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Analysing Damage on Pavement due to Axle load Spectrum: A Case study of Lingda to Samrkha Road

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*Abstract— **Overloading is one of the major factors for the pavement deterioration. Overloading mainly occurs, as truck owners have a tendency to gain more profit with the same investment and modern trucks are capable of handling very heavy load. To reduce the effect of overloading different government agencies have prescribed the value of maximum allowable load limit, which must be obeyed by all the truck operators and truck owners. In the present study, Weight in Motion method is used for the axle load survey. Pavement condition rating is also done as per IRC: 82 – 2015. Axle load Spectrum is generated with the help of axle load study. Based on the Axle load survey, stress – strain analysis is done with the help of ANSYS software. Based on the Stress, strain and deformation value damage analysis for different vehicle class has also been performed. In the present study, stretch of SH – 60 (Lingda to Samrkha via Bhalej) is selected for the overloading study.***

Keywords— Overloading, Weight in Motion, Pavement Condition Rating, Axle Load Spectrum, ANSYS Software

INTRODUCTION

There are many factors which play an important role in pavement deterioration Such as Overloading, Load on axle, Number of axles, Wheel configuration, Type of pavement, Region, Temperature, Rainfall etc. But, the pavement deterioration is mainly caused due to overloading of vehicles. The truck owners have a tendency to gain more profit with the same investment. Because the Morden trucks are capable of handling heavier load even more than the legal axle load limit. Different axles will have a different load under a mixed traffic condition, which may cause a different amount of distress or damage to the pavement. To act as a safeguard for the pavement against overloading government or different agencies have suggested different values for Legal axle load limit or Maximum allowable load limit. In India, according to CSIR Report 2001, Legal axle load limit is taken as 10.2 tonnes, 19 tonnes and 24 tonnes for Single axle, Tandem axle and Tridem axles respectively.

STUDY AREA LOCATION

The location of the study area starts from Lingda to Samrkha via Bhalej. The total length of the stretch is 14.300 km. Map view of the study area is shown in the figure,

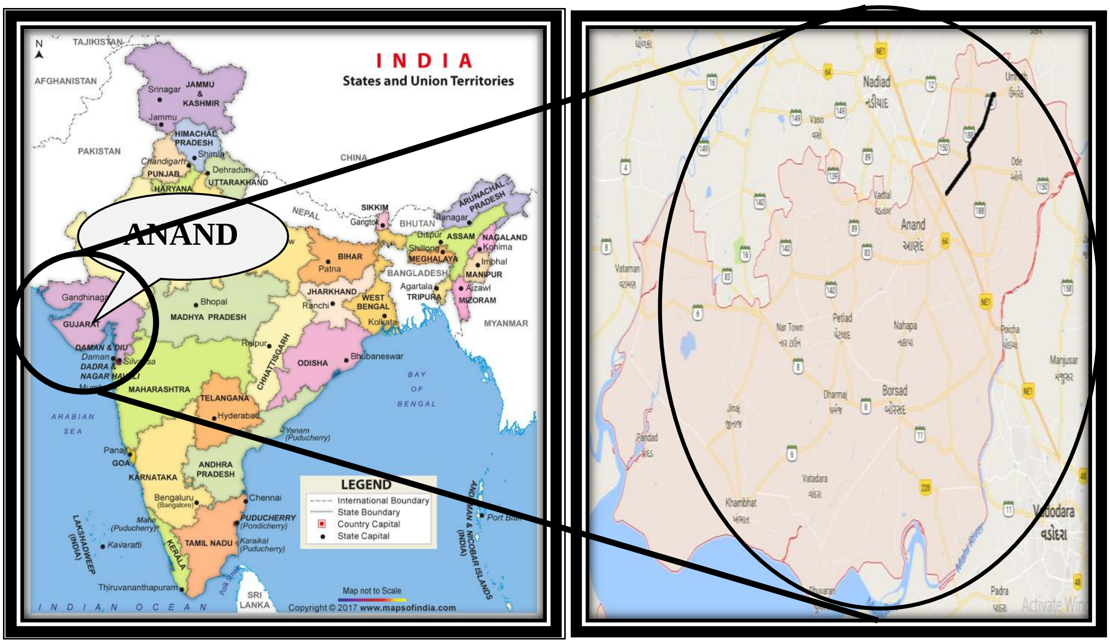


Fig.1 Location of Study area

METHODOLOGY

To analyse damage due to axle load spectrum, various types of the survey such, Pavement Condition survey, Traffic survey and Axle load survey should be carried out.

Pavement Condition Survey

Pavement Condition survey is conducted by visual inspection. Various types of distresses such as Potholes, Patching, Rutting, Corrugation, Alligator cracking, Longitudinal and transverse cracking are identified and measured manually. Pavement Condition rating is done as per IRC – 82:2015. Result of pavement condition survey is shown below,

TABLE 1

SUMMARY OF PAVEMENT CONDITION SURVEY

Chainage		Type of distress							
From (Km)	To	Cracking			Ravelling (m^2)	Pot holes Area (m^2)	Rutting (m^2)	Patching (m^2)	Corrugation (m^2)
		Alligator (m^2)	Longitdinal (m)	Transeverse (m)					
00/00	01/00	4.03	22.8	0	22.63	0.310	2.075	7.29	0
01/00	02/00	17.02	7.3	2.4	6.59	0.147	4.74	14.79	0
02/00	03/00	24.56	5.4	9.2	9.04	0.133	3.28	46.01	0
03/00	04/00	16.56	15.1	0	0	0.187	2.95	3.04	0
04/00	05/00	15.65	6.8	0	2.24	0.079	3.2	2.48	0
05/00	06/00	48.47	11.9	3.2	156.97	0.104	20.86	0	0
06/00	07/00	130.25	6.5	0	70.73	0.085	12.87	28.56	0
07/00	08/00	46.93	11.7	0	22.83	0.205	10.67	51.27	0
08/00	09/00	194.51	1.8	0	26.07	0	7.35	55.24	0
09/00	10/00	104.85	8.9	0	33.6	0.053	7.52	53.62	0
10/00	11/00	35.67	8.6	0	27.5	0.317	14.32	8.71	0
11/00	12/00	32.97	0	0	12.61	0	15.37	9.05	0.91
12/00	13/00	1.82	0	0	11.77	0.018	1.72	9.45	0
13/00	14/300	1.24	4	0	6.88	0	0.36	3.68	0
Total area of distress		674.53	110.8	14.8	409.46	1.643	107.285	293.19	0.91

TABLE 2 - PAVEMENT CONDITION RATING

Distress type	Percentage of distress (%)	Weighted Rating Value
Cracking	5.6	1.2
Ravelling	2.82	0.9
Pot holes	0.01	1.25
Rutting	0.75	2.9
Patching	2.04	0.9
Final Rating Value		1.43
Condition		Fair

B. Traffic Survey

CVC (Classified Volume Count) survey was conducted at Bhalej. The summary of Classified Volume Count Survey is given below,

TABLE 3 - SUMMARY OF CLASSIFIED VOLUME COUNT SURVEY

Sr No	Type of Vehicles	Total Commercial Vehicles
1	Bus	133
2	2 Axle Truck	505
3	3 Axle Truck	525
4	Multi Axe Truck	368
Total Commercial Vehicles		1503

C. Axle Pad Survey

The most significant parameter for the pavement performance is Axle load. To measure the axle load, axle load survey should be carried out. There are mainly two methods to weigh axle loads – (1) Static weighing (2) Weight in motion method. The most commonly used method for axle load survey is weigh in motion method (WIM). In the present study, weight in motion method is used.

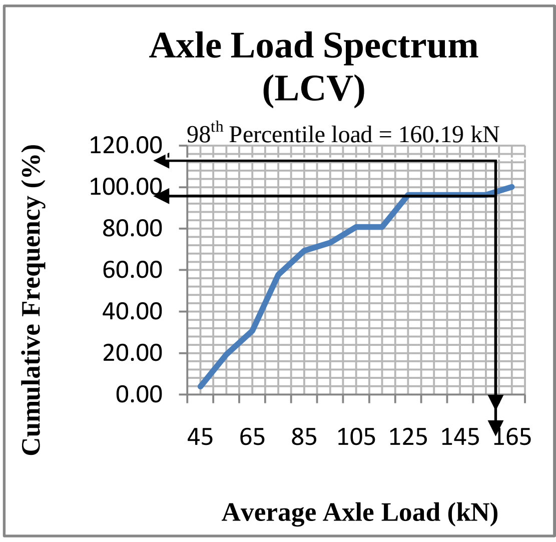
The sample size of the Axle pad survey as per IRC:37 – 2012 is 464. Axle pad survey is also useful to determine the value of Load Equivalency Factor, Equivalent Single Axle Load, and Vehicle Damage Factor. The summary of Load Equivalency Factor, Equivalent Single Axle Load, and Vehicle Damage Factor is shown below,

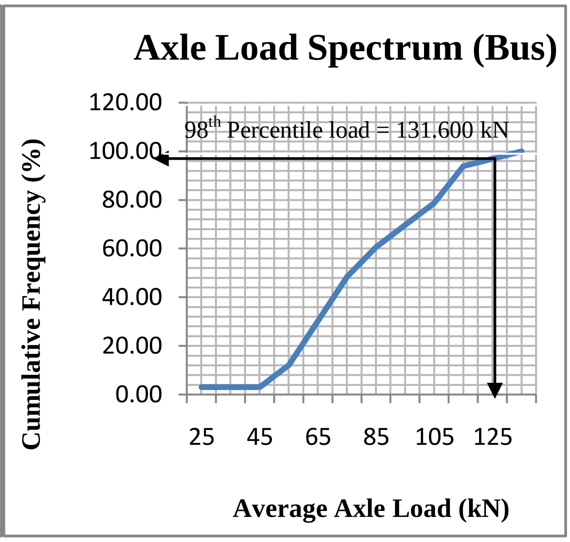
TABLE 4 - CALCULATION OF LEF, ESAL AND VDF

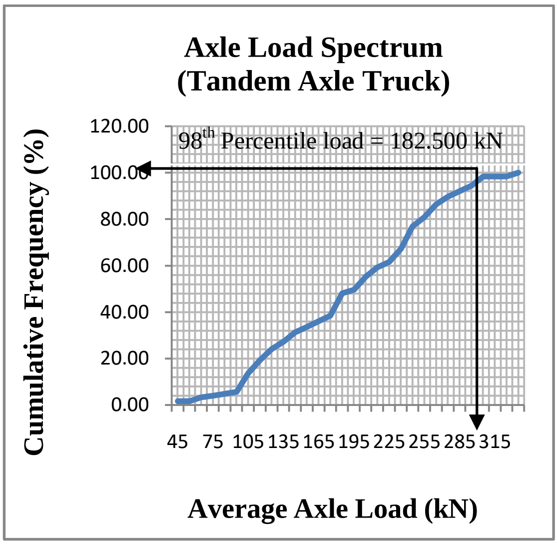
Sr no	Vehicle Classification	No of Vehicles weighed	Load Equivalency Factor (LEF)	ESAL	VDF
1	Bus	33	0.37	12.21	3.47
2	LCV	26	0.60	15.60	
3	Single Axle Truck	100	1.23	123	
4	Tandem Axle Truck	125	2.51	313.75	
5	Tridem Axle Truck	95	7.14	678.3	
6	Multi Axle Truck	37	8.19	303.03	

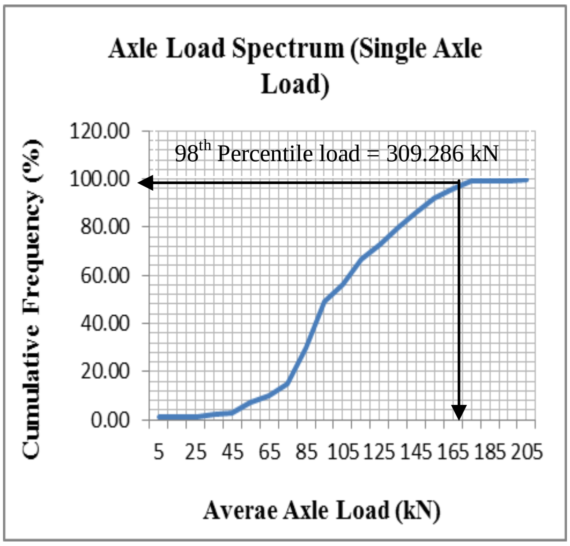
D. Axle Load Spectrum

Axle Load Spectrum for different vehicle class are shown below,









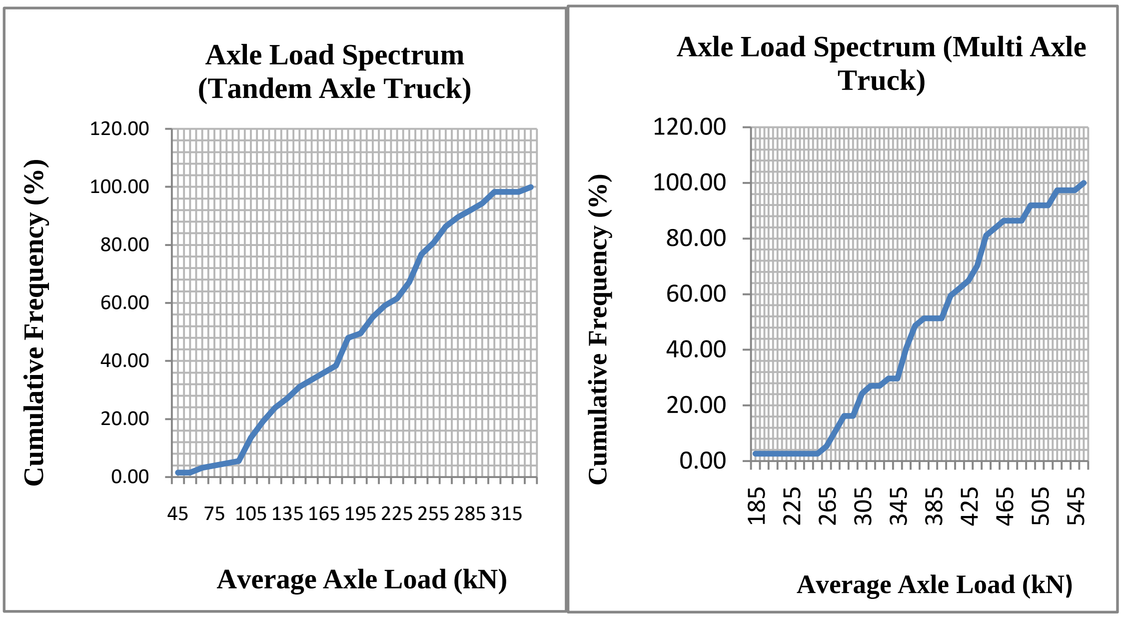


Fig.2 Axle Load Spectrum for different vehicle class

E. Result Analysis

In the present study, ANSYS R 15.0 is used to determine the value of stress, Strain and deformation. It requires the material properties like Unit weight, Modulus of Elasticity, Pavement layer thickness, Poisson's ratio, for each pavement layer. 98th percentile load is applied on pavement surface for each vehicle classes.

The analysis of single axle truck using ANSYS is presented here. The 98th percentile load for Single Axle Truck is 182.500 kN. Load on each rear tandem wheel is 32.500 kN. Stress, Strain and deformation are determined using ANSYS software as shown in following figures.

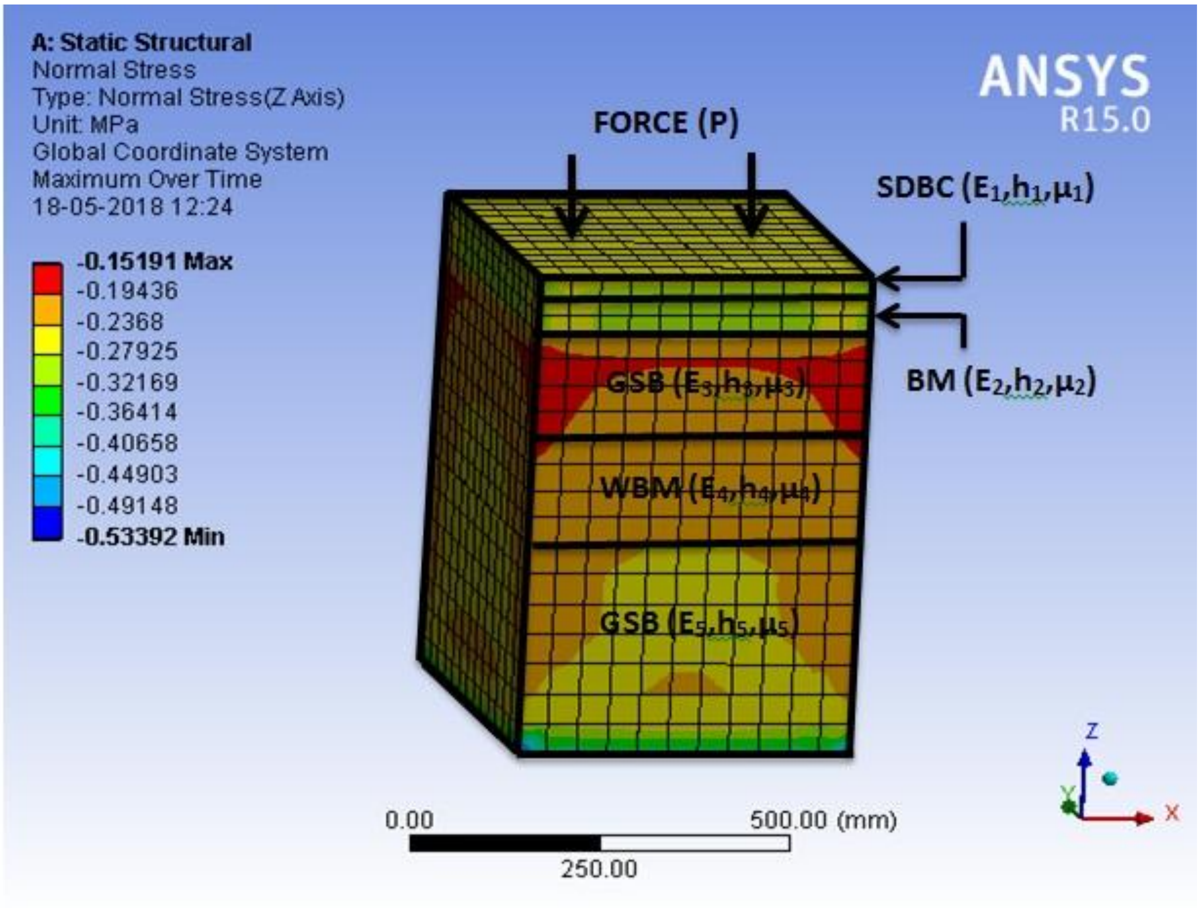


Fig. 3 Vertical Compressive stress using ANSYS Software

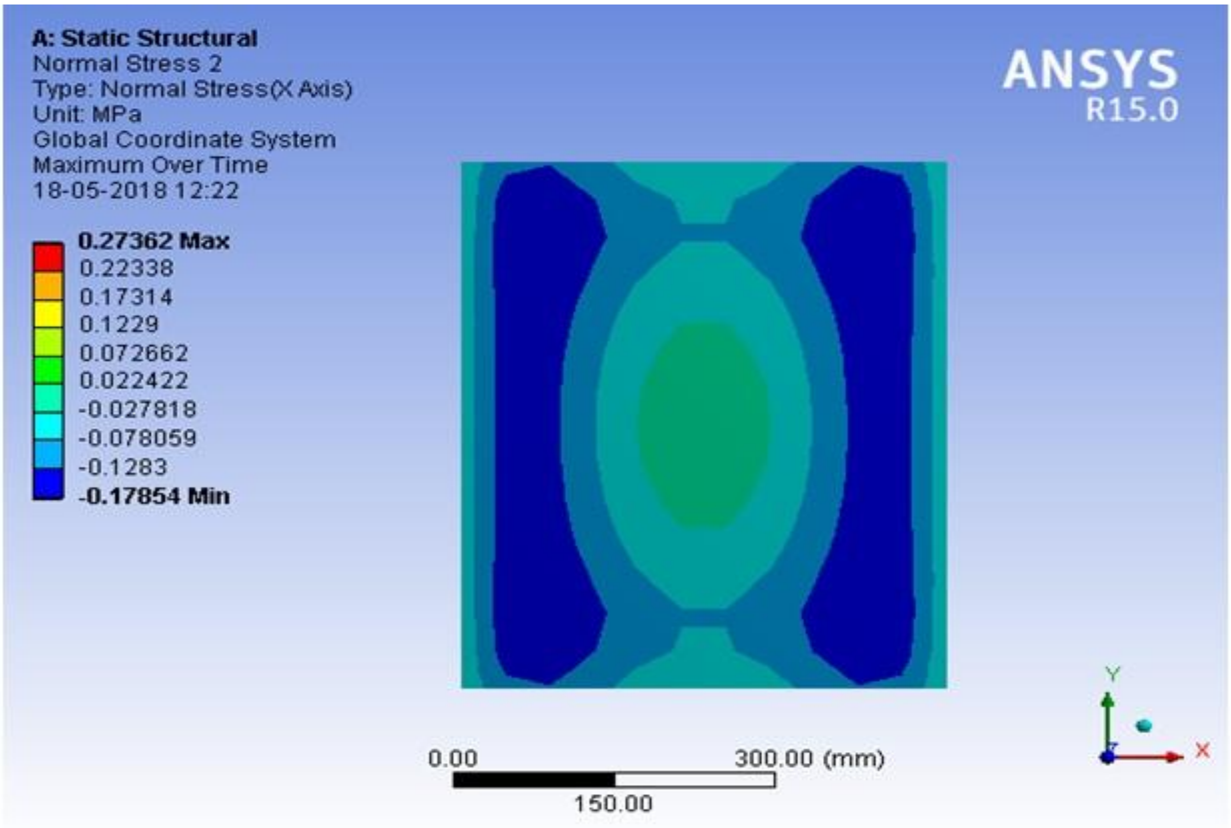


Fig. 4 Horizontal tensile stress using ANSYS Software

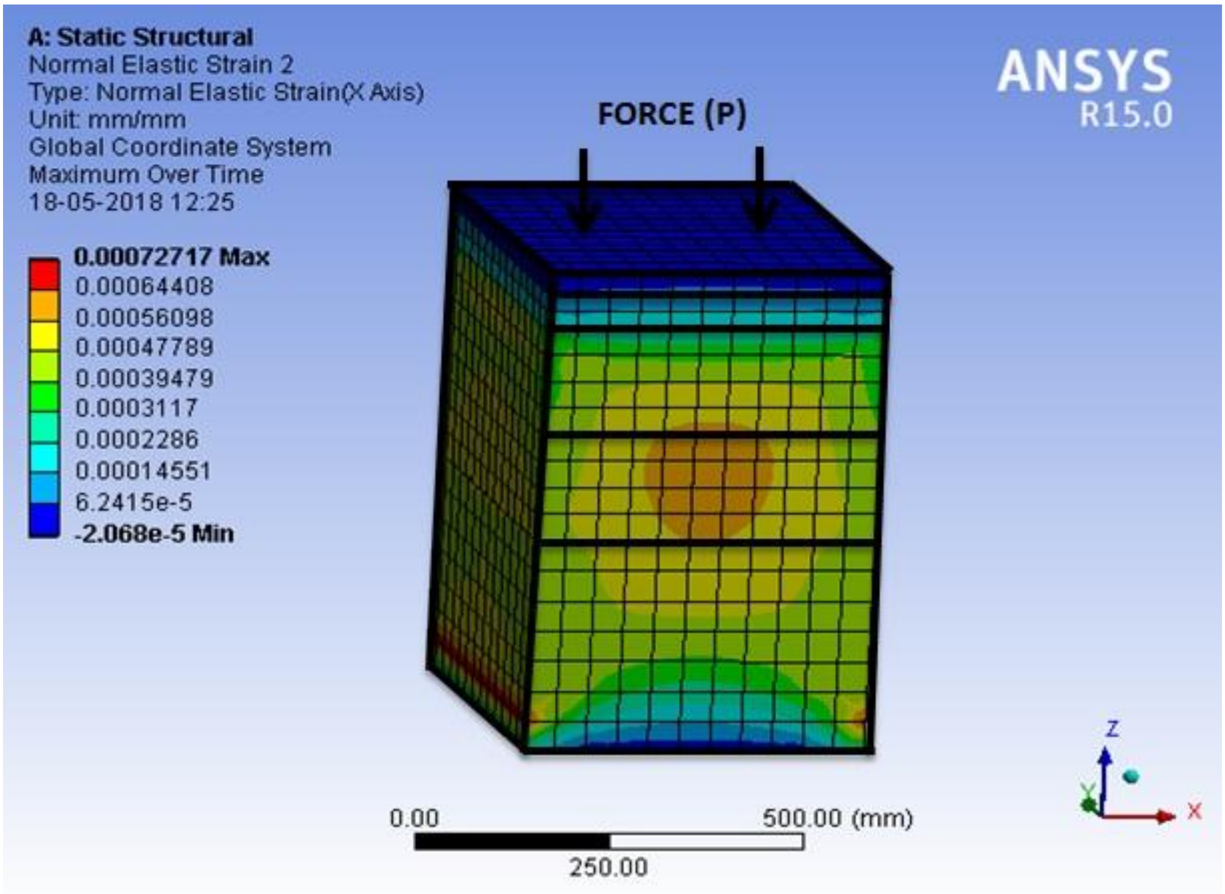


Fig. 5 Horizontal tensile strain using ANSYS Software

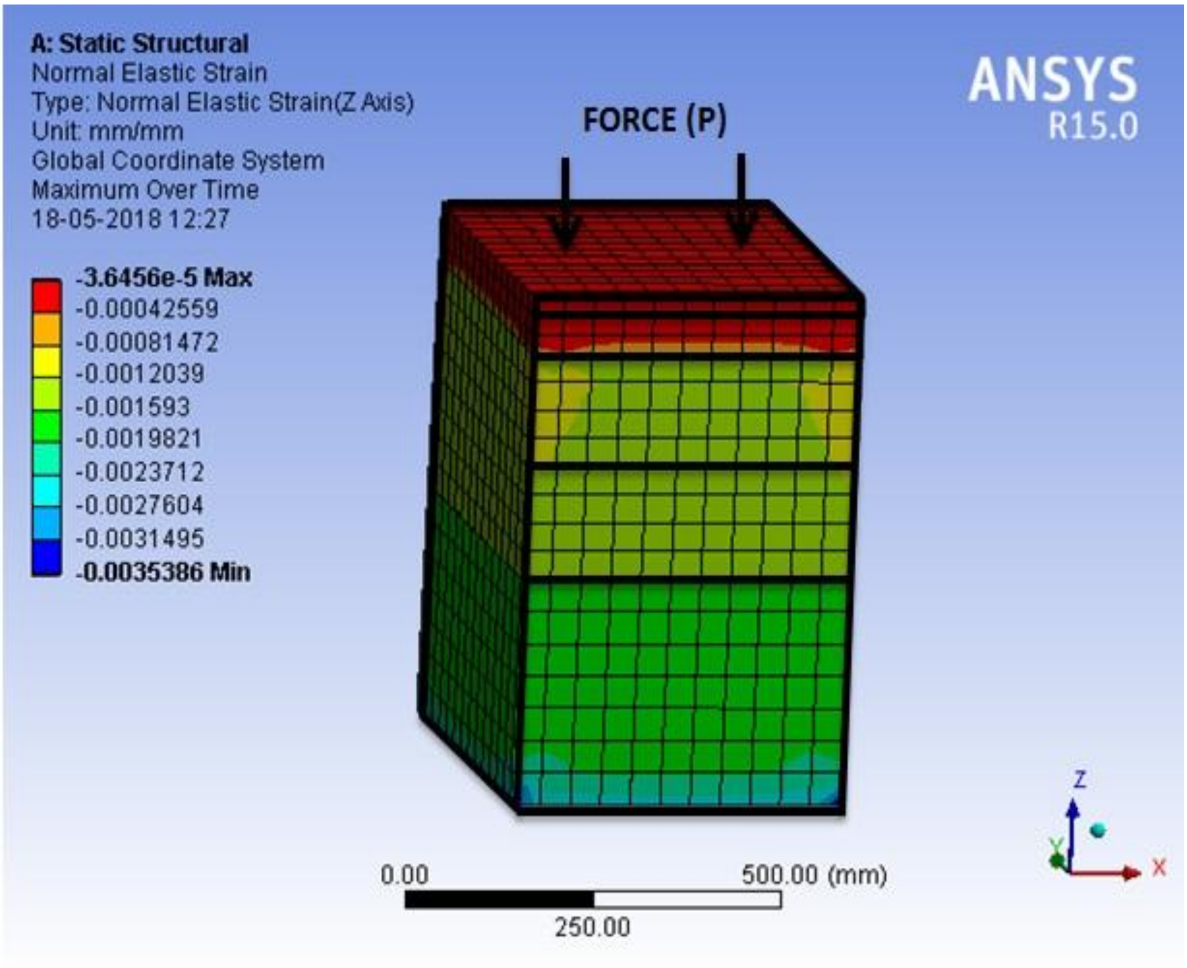


Fig. 6 Deformation in vertical direction using ANSYS Software

F. Result Analysis

To check that whether the pavement is safe or unsafe under rutting and fatigue, it necessary to check actual strain value with Allowable strain values. Actual strain values are determined using ANSYS Software. Equations given in IRC - 37: 2012 are used to determine allowable strain value for fatigue and rutting model. Comparison of Actual strain value and allowable strain value is given below,

TABLE 5 - COMPARISON OF ACTUAL AND ALLOWABLE STRAIN VALUE

Vehicle type	Vertical Compressive Strain from ANSYS	Horizontal Tensile Strain from ANSYS	Allowable Vertical Compressive Strain	Allowable Horizontal Tensile Strain	Safe / Unsafe (Rutting)	Safe / Unsafe (Fatigue)
Dual wheel (LCV)	0.21*10-2	0.29*10-3	$0.306*10^{-3}$	$0.168*10^{-3}$	Unsafe	Unsafe
Dual Wheel (Bus)	0.15*10-2	0.17*10-3	$0.306*10^{-3}$	$0.168*10^{-3}$	safe	Unsafe
Dual wheel (Single Axle Truck)	0.27*10-2	0.31*10-3	$0.306*10^{-3}$	$0.168*10^{-3}$	Unsafe	Unsafe
Tandem Dual Wheel (Tandem Axle Truck)	0.26*10-2	0.29*10-3	$0.306*10^{-3}$	$0.168*10^{-3}$	Unsafe	Unsafe
Tandem Dual Wheel (Tridem Axle Truck)	0.26*10-2	0.32*10-3	$0.306*10^{-3}$	$0.168*10^{-3}$	Unsafe	Unsafe
Tridem Dual wheel (Multi Axle Truck)	0.22*10-2	0.27*10-3	$0.306*10^{-3}$	$0.168*10^{-3}$	Unsafe	Unsafe

CONCLUSIONS

The pavement Condition survey shows that pavement is in fair condition, So it requires a preventive maintenance. From the result analysis, it can be concluded that the deformation is observed maximum at the top of surface. It decreases as the depth of the pavement increases. Vertical compressive stress is found to be maximum at mid – depth. Vertical compressive stress is compared with the Bousiqness's theory at mid – depth. Stress in Horizontal direction is maximum at middle of the section and decreases with increase in radial distance. Vertical compressive strain is found to be maximum at top of the surface and decreases with increase in depth of the pavement. Horizontal tensile strain is found to be maximum in GSB layer and minimum in top layer. So, it is inversely proportional to the modulus of elasticity. Comparison of Actual and Allowable Strain shows that Pavement is unsafe for rutting under the dual wheel load, Tandem dual wheel load and tridem dual wheel load of each vehicle class and is unsafe for fatigue under the dual wheel load (except dual wheel of Bus), Tandem dual wheel load and tridem dual wheel load.

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