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Performance Evaluation of Flexible Pavements: A Case Study

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Abstract: Flexible pavements get distress during their service life because of increase in traffic particularly commercial vehicles. The present study focuses on finding the increase of magnitude of deformations from 2008 to 2015 traffic data using ANSYS for which the BRTS stretch in Visakhapatnam is considering five locations along the stretch.

Keywords **:Traffic, Deformations, Flexible pavements, ANSYS.**

I. INTRODUCTION

The city of Visakhapatnam is situated on the north-east coasts of Andhrapradesh and it is one of the fastest growing cities in Asia and turning into a metropolis with rapid industrialization and tourism attractions. City of Visakhapatnam is the most protected natural harbour in India. Due to the presence of Eastern Naval Command, Steel plant, HPCL, the city has been the home to people from different parts of the country and the city is well connected with daily flights from Delhi, Chennai, Hyderabad, Mumbai, Bangalore, Tirupati and Raipur. All these factors are leading to high growth of population in the city. Visakhapatnam has experienced high growth in population and the same trend is expected to continue over the next two decades.

With high growth of population, there is an increasing number of road users and leading to more number of vehicles. Pavements are designed to carry estimated loads during their service life but they get distress due to heavy growth of commercial vehicles. A typical flexible pavement cross section comprises of four layers namely surface course, base course, subbase course and subgrade layer.
The heavy growth of traffic will distress the flexible pavement in the form of rutting. Rutting is one of the major distresses observed in flexible pavements. The figure1 shows the rutting failure in flexible pavements.

Fig.1. Rutting in flexible pavements

The present study area is considered in Visakhapatnam which is a BRTS stretch. There are two BRTS stretches in Visakhapatnam named as PTC (Pendurthi Transit Corridor) and STC (Simhachalam Transit Corridor). PTC is of 20km length and STC is of 18.4km length. Five different locations are considered along the STC for the analysis. The five locations selected along the STC are Rama talkies (A), Maddilapalem (B), Hanumanthwaka (C), Adavivaram (D), and between Goshala-Vepagunta (E).The five study areas are represented as shown in table1.

Table1. Representation of study areas

Sl no	Study area	Representation
1.	Rama talkies	A
2.	Maddilapalem	B
3.	Hanumanthwaka	C
4.	Adavivaram	D
5.	Goshala-Vepagunta	E

The flexible pavement selected in above five locations is modeled using ANSYS and the performance analysis of pavement is compared with past and present vehicular data to observe the increase in deformations and stresses due to commercial vehicles.

II. METHODOLOGY

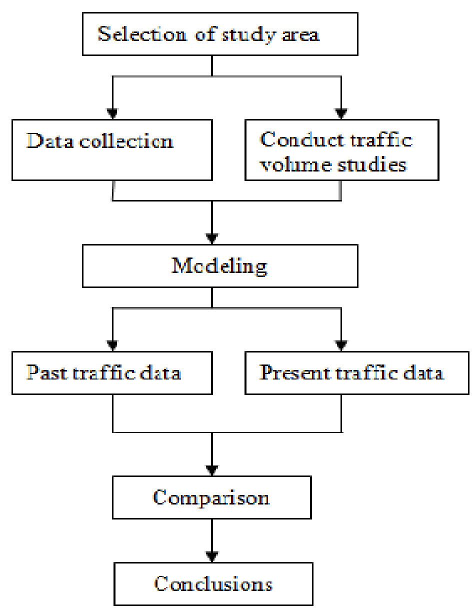

Fig.2. Methodology of project

A. Input parameters

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The properties of flexible pavement at all locations considered for the analysis is shown in table1.

Table1. Properties of flexible pavement of BRTS stretch

Sl no	Layer	Thickness (mm)	Young's modulus , E (MPa)	Poisson's ratio(μ)
1.	Surface	140	3000	0.4
2.	Base	250	1400	0.3
3.	Subbase	230	1300	0.3
4.	Subgrade	100	600	0.4

The young's modulus, poisson's ratio and thickness of different layers are used as input parameters for modeling the pavement in ANSYS.

B. Traffic data

The past traffic data on roads Rama talkies, Maddilapalem, Hanumanthwaka, Adavivaram and Goshala is collected to model the pavement in ANSYS to know the stresses and deformations developed in the pavement because of traffic existing at the time of design of pavement. The traffic data collected is presented in table2.

Table2. Traffic details of study areas

Sl no	Location	Peak Hour	Peak hour traffic	Commercial vehicles
1.	Rama talkies	5:30-6:30pm	5036	182
2.	Maddilapalem	6:30-7:30pm	3622	148
3.	Hanumanthwaka	8:30-9:30am	1654	58
4.	Adavivaram	9:45-10:45am	1126	76
5.	Goshala	9:30-10:30am	538	10

III. MODELING

The young's modulus, poisson's ratio and thickness of different layers are used as input parameters for the analysis. The pavement is modeled using PLANE 82 quadrilateral elements. The boundary conditions are i) the subgrade layer has its displacements completely restrained. ii) The sides of the pavement model have no restraints in vertical direction but they are completely restrained over the other two possible displacements. Meshing of pavement is done which is shown in fig8.

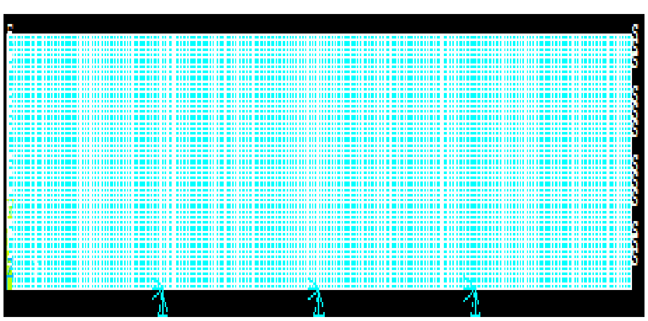

Fig.3. Meshing of pavement

The pavement is modeled for the past traffic considering the commercial vehicles and the obtained results are presented in results chapter.

IV. RESULTS

5.1 Deformations in Five Locations:

The flexible pavements under consideration are loaded for the commercial vehicles and the obtained deformations in various layers through modeling are presented below.

A. Rama talkies location

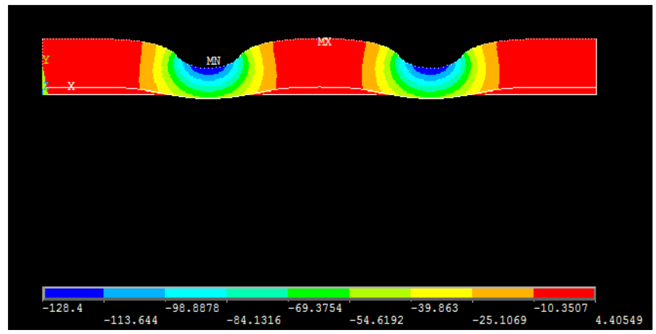

Fig.4.Deformations in pavement at location A

The deformations developed for the flexible pavement at ramatalkies location are of 4 to 128mm for the present traffic loading shown in figure4.

B. Maddilapalem location

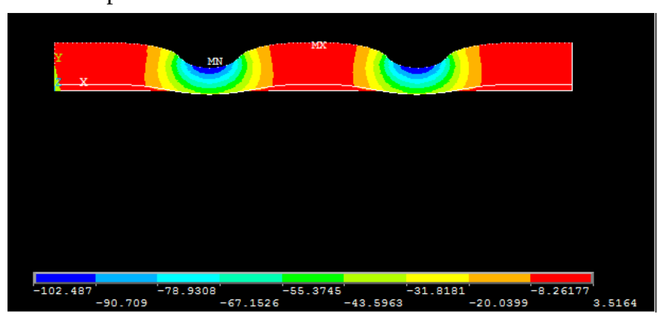

Fig.5.Deformations in pavement at location B

The deformations developed for the flexible pavement at ramatalkies location are of 3 to 100 mm for the present traffic loading shown in figure 5.

C. Hanumanthwaka location

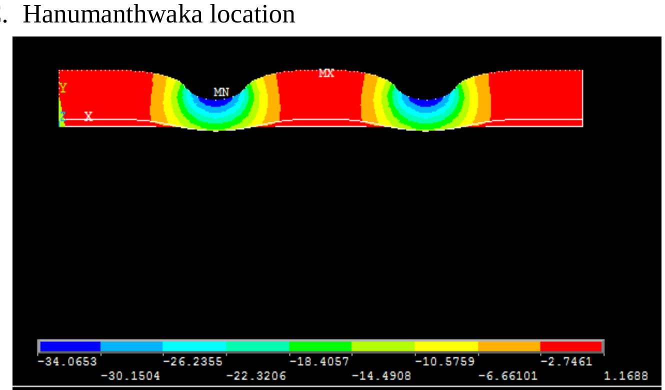

Fig.6.Deformations in pavement at location C

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The deformations developed for the flexible pavement at ramatalkies location are of 1 to 34 mm for the present traffic loading shown in figure6.

D. Adavivaram

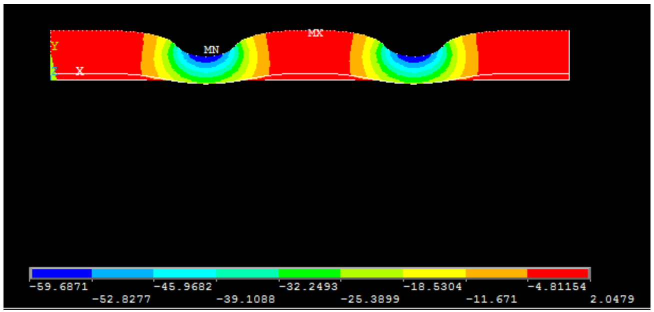

Fig.7.Deformations in pavement at location D

The deformations developed for the flexible pavement at ramatalkies location are of 2 to 60 mm for the present traffic loading shown in figure7.

E. Goshala

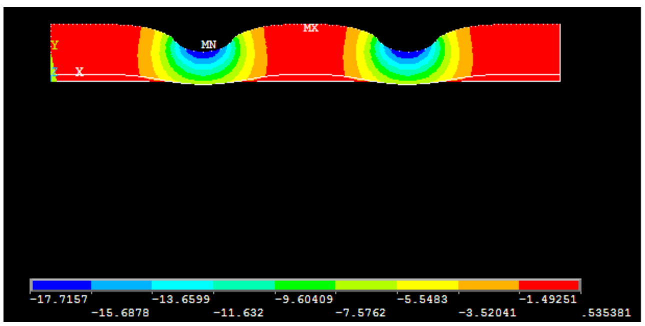

Fig.8.Deformations in pavement at location E

The deformations developed for the flexible pavement at ramatalkies location are of 17 mm for the present traffic loading shown in figure8.

5.2 Comparison of flexible pavement performance for present and past traffic:

The flexible pavements considered at different locations are loaded for present and past traffic and the observed deformations in various layers are plotted as shown below.

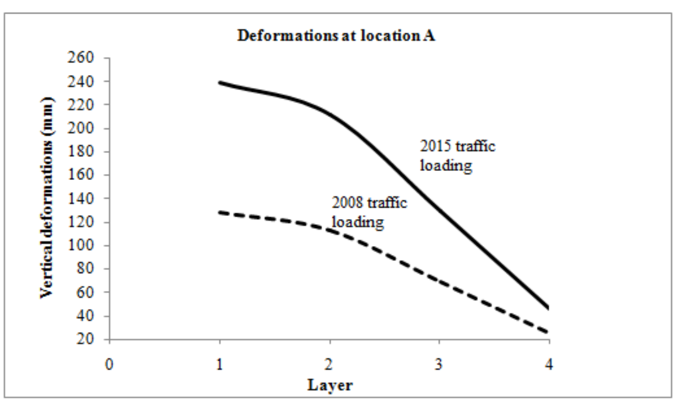

Fig.9.Deformations at location A for past and present traffic

Figure9 shows the deformations in various layers for the present and past traffic. It is observed that deformations for the present traffic are of 240mm and for past traffic it is of 120mm.

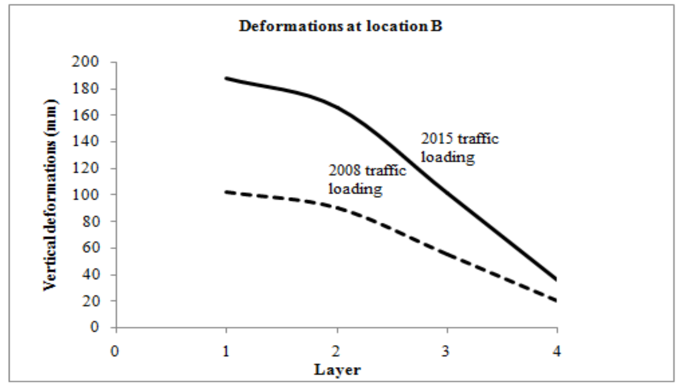

Fig.10.Deformations at location B for past and present traffic

Figure10 shows the deformations in various layers for the present and past traffic. It is observed that deformations for the present traffic are of 190mm and for past traffic it is of 100mm.

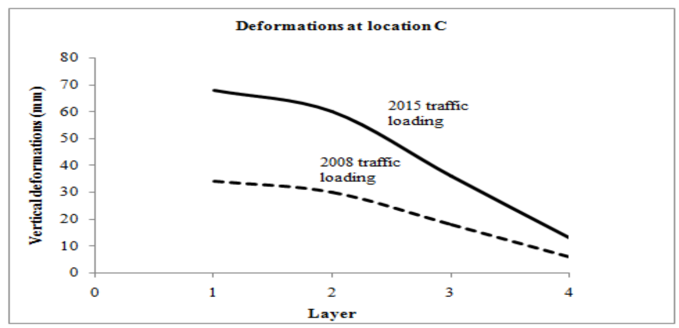

Fig.11.Deformations at location C for past and present traffic

Figure11 shows the deformations in various layers for the present and past traffic. It is observed that deformations for the present traffic are of 70mm and for past traffic it is of 35mm.

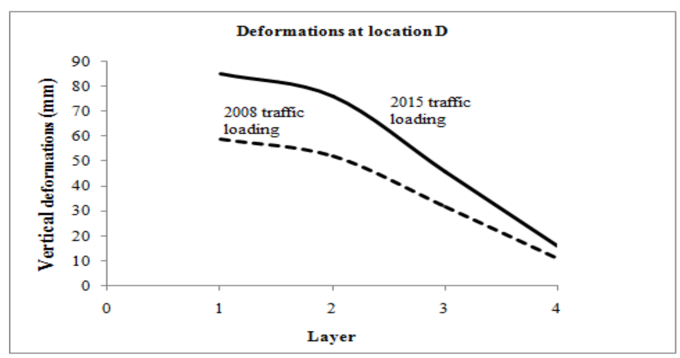

Fig.12.Deformations at location D for past and present traffic

Figure12 shows the deformations in various layers for the present and past traffic. It is observed that deformations for the present traffic are of 90mm and for past traffic it is of 60mm.

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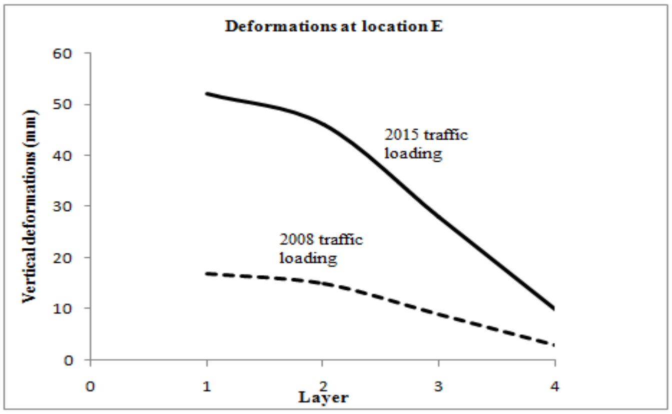

Fig.13.Deformations at location E for past and present traffic

Figure13 shows the deformations in various layers for the present and past traffic. It is observed that deformations for the present traffic are of 50mm and for past traffic it is of 15mm.

V. CONCLUSIONS

[1] Deformations developed for the location A and B are increased highly with magnitude of 240mm, 190mm for 2015 traffic and 120mm, 100mm for 2008 traffic.

[2] Deformations developed for the location C, D and E are moderate with magnitudes of 70mm, 90mm, 55mm for 2015 traffic and 35mm, 60mm, 15mm for 2008 traffic.

[3] Low Young's modulus of pavement layers are one of the reasons for distress in all the flexible pavements considered.

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