	Final VDF		2.40	1.98	3.72	4.60	6.42

MSA	**Location**	**MSA**			
		10 Years	**15 Years**	**20 Years**	**Designed for**

					20Y MSA
MSA CALCULATION	Hanuman junction at Chainage 350+500	31.16	58.71	98.27	98.00

6.1.3 Layer Selection

Bituminous Layer: The surfacing consists of a wearing course or a binder course plus wearing course. The most commonly used wearing courses are surface dressing, open graded premix carpet, mix seal surfacing, semi-dense bituminous concrete and bituminous concrete. For binder course, MORTH specifies, it is desirable to use bituminous macadam (BM) for traffic upto to 5 msa and dense bituminous macadam (DBM) for traffic more than 5 msa. The modulus for the bituminous material are obtained from the Table 9.2 in IRC 37: 2018

In this study we designed pavement by adopting VG40 bitumen for both DBM & BC : the resilience modulus is **3000Mpa**

Existence soil soaked CBR value of 4.6% & 47 MSA

Catalogue for pavement with bituminous surface course with granular base and sub-base - Effective CBR 5% (Plate-1)

GSB = 200mm

WMM = 250mm

BASE / BINDER COURSE = 140mm

SURFACE COURSE = 40mm

SUBGRADE = 500mm

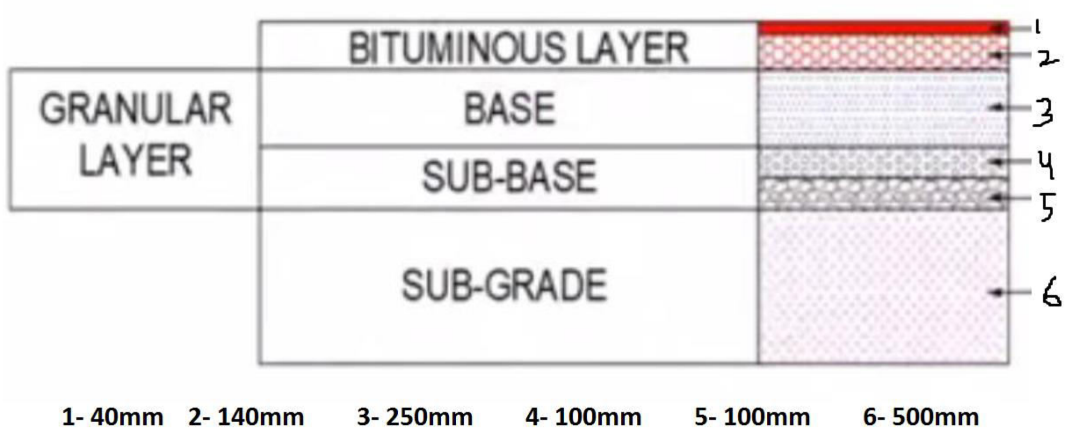

Fig. 5: Adopted layer thickness.

6.1.4 Failure Criteria and Strain Calculation (Permissible)

a) Vertical strain (90% reliability)

$N_R = 1.41 \times 10^{-8} [1/ \varepsilon_v]^{4.5337}$

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$98 \times 10^6 = 1.41 \times 10^{-8} \times [1/\varepsilon_v]^{4.5337}$

$\varepsilon_v = 0.0003204$

b) Horizontal strain (90% reliability):

$N_F = 0.561 \text{ X C X } 10^{-4} \text{ X } [1/\varepsilon_t]^{3.89} \times [1/M_{RM}]^{0.854}$

$C = 10^M$ & $M = 4.84 [V_{be} / (V_{be} + V_a)]^{4.5337}$

Use, V_{be} =11.5 (Actual V_{be} : 11 to 13) & V_a = 3.5 (Actual V_a : not less than 3%)

M = 0.37 , C = 2.35

M_{RM} = 3000 Mpa (Figure 7.6)

$\varepsilon_t = 0.000153$

61.5 Modulus for each layer:

Sub-grade modulus = 63.52 Mpa (From figure 6.4)

Bitumen layer modulus = 3000 Mpa (From figure 6.6)

Granular DBM layer:

Granular layer modulus = $M_{GRAN} = 0.2 (h)^{0.45} \times M_{support}$

h = Thickness of the DBM layer

$M_{GRAN} = 0.2 (250+200)^{0.45} \times 48.736 = 152.344$ Mpa

Granular layer modulus = 152.344 Mpa

6.1.6 Actual strain by IITPAVE

Inputs:

Wheel load = 20000 N

Tyre Pressure = 0.56 MPa

Poissons's Ratio = 0.35

Radial distance = 155mm

Strain Comparison:

1. Actual horizontal strain < = Permissible horizontal strain
2. Actual vertical strain < = Permissible vertical strain

<u>**Trail – 1:**</u>

SURFACE COURSE = 30mm, BASE / BINDER COURSE = 100mm, WMM = 250mm, GSB = 200mm, SUBGRADE = 500mm

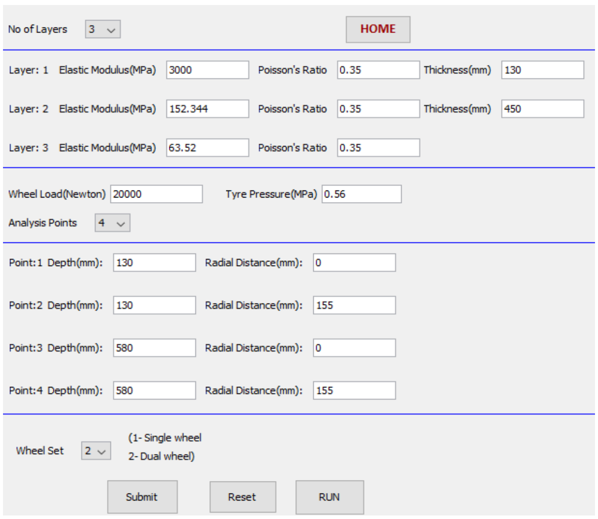

Fig. 6: Trail 1 input.

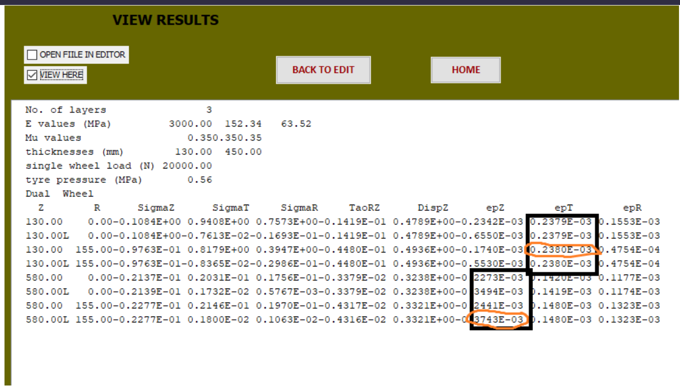

Fig. 7: Trail 1 output.

Strain Comparison:

Permissible horizontal strain = 0.000153, Actual horizontal strain = 0.0002380

Permissible vertical strain = 0.0003204, Actual vertical strain = 0.0003743

Here, 1. Actual horizontal strain > Permissible horizontal strain

2. Actual vertical strain < Permissible vertical strain

Hence Pavement is unsafe.

<u>Trail – 2:</u>

SURFACE COURSE = 50mm, BASE / BINDER COURSE = 150mm, WMM = 200mm, GSB = 200mm, SUBGRADE = 500mm

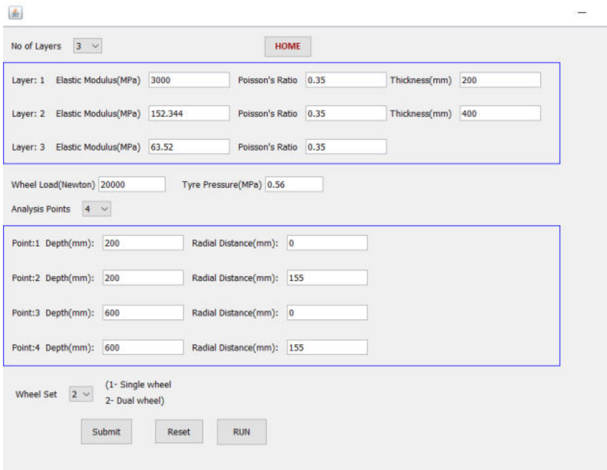

Fig. 8: Trail 2 input.

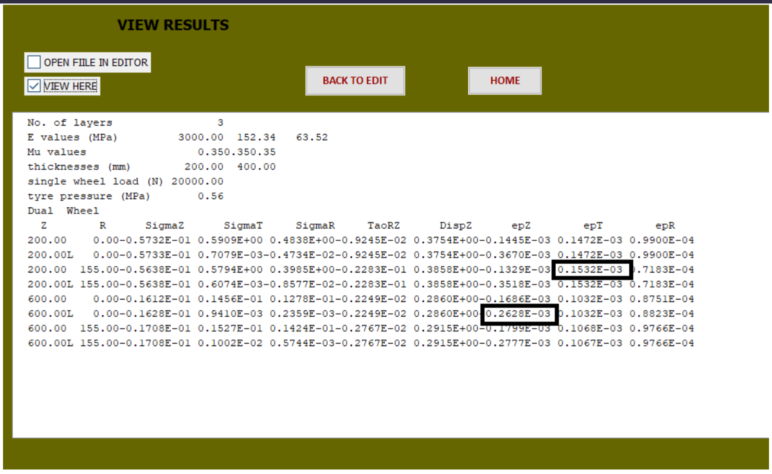

Fig. 9: Trail 2 output.

Strain Comparison:

Permissible horizontal strain = 0.000153, Actual horizontal strain = 0.000153

Permissible vertical strain = 0.0003204, Actual vertical strain = 0.0002628

Here, 1. Actual horizontal strain = Permissible horizontal strain

2. Actual vertical strain < Permissible vertical strain

Hence Pavement is Safe.

6.2 Widening and strengthen of pavement

Road transport required much less capital Investment as compared to other modes of transport such as railways and air transport. The cost of constructing, operating and maintaining roads is cheaper than that of the railways. Roads are generally constructed by the government and local authorities and only a small revenue is charged for the use of roads. The NH-16 Having 4lane 2way traffic road, the increment in the vehicle loads the possibility to widen the road to 6lane two-way traffic. The widening of road not only an increasing the carriageway length it's a strength based and economical point of view concept. The 6lane width is 21meters, the existed pavement length was 14meters. The possibility widens the road by both sides of 3.5meters.

6.2.1 Procedure

1. Centre line marking of road: 6lane road carriage way length 21meters in that 50%is 10.5meters. do the center line marking for both sides of 10.5meters.
2. Excavating the soil as per designed depth (starts from sub-grade).
3. Subgrade layer construction as per designed depth.
4. Granular layer construction as per designed depth.
5. Wet mix macadam layer construction as per designed depth.
6. DBM layer construction as per designed depth. And the DBM layer construction up-to the level of existed pavement height.
7. BC layer construction: The BC layer laid for whole road length means 21meters length. This BC layer top or surface layer of the road.
8. The procedure mentioned above is suitable for good pavement, if the pavement has distressed area at that case the construction procedure is different. Based on the distressed area the construction procedure differs. The distressed portion is lesser than

10% means minor cracks on road its considerable and the construction procedure similar to good pavement. If the distressed portion is above to the 10% means fatigue and rutting failure in the flexible pavement not considerable.

9. The selected distressed portion cut for entire length of the pavement up-to subgrade level. After cutting the pavement excavate up to subgrade level and fill with the morum soil and its free to pass the traffic and after 15days compacted the layer with compactors and lay the wet mix layer after that DBM layer it's leveled with existed pavement. The completion of construction of DBM layer, bc layer will lay for whole length of the pavement.

7. CONCLUSIONS

1. The thickness of pavement varies with the change in the value of C.B.R. With higher value of C.B.R. the pavement thickness is less and vice versa. In this study we used 90th percentile existing soil CBR value 4.6% & Borrow soil CBR value 8.5%.
2. The Pavement layer thickness for construction of 6-lane flexible pavement as per IRC 37 -2018 designed those thickness are;

Layer	Thickness (mm)
Sub grade (Borrow soil)	500
Sub base course	200
Base course (WMM)	200
Base binder course (DBM)	150
Surface course (BC)	50

3. Due to the saving in Pavement thickness is less quantity of material will be applicable so that, huge amount of money can be saved. As per designed values of layer thicknesses the widening of road will be constructed. The existed road leveled with the newly widened and constructed with DBM layer and the top or surface layer of the pavement is constructed for whole carriageway length.
4. By adopting the technique of widening of flexible pavement the cost of construction is decreases and there is no restriction for flow of vehicles (traffic).

7.1 Future Scope

1. The present study is made on one road and the pattern of deterioration is determined on basis of the analysis. However, the more realistic pattern of deterioration can be developed by studying the different road.
2. The study can also be with different bitumen grades, modified bitumen, RAP utilization.
3. The study can also be elaborated by varying the various factors such as temperature and Rainfall Data.
4. Further this research work can be carried with different materials to improve CBR values by soil stabilization technique.
5. It is of paramount importance to regulate and control the development activities in land abutting the Right of Way (ROW) of Highways so as to ensure availability of

adequate clearances, enhance safety of traffic, obviate possible encroachments of ROW in future, etc. it is a long stretch and the development around the highway was stuck because of heavily clogged roads.

6. The widening of the road would not only ease the traffic and reduce travel time but would also result in development of residential housing, Industrial Area along the road.

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