DESIGN OF FLEXIBLE PAVEMENT USING IITPAVE

An internship/summer project report in the fulfilment of the requirements

for the award of the degree of

B. Tech.

in

Civil Engineering

Submitted By

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BONAFIDE CERTIFICATE

This is to certify that the internship titled **"DESIGN OF FLEXIBLE PAVEMENT USING IITPAVE"** is a Bonafide record of the work done by **RASWANTH PRASATH S V (103119113)** of the Department of Civil Engineering, National Institute of Technology, Tiruchirappalli during the period 20th May 2022 to 1st August 2022 under my guidance and supervision as a part of the requirement for obtaining his Bachelor of Technology Degree in Civil Engineering.

Dr. V. Sunitha	Dr. S.T. Ramesh
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ABSTRACT

This internship aims at collection of data related to traffic studies and create a excel template for designing the flexible pavement as per the guidelines of IRC: 37-2018. Later it is analysed using the IITPAVE Software to check whether it satisfies the specific requirements. In this work, emphasis was given on traffic volume and the analysis was carried out through primary traffic flow surveys at Ongur to Pillaipakkam. Traffic flow is studied by manual methods. With the help of the data collection, an attempt had been made to understand the traffic patterns during different time periods. Traffic control at that junction is also dependent on the traffic flow characteristics. Hence the results from the present study are helpful in finding the current traffic flow and helps in determining the design traffic which will be used in designing the pavement. From the obtained data, the design of flexible pavement is carried out using IRC: 37-2018 guidelines.

IIT PAVE software is an improved version of FPAVE which is developed by research scheme R-56 of MORTH. This is a multilayer analysis programmer used for design, analysis of the flexible or bitumen pavement using IRC: 37-2018 guidelines. In this software we enter thickness of pavement layers, loads applied over the surface of pavement, tire pressure, spacing between the wheels and Poisson´s ratio as inputs. After running the software actual horizontal tensile strain and vertical compressive strains at critical locations of the pavement are obtained as output.

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CHAPTER 1
INTRODUCTION

1.1 GENERAL:

Indian roads congress has specified the design procedures for flexible pavements based on CBR values. The Pavement designs given in the previous edition IRC:37-1984 were applicable to design traffic at maximum 30 million standard axles (msa). The earlier code is empirical which has limitations regarding applicability and extrapolation. This guideline follows analytical designs and developed a new set of designs up to 150 msa in IRC:37-2018.

This report documents the design of flexible pavement based on the traffic data collected using IITPAVE software. The gathered information was analysed to gain insights into pavement characteristics resulting in superior performance. The pavement is designed based on IRC:37-2018. Indian roads congress has specified the design procedures for flexible pavements based on CBR values. A excel template is also created to easily design and analysis the pavement for upcoming projects.

1.2 OBJECTIVES:

The study was carried out with the following objectives:

- To understand the design of flexible pavement and its methodology
- To analysis traffic by using collected traffic volume count data by adopting suitable PCU values.
- To analyze the depth using IIT pave software.
- To design flexible pavement using Excel according to IRC-37 and analyzing pavement in IITPAVE software.

1.3 ORGANIZATION OF REPORT:

The report consists of 3 chapters and is organized as below.

Chapter 1: Introduction

Chapter 2: Design of Flexible Pavement

Chapter 3: Conclusion and Observation

CHAPTER 2

DESIGN OF FLEXIBLE PAVEMENT

2.1 GENERAL

The flexible pavement is designed by an empirical method, as per the IRC guidelines (IRC: 37-2018) which is based mainly on CBR value of subgrade soil and design charts to determine the total pavement thickness. The design of flexible pavement is done according to IRC: 37-2018 guidelines using excel and it is analysed in IIT PAVE software. A flexible pavement is modelled as an elastic multilayer structure. The mechanistic empirical software called IITPAVE is used to analyse the pavement. The stress analysis IITPAVE software is used to compute the stresses and strains at critical location of the pavement. Horizontal Tensile strain at the bottom of the bitumen layer and Vertical Compressive strain on the top of the subgrade are considered as the critical parameters to limit cracking and rutting in bituminous and non-bituminous layers. The allowable tensile and compressive strains at critical location of the pavement are calculated using empirical equations mentioned in IRC: 37-2018 guidelines which is later compared with the actual tensile and compressive strains as computed by IIT PAVE software.

2.2 DESIGN PRINCIPLES

The flexible pavements have been modelled as a three-layer structure and stresses and strains at critical locations have been computed using the linear elastic model. To consider the aspects of performance, the following three types of pavement distress resulting from repeated (cyclic) application of traffic loads are considered:

1. vertical compressive strain at the top of the sub-grade can cause sub-grade deformation resulting in permanent deformation at the pavement surface.
2. horizontal tensile strain or stress at the bottom of the bituminous layer can cause fracture of the bituminous layer.
3. pavement deformation within the bituminous layer.

2.2.1 Performance Criteria

The following performance criteria are used in these guidelines for the design of bituminous pavements.

Fatigue cracking criteria for bituminous layer

With every load repetition, the tensile strain developed at the bottom of the bituminous layer develops micro cracks, which go on widening and expanding till the load repetitions are large enough for the cracks to propagate to the surface over an area of the surface that is unacceptable from the point of view of long-term serviceability of the pavement. The phenomenon is called fatigue of the bituminous layer and the number of load repetitions in terms of standard axles that causes fatigue denotes the fatigue life of the pavement. The two equations for the conventional bituminous mixes designed by Marshall Method are given

$$N_f = 1.6064 \times C \times 10^{-04}[1/\varepsilon_t]^{3.89} \times [1/M_{Rm}]^{0.854} \quad (for\ 80\ \%\ reliability) \tag{1}$$

$$N_f = 0.5161 \times C \times 10^{-04}[1/\varepsilon_t]^{3.89} \times [1/M_{Rm}]^{0.854} \quad (for\ 90\ \%\ reliability) \tag{2}$$

where,

$N_f =$ fatigue life of bituminous layer (cumulative equivalent number of 80 kN standard axle loads that can be served by the pavement before the critical cracked area of 20 % or more of paved surface area occurs)

$\varepsilon_t =$ maximum horizontal tensile strain at the bottom of the bottom bituminous layer (DBM) calculated using linear elastic layered theory by applying standard axle load at the surface of the selected pavement system

$M_{Rm} =$ resilient modulus (MPa) of the bituminous mix used in the bottom bituminous layer, selected as per the recommendations made in these guidelines.

$C = 10^M$

Where $M = 4.84\left(\frac{V_{be}}{V_a+V_{be}} - 0.69\right)$

V_a = per cent volume of air void in the mix used in the bottom bituminous layer

V_{be} = per cent volume of effective bitumen in the mix used in the bottom bituminous layer

The mix volumetric parameters used are: Va of 3.5% and Vbe of 11.5% and fatigue equation ‘C’ factor of 2.35 for pavement cases (2), (3) and (5) mentioned in 12.2. For (1), (4) and (6) pavement cases, for design traffic of 5, 10 and 20 msa, the Va , Vbe and ‘C” factor values considered are 4.5%, 10.5% and 1.12 and for 20, 30, 40 and 50 msa, the values are 3.5%, 11.5% and 2.35 respectively.

The factor ‘C’ is an adjustment factor used to account for the effect of variation in the mix volumetric parameters (effective binder volume and air void content) on the fatigue life of bituminous mixes [9] and was incorporated in the fatigue models to integrate the mix design considerations into the fatigue performance model.

Subgrade rutting criteria for bituminous layer

The distress of rutting is more critical in the subgrade under the pavement crust. This type of cracking is usually initiated at the top of the subgrade layer after repeated application of the axle loads. This initiation means that the actual vertical compressive strain at the top of the subgrade layer has exceeded a certain limit, which is the allowable strain. The allowable compressive strains were calculated using the rutting criteria equation as outlined in the Appendix I of IRC:37-2018. The equation is as follows.

$$N_R = 4.1656 \times 10^{-08} [1/\varepsilon_V]^{4.5337} \qquad (for\ 80\ \%\ reliability) \qquad (3)$$

$$N_R = 1.4100 \times 10^{-08} [1/\varepsilon_V]^{4.5337} \qquad (for\ 90\ \%\ reliability) \qquad (4)$$

where,

N_R= subgrade rutting life (cumulative equivalent number of 80 kN standard axle loads that can be served by the pavement before the critical rut depth of 20 mm or more occurs)

ε_V = vertical compressive strain at the top of the subgrade calculated using linear elastic layered theory by applying standard axle load at the surface of the selected pavement system

2.2.2 Reliability

According to IRC 37 guidelines, 90% reliability is recommended for design traffic of 20msa or more and 80% reliability for design less than 20 msa. And also recommend 90% reliability performance equation for subgrade and fatigue cracking of bottom bituminous layer for all important roads such as Expressways, National Highways, State Highways and Urban Roads.

2.2.3 Analysis of Flexible Pavement

For computing the stresses, strains and deflections, the pavement has been considered as a linear elastic layered system. IITPAVE software, developed for analysis of linear elastic layered systems, has been used for analysis and design of pavements. As mentioned previously, the vertical compressive strain on top of subgrade and the horizontal tensile strain at the bottom of the bituminous layer are the critical mechanistic parameters which need to be controlled for ensuring satisfactory performance of flexible pavements in terms of subgrade rutting and bottom-up cracking of bituminous layers. Table 1 presents the standard conditions recommended in these guidelines for the pavement analysis.

Table 1: Standard Conditions for Pavement Analysis using IITPAVE

Analysis Conditions	
Material response model	Linear elastic model
Layer interface condition	Fully bonded (all layers)
No. of Wheels	Dual wheel
Contact stress for critical parameter analysis	0.56 MPa for tensile strain in bituminous layer and vertical compressive strain on subgrade; 0.80 MPa for Cement treated base
Critical Mechanistic Parameters	
Bituminous layer	Tensile strain at the bottom
Cement treated base	Tensile stress and tensile strain at the bottom
Subgrade	Compressive strain at the top

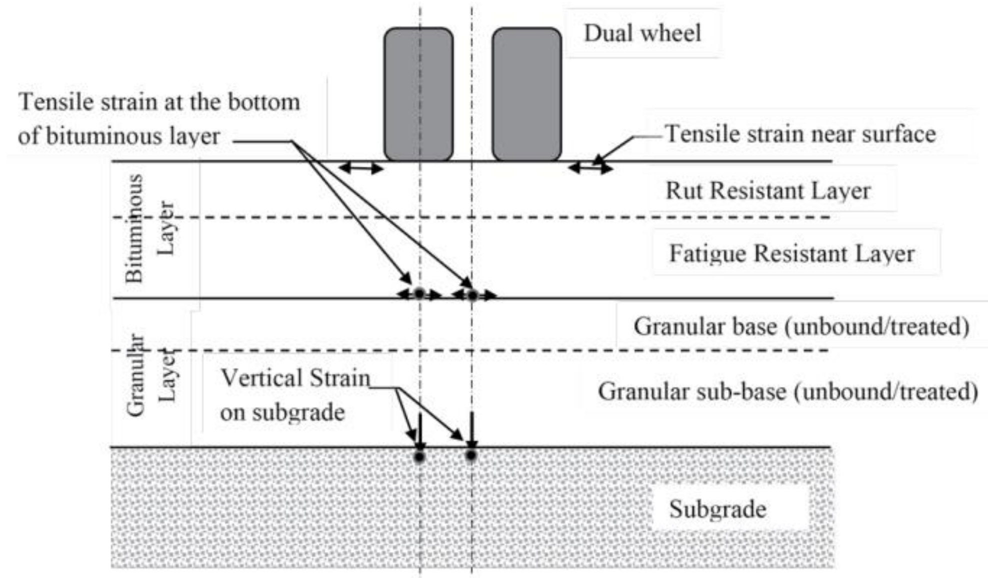

Figure 1: Compositions of Flexible pavement (for which the locations at which different critical mechanistic)

2.2 TRAFFIC

This section covers the estimation of design traffic for new roads. The relative structural damage caused to the pavement by different types of axles carrying different axle loads is considered using Vehicle Damage Factors (VDFs) in the estimation of design traffic.

2.2.1 General

The design traffic is estimated in these guidelines in terms of equivalent number of cumulative standard axles (80 kN single axle with dual wheels). For estimating the factors required to convert the commercial traffic volumes into equivalent repetitions of the standard axle, it is necessary to measure the axle load spectrum relevant for the stretch of road under consideration.

The following inputs are required for estimating the design traffic (in terms of cumulative standard axle load repetitions) for the selected road for a given design period.

- **i.** initial traffic (two-way) on the road after construction in terms of the number of commercial vehicles (having the laden weight of 3 tonnes or more) per day (CPVD)
- **ii.** average traffic growth rate(s) during the design life period
- **iii.** design life in number of years
- **iv.** spectrum of axle loads

v. factors for estimation of the lateral distribution of commercial traffic over the carriageway

Only the commercial vehicles having gross vehicle weight of 3 tonnes or more are considered for the structural design of pavements.

2.2.2 Traffic Growth Rate

Traffic growth rates shall be established for each category of commercial vehicles. In the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic.

2.2.3 Design Period

The design period to be adopted for pavement design is the time span considered appropriate for the road pavement to function without major rehabilitation. It is recommended that a design period of 20 years may be adopted for the structural design of pavements for National Highways, State Highways and Urban Roads. For other categories of roads, a design period of 15 years is recommended. Pavements for very high-density corridors (more than 300 msa) and expressways shall preferably be designed as long-life pavements. Otherwise, for such corridors, the pavement shall be designed for a minimum period of 30 years.

2.2.4 Vehicle Damage Factor

The vehicle damage factor (VDF) is a multiplier for converting the number of commercial vehicles of different axle loads and axle configurations to the number of standard axle-load (80 kN single axle with dual wheels) repetitions. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the axle configuration, axle loading, terrain, type of road, and from region to region. The axle load equivalency factors are used to convert different axle load repetitions into equivalent standard axle load repetitions.

The equations for computing equivalency factors for single, tandem and tridem axles given below should be used for converting different axle load repetitions into equivalent standard axle load repetitions. The exact VDF values are arrived after extensive field surveys.

$$\text{Single axle with single wheel on either side} = \left(\frac{Axle\ load\ in\ kN}{65}\right)^4 \quad (5)$$

Single axle with dual wheel on either side = $\left(\frac{Axle\ load\ in\ kN}{80}\right)^4$ (6)

Tandem axle with dual wheel on either side = $\left(\frac{Axle\ load\ in\ kN}{148}\right)^4$ (7)

Tridem axle with dual wheels on either side = $\left(\frac{Axle\ load\ in\ kN}{224}\right)^4$ (8)

When information on the axle loads is not available and the proportion of heavy vehicles using the road is small, the indicative values of Vehicle Damage Factor given in Table 2. below can be used.

Table 2: Indicative VDF values

Initial (Two-Way) Traffic Volume in Terms of Commercial Vehicles Per Day	Terrain	
	Rolling/Plain	Hilly
0-150	1.7	0.6
150-1500	3.9	1.7
More than 1500	5	2.8

2.2.5 Lateral Distribution of Commercial Traffic over the Carriageway

- **Single lane roads:** Traffic tends to be more channelized on single 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.
- **Two-lane single carriageway roads:** The design should be based on 75 % of the commercial vehicles in both directions.
- **Four-lane single carriageway roads:** The design should be based on 40 % of the total number of commercial vehicles in both directions.
- **Dual carriageway roads:** For the design of dual two-lane carriageway roads should be based on 75 % 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 % and 45 % respectively.

2.2.6 Computation of Design Traffic

The design traffic is considered in terms of the cumulative number of standard axles in the lane carrying maximum traffic during the design life of the road. This can be computed using the following equation:

$$N_{Des} = \left(\frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F\right) \qquad (9)$$

where,

N_{Des} = the cumulative number of standard axles to be catered for the design in terms of million standards axle (msa)

A = the initial traffic in the year of completion of construction in terms of the number of commercial vehicles per day

D = lateral distribution factor

F = vehicle damage factor (VDF)

n = design period, in years

r = the annual growth rate of commercial vehicles (r = -0.075 if growth rate is 7.5 percent per annum)

The traffic in the year of completion of construction may be estimated using equation 10.

$$A = P(1+r)^x \qquad (10)$$

where,

P = number of commercial vehicles per day as per last count and x = number of years between the last count and the year of completion of construction.

2.4 LAYERS OF FLEXIBLE PAVEMENT

A flexible pavement considered in these guidelines essentially consists of three functional layers above the subgrade. These are: sub-base, base, and bituminous layers. As per the guidelines of IRC: 37-2018, five different combinations of layers of pavement options are available for classified traffic and various material properties. The combinations contain layers of sub-base, base, binder and surface courses. Each combination of layers has been suggested

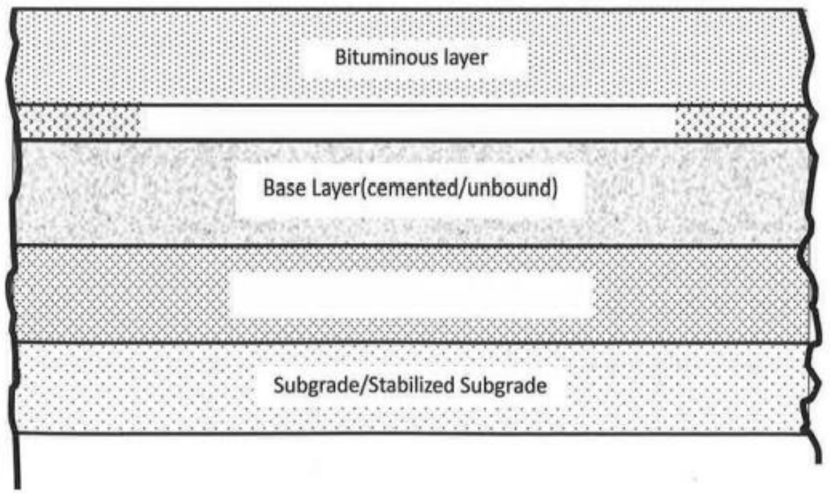

Figure 2: Layers of Flexible Pavement

for different environmental conditions and traffic. A flexible Pavement covered in these guidelines consist of different layers as shown in fig. below-

2.4.1 Subgrade

Sub-base materials comprise natural sand, gravel, crushed stone or combinations thereof meeting the prescribed grading and physical requirements. The sub-base material should have a minimum CBR of 20 % for traffic up to 2 msa and 30 % for traffic exceeding 2 msa respectively. Sub-base usually consists of granular or WBM and the thickness should not be less than 150 mm for design traffic less than 10 msa and 200 mm for design traffic of 10 msa and above.

Resilient Modulus of the Subgrade

Resilient modulus, which is measured considering only the elastic (or resilient) component of the deformation (or strain) of the specimen in a repeated load test is considered to be the appropriate input for linear elastic theory selected in these guidelines for the analysis of flexible pavements.

$$M_{RS} = 10.0 \times CBR \qquad (for\ CBR \leq 5\%) \qquad (11)$$

$$M_{RS} = 17.6 \times CBR^{\ 0.64} \qquad (for\ CBR \leq 5\%) \qquad (12)$$

Where, MRS = Resilient modulus of subgrade soil (in MPa). CBR = California bearing ratio of subgrade soil (%). Poisson’s ratio value or subgrade soil may be taken as 0.35.

2.4.2 Sub-Base

The recommended designs are for unbounded granular bases which comprise conventional water bound macadam (WBM) or wet mix macadam (WMM) or equivalent confirming to most specifications. The materials should be of good quality with minimum thickness of 225 mm for traffic up to 2 msa an 150 mm for traffic exceeding 2 msa.

Minimum thicknesses of granular sub-base layers

Irrespective of the design traffic volume, the following minimum thicknesses of granular sub-base layers may be provided. Preferably the subgrade soil should have a CBR of 2%. If the CBR

Resilient modulus of GSB layer

The elastic/resilient modulus value of the granular layer is dependent on the resilient modulus value of the foundation or supporting layer on which it rests and the thickness of the granular layer.

2.4.3 Base

The base layer consist of wet mix macadam, water bound macadam, crusher run macadam etc. Relevant specification of IRC is to be adopted for the construction. Poisson's ratio of granular bases and sub-bases may be taken as 0.35.

2.4.4 Bituminous Layer

A bituminous pavement generally consists of bituminous surfacing course and a bituminous base/binder course. The surfacing consists of a wearing course or a binder course and wearing course. The most used wearing courses are surface dressing, open graded premix carpet, mix seal surfacing, semi-dense bituminous concrete and bituminous concrete. For binder course, MOST specifies, it is desirable to use bituminous macadam (BM) for traffic up to 5 msa and dense bituminous macadam (DBM) for traffic more than 5 msa. Binder layer consists of DBM and BM are to be adopted for construction. It is act like as load distribution and supporting layer. Surface layer consists of BC, SDBC and PC are to be adopted for construction.

Table 3: Summary of Bituminous Layer Options Recommended

Traffic Level	Surface course		Base/Binder Course	
	Mix Type	Bitumen type	Mix type	Bitumen type
>50 msa	SMA	Modified bitumen or VG40	DBM	VG40
	GGRB	Crumb rubber modified bitumen		
	BC	With modified bitumen		
20-50 msa	SMA	Modified bitumen or VG40	DBM	VG40
	GGRB	Crumb rubber modified bitumen		
	BC	With modified bitumen		
<20 msa	BC/SDBC/PMC/MSS/ Surface Dressing (besides SMA, GGRB and BC with modified binders)	VG40 or VG30	DBM/BM	VG40 or VG30

Resilient Modulus of Bituminous Mixes

Resilient modulus of bituminous mixes depends upon the grade of binder, frequency/load application time, air voids, shape of aggregate, aggregate gradation, maximum size of the aggregate, bitumen content, etc.

Table 4: Indicative Values of Resilient Modulus (MPa) of Bituminous Mixes

Mix type	Average Annual Pavement Temperature °C				
	20	**25**	**30**	**35**	**40**
BC and DBM for VG10 bitumen	2300	2000	1450	1000	800
BC and DBM for VG30 bitumen	3500	3000	2500	2000	1250
BC and DBM for VG40 bitumen	6000	500	4000	3000	2000
BC with Modified Bitumen	5700	3800	2400	1600	1300
BM with VG10 bitumen	500 MPa at 35°C				
BM with VG30 bitumen	700 MPa at 35°C				

Resilient moduli of 2000 MPa (VG30 binder mix for BC as well as DBM) and 3000 MPa (VG40 binder mix for BC as well as DBM) were considered for less than 20 msa and 20 to 50 msa categories respectively. It may be noted that, for expressways and national highways, even if the design traffic is less than 20 msa, VG40 bitumen shall be used for surface as well as DBM layers.

2.5 PAVEMENT DESIGN AS PER IRC 37:2018

Pavement design is carried out in accordance with IRC: 37:2018 for the following base and sub-base options.

- Unbound - Granular base and sub-base

Design Inputs	
Design Life	20 years
Design Traffic	20.4 msa
Design CBR	10%

Traffic Volume count is attached in Annexure 1.

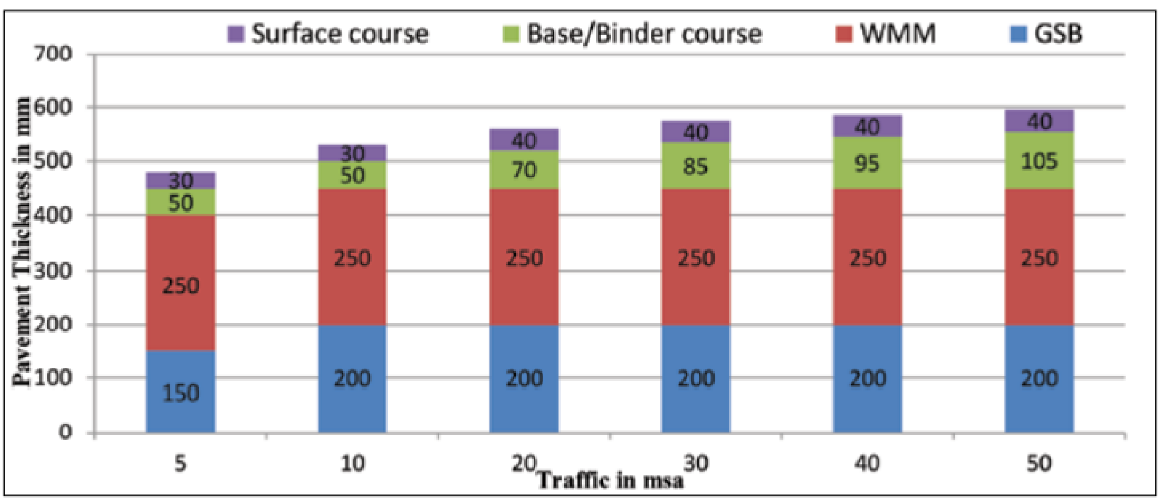

Figure 3: Catalogue for Pavement with Bituminous Surface Course with Granular Base and sub-base - Effective CBR 10% (Plate-6)

From PLATE 6, BC = 40 mm, DBM = 70 mm, WMM = 250 mm, GSB-200 mm.

Actual Strains in the Pavement Structure

The actual tensile strains were calculated using the various pavement design parameters as inputs in the IITPAVE programs. The actual strains are computed using various trial pavement structural layer combinations. An average pavement temperature of 25 ℃ has been considered for pavement design and selection of modulus of bitumen. The tyre pressure used in the analysis was 0.56 MPa (560 K.pa). Standard axle used was dual type, having a mass of 8160 kg. This resulted in a single tyre load of 20 kN. The Poisson's ratio of bituminous layer, granular layer and sub-grade layers is taken as 0.35. The pavement layer thickness is derived for the traffic volume of 20 msa corresponding to 10 % CBR, the pavement crust thickness is tabulated below according to IRC: 37 - 2018 plate 5.

2.6 ANALYSIS OF PAVEMENT BY USING IIT PAVE SOFTWARE

Before carrying out IITPAVE analysis, the flexible pavement is designed as per IRC: 37-2018 guidelines and the thickness of each layer in pavement structure are determined. In the IIT PAVE software, the elastic modulus, Poisson’s ratio, thickness of different layers, wheel load and tyre pressure of a vehicle, radial distance between two tyres are given as input. After entering the input data, click on submit button. After this, click on the run button, this gives the stresses and strains result at different layers by analysing the input data fed. The strains obtained are compared with the allowable strains. If the actual strains obtained from IITPAVE software is less than the allowable strains obtained from IRC: 37-2018, then the given pavement thickness is said to be safe and satisfied.

Actual vertical compressive strains are lesser than the Allowable vertical compressive strains shows that the pavement designed is safe.

Allowable Horizontal Tensile strain in Bituminous Layer is 0.0004528

Allowable vertical compressive strain on subgrade is 0.000224204

From IITPAVE software the computed strains are:

Horizontal tensile strain in bituminous layer is 0.0001948

Vertical compressive strain on subgrade is 0.0002225

Hence pavement composition is safe.

Design Traffic						
Traffic in CVPD as per last count	P	750				
Type of carriage way		Four-lane single carriageway roads				
Lane distribution factor	D	50%				
Annual growth rate of commercial vehicles in percentage	r	6%				
Construction Period	x	3 Years				
The traffic in the year of completion of construction	A	868.22				
Vehicle damage factor	F	3.9				
Type of Terrain		Rolling/Plain				
Category of Road		National Highway (NH)				
Design Period	n	20 Years				
The cumulative number of standard axles to be catered for during the design in terms of msa	N	20.4 msa				
Average Annual Pavement Temperature °C		25 °C				
Effective CBR	CBR	10				
Effective resilient modulus of Subgrade		76.83 MPa				
Type of Bitumen		BC and DBM for VG30 bitumen				
Resilient Modulus of Bituminous Mixes		3000.00 MPa				
Type of Base layer		Bituminous Surface Course with Granular Base and Sub-base				
Thickness of Individual Layers (in mm)	**Total Pavement Thickness (mm)**	**Surface Course**	**Base / Binder Course**	**WMM**	**GSB**	
Plate6	560	40	70	250	200	
Resilient Modulus of the Subgrade	76.83 MPa					
Resilient modulus of Granular layer	240.15 MPa					
Reliability Factor	90 %					
Allowable Vertical Tensile Strain (ε_v)	0.000453					
Allowable Horizontal Tensile Strain (εt)	0.000224					
Center to center distance between Tyres	310 mm	Load on single wheel (N)	20000 N	Tyre Pressure	0.56	

IITPAVE INPUTS					
No of Layers	3				
Layer:1 Elastic Modulus (Mpa)	3000	Poison Ratio	0.35	Thickness(mm)	110
Layer:2 Elastic Modulus (Mpa)	240.15	Poison Ratio	0.35	Thickness(mm)	450
Layer:3 Elastic Modulus (Mpa)	76.83	Poison Ratio	0.35		
Wheel Load (N)	20000	Tyre Pressure (Mpa)	0.56		
Analysis Point	4				
Point:1 Depth(mm)	110	Radius(mm)	0		
Point:2 Depth(mm)	110	Radius(mm)	155		
Point:3 Depth(mm)	560	Radius(mm)	0		
Point:4 Depth(mm)	560	Radius(mm)	155		
Wheel Set	2				

IITPAVE OUTPUT			
Tensile strain @ bottom ofbituminous layer		**Vertical compressive strain @ top of the subgrade**	
Allowable	Actual by IITPAVE	Allowable	Actual by IITPAVE
0.0004528	0.0001948	0.000224204	0.0002225

The detailed output of IIT-Pave is attached in Annexure – 2

CHAPTER 3
CONCLUSION

3.1 GENERAL

Recommendations for Pavement Design:

• The flexible pavement has been designed for design life of 20 years.

• The sub-base and base courses are designed for design traffic of 20.4 MSA and design CBR of 10 %.

3.2 CONCLUSION

The Flexible pavement is designed by following IRC:37-2018 guidelines and the pavement is analysed by IIT PAVE software

1) The composition of the pavement for 20.4 msa is BC = 40mm, DBM = 70mm, WMM = 250mm, GSB = 200mm

2) The allowable tensile strain and actual tensile strain in bituminous layer from IRC: 37-2018 is 452.8 micro strains and 194.8 micro strains.

3) The allowable compressive strain and actual compressive strain from IRC: 37-2018 and IIT PAVE is 224.2 micro strains and 222.5 micro strains.

ANNEXURE – 1

Traffic Data Collection Table

Table 5: Classified Traffic Volume Count

Classified Traffic Volume Count										
Location	**NH 32**									
From	**Ongur**				**To**	**Pillaipakkam**				
Time	**2W**	**3W**	**Car/Jeep**	**Bus**	**LCV**	**Truck**		**Agri Tractor**	**Other**	**Total**
						2-axle	**Multi-axle**			
12:15PM – 12:45 PM	117	10	214	33	17	24	27	0	0	442
12:45PM – 1:15 PM	108	4	229	38	19	26	11	1	1	437
1:15PM – 1:45 PM	95	3	219	28	19	32	27	1	0	424
1:45PM – 2:15 PM	135	7	210	34	21	21	18	3	0	449
2:15PM – 2:45 PM	108	6	208	25	24	20	31	2	0	424
2:45PM – 3:15 PM	98	5	184	30	25	23	35	0	0	400
Total	661	35	1264	188	125	146	149	7	1	2576
Percentage	25.7	1.4	49.1	7.3	4.9	5.7	5.8	0.3	0.0	100

Analysis Of Data

Table 6: Traffic Flow Rate

Types of Vehicles		PCE	Group 1	Group 2	Group 3	Group 4	Group 4	Group 5
			12:15PM – 12:45 PM	12:45PM – 1:15 PM	1:15PM – 1:45 PM	1:45PM – 2:15 PM	2:15PM – 2:45 PM	2:45PM – 3:15 PM
2W		0.5	117	108	95	135	108	98
3W		0.8	10	4	3	7	6	5
Car/Jeep		1	214	229	219	210	208	184
Bus		3	33	38	28	34	25	30
LCV		2.2	17	19	19	21	24	25
Truck	2- axle	4.5	24	26	32	21	20	23
	multi- axle	4.5	27	11	27	18	31	35
Agri Tractor		1.5	0	1	1	3	2	0
Other		4	0	1	0	0	0	0
Total Vehicles in PCU			646.4	614	661.7	611.3	627.1	643
Flow Rate (PCU/hr)			3878.4	3684	3970.2	3667.8	3762.6	3858

Table 7: Recommended PCU Factors for Various Types of Vehicles (IRC-64,1990)

Vehicle	Value of PCU
Motorcycle (2- wheeler)	0.50
3-wheeler	0.80
Car	1.00
Bus	3.00
Truck-trailer	4.50
Agri Tractor, Light Commercial Vehicles (LCV)	1.50
Bicycle	0.50
Other (animal drawn/pushcart)	4.00

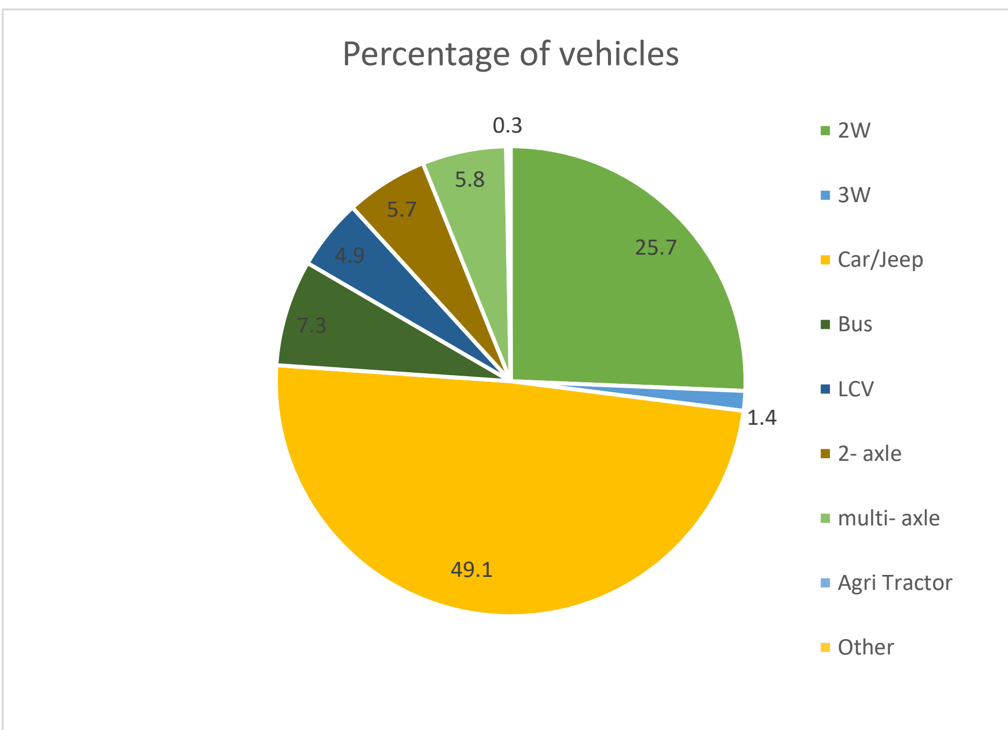

Figure 4: Percentage of Vehicles

ANNEXURE – 2

IITPAVE Analysis

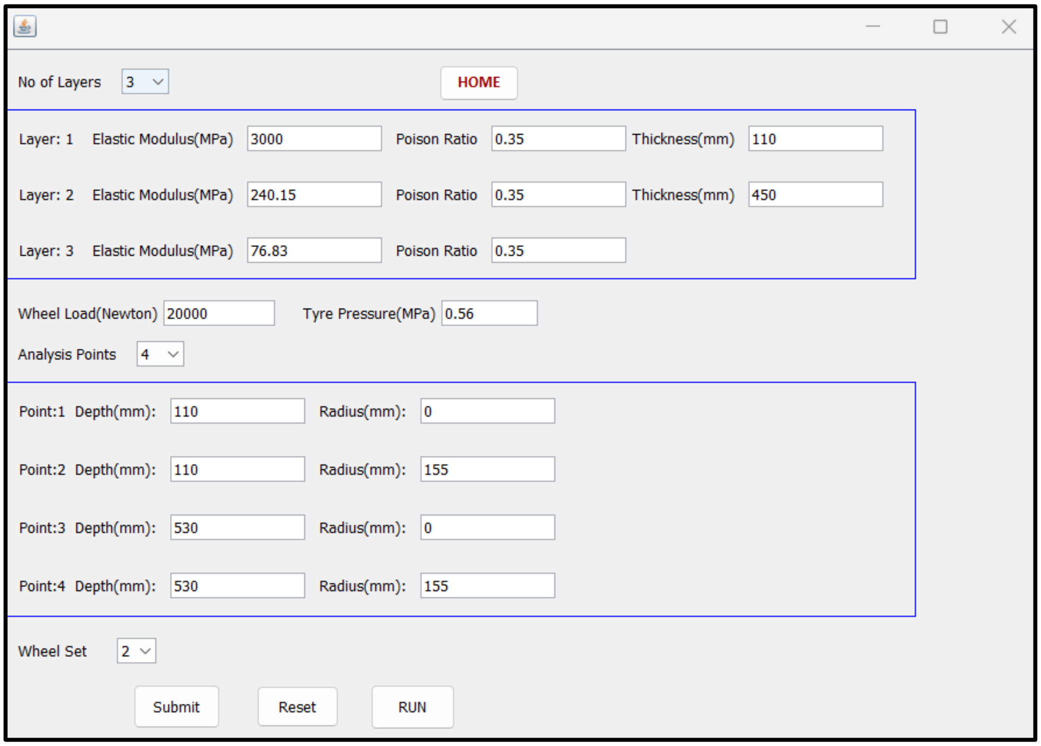

Figure 5: Input to IITPAVE Software

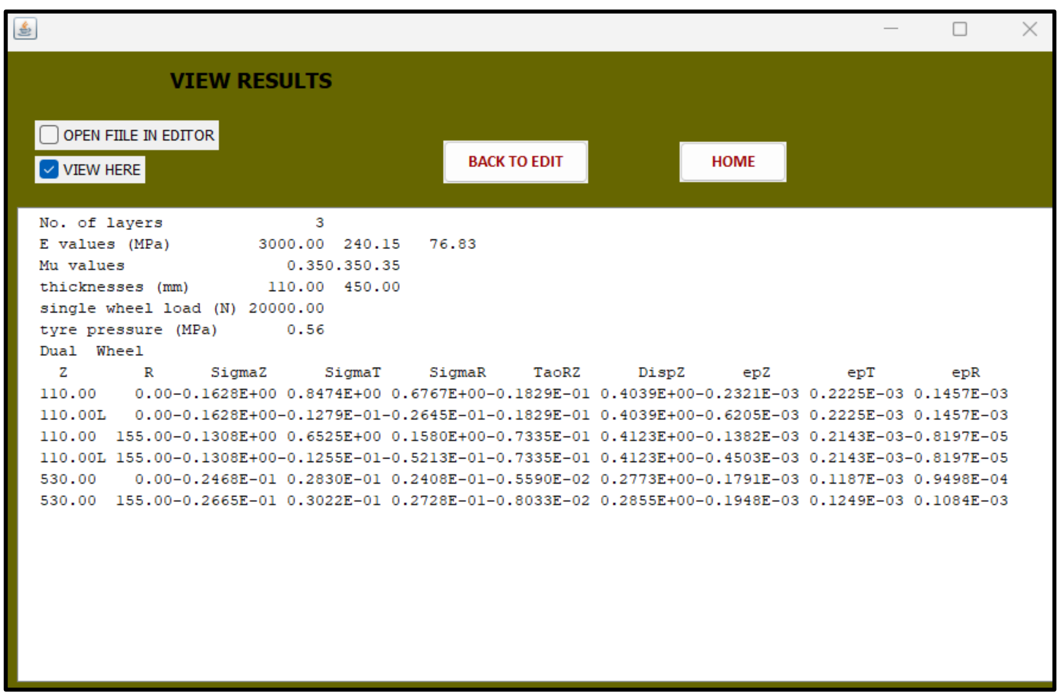

Figure 6: Output from IITPAVE Software

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