

Effect of Texture on Concrete Pavement Based on the Study of Yamuna Expressway

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Abstract

The rigid pavement design of the expressways has given higher speed but has somehow compromised in the surface friction part too and to balance this part,there has been a provision of higher texture depths which has given better griping value both in dry and wet conditions. There are a number of accidents due to the tirebursting phenomenon, that is occurring in the rigid pavement, Texture provided on the pavement is basically a series of repeating figures drawn transverse to the moving direction in order to attain a desired value of skid resistance and friction So as to avoid skidding in any condition. But in view of this there is an abrupt increase in the amount of energy being produced and this is causing the problem of tire bursting. The kinetic theory of gases has given the kinetic energy of the enclosed gas before the test and after the test. Since there is an increase in the pressure of the tires hence using Gay Lussac's law we concluded there will be an increase in the temperature. The increase in the kinetic energy gave us the conclusion about the mean texture depth that can be adopted Friction analysis and the contact area patch analysis has also given the reasons why low inflation preshave and the poor quality of the tires can lead to the tire bursting phenomenon.

Hence this paper has analyzed the amount of energy that is contributed by the higher texture depths into the rollingtire rolls on the surface of the rigid pavement and how it gets distributed into the atmosphere and absorbed by the rolling tire.

Keywords: texture, energy,tire bursting, tire pressure,

1. Introduction

Two types of pavement are laid in India-rigid pavement and flexible pavement. In simple terms, a flexible pavement can be defined as a pavement layer comprising of a mixture of aggregates and bitumen, heated and mixed properly and then laid and compacted on a bed of granular layers. Rigid pavements, on the other hand, are made from cement concrete or reinforced concrete slabs, laid over a low-strength concrete layer or on a well-compacted layer of aggregates or both.

Till now, flexible pavement has been preferred over rigid pavement due to the low initial costs. However, with the increasing availability y of cement in the country coupled with the rising prices of bitumen, the government's decision to opt for rigid pavement is

being perceived as a prudent one. Raw material for the cement industry is limestone which are available in abundance in India and no foreign currency are required. Main ingredient of flexible pavement mix is bitumen which is a by product of refinery. Raw material for refinery is crude oil, majority of which have been imported from oil exporting countries and no huge amount of foreign currency are required.

The stability of the roadway surface is very important aspect in the design of the pavement and should be non-yielding to allow the heavy wheel loads of traffic to move with minimum possible rolling resistance. The surface of road should also be uniform along the longitudinal profile so as to provide the fast moving vehicles move safely and comfortably at the design speed. The main objective of a well designed and constructed pavement is to have elastic deformation within the permissible limits so that the roadway can sustain a large number of repeated load applications during its design life.

1.2 Bursting Of tires

This is one of the common cause in the accidents that have been occurring in the major highway and expressway systems. Broadly bursting of a tire occurs when there is a rapid loss of pressurized air from within the tire. When there is a compromise with respect to the structural integrity of the tire, the tire is unable to hold all the air inside. Due to this situation, the pressurized air escapes out tearing apart the tire and rapidly causing an explosion and severe damage to the tyre surface. The major causes of the tire burst are listed below:

1.2.1 DIRECT IMPACT- Due to the poor condition of the pavement surface there is a high possibility of a direct impact of the tire resulting in slashing of the tire surface at some point which becomes an open invitation for all the pressurized air to escape out thus leading to tire burst.

1.2.2 High Temperature- Since most of India lies in the tropical or a subtropical region so it is prone to hot weather resulting in high temperatures and in general heat is the enemy for different parts of the vehicle especially the tire. Due to high temperature there is an excessive build-up of heat in the tires and this increase in temperature inside the moving tire results in an increase in the pressure within the tire. The friction between the pavement surface and the moving tire helps this process and weakens the tire which may result in bursting of tires due to this heat build-up.

1.2.3 Under Inflation- Another one of the major causes of the bursting of the tires, Over inflation is not of a major concern under inflation is the reason behind more than 75 % of tire burst induced accidents. Such under inflation tires suffer from excessive flexing and that increases the contact patch with the pavement surface which leads to the accumulation of excessive frictional force and in turn build up the heat inside the tire. The building up of heat is much higher than those induced during the hot summer.

1.2.4 High Speed- Every tire is meant to function best at a particular speed and there is a

maximum speed that the tire can hold. Beyond the particular speed will increase the friction levels and wear quickly so in this case more than one factors are responsible for the bursting oftires.

1.2.5.1 Skidding-Accidents occur on concrete pavement due to smoothness of travelling surface.Rear vehicle collides front vehicle specially in wet season when break is applied and water over surface acts as lubricant between wheel and pavement surface.To make pavement surface skid resistance,textures are provided over surface. Though travelling surface become skid resistance by providing texturing and accident has been avoided.

1.2.5.2 Energy Produced- Huge quantity of extra energy are produced due to texturing on the surface in form of heat.Major part of heat are diffused in environment which causes some environmental impact.some part of heat are transmitted inside tire through wheel of the vehicle and increased temperature of the air inside tire.The increase in temperature in tire increases pressure of air inside tire.Finally,tire bursts causes a vital accident when travelling time is more.

2. Texture and Tires Skid Resistance

2.2.1 L.Tighe (2008) Study to determine the optimum surface friction and the mean texture depth for cement concrete surface had been studied.

2.2.2 Evaluation Of Frictional Properties

The pavement surface condition is evaluated in terms of (a) skid-resistance as a safety measure and (b) surface skid-resistance action under the wet condition as a performance indicator. For both these conditions the main objective is to determine safe breaking distance under different operating conditions related to surface, climate, speed and tired tread designs.

2.2.3 Pavement Surface Friction

The skid resistance of pavement surface is essentially a resistive force that develops opposite to the direction of motion in the contact plane between the tire and the surface of the pavement under a locked or non-rotating wheel. Skidding occurs when the available frictional resistance is less than the frictional demand at the interface between the tire and surface of the pavement (Kennedy et al.,1990).

2.2.4.1 Types Of Frictions

The development of friction on the surface of payment is purely based on the application of wheel load with respect to its direction of rolling.

2.2.4.2 Longitudinal Friction

The longitudinal frictional resistance for skin friction is developed when(a) the pneumatic tire rolls freely over a payment surface without any type of braking and(b) the brake is applied constantly to the Rolling tire(Meyer, 1982).

2.2.4.3 Lateral Or Side Force Fiction

To compensate for the sliding out of a vehicle when Driver Singh a horizontal curve aside for CE friction is developed between the tire and pavement surface on a transverse/superelevated.

2.2.5 Factors Affecting Surface Friction/Skid Resistance.

The several factors affecting the coefficient of friction is given below (Wilson & Dunn 2005).

2.2.5.1 Factors Related To Pavement Characteristics And Materials.

The factors affecting the coefficient of friction in this regard are the micro and macro-texture of pavement surfaces, mineral composition of aggregate, aggregate gradation, shape of the aggregate, bitumen content and the type of bituminous mix, tining-pattern and tining depth of concrete pavement and road curvature is horizontal and vertical planes.

2.2.5.2 Factors Related To Driving Dynamics

Linear and curvilinear speeds(on horizontal curves that depend on the radius of curvature and super-elevation), slip speed. slip ratio, brake efficiency, acceleration, deceleration, braking speed, location of drive wheel with reference to the configuration of vehicle axles,

3. Data Collection and Experimental Investigation

3.1 Yamuna expressway

Yamuna expressway also known as Taj Expressway is basically a 6 lane, extendable to 6-lanes, 165 km long access-controlled expressway which connects Greater Noida with Agra in the territory of Uttar Pradesh. It is one of India's longest sine expressways. This expressway starts from Pari- chowk in Greater Noida and ends at Kuberpur in Agra. It is monitored and maintained by a body called Yamuna Expressway Industrial Development Authority (YEIDA).

With due permission from the concerned authority some basic technical ,features of the expressway were obtained. Below is the table of features of theExpressway:

S.NO.	DESCRIPTION	DATA
1.	Total number of lanes	6: 3.5 m width each
2.	Permissible speed	100 kmph for LMV 60 kmph for HMV
3.	Maximum Allowable speed	120 kmph
4.	Total length	165.5 km
5.	Right of Way	100 m wide
6.	Pavement Width	15.70 m
7.	Maximum axle load design	20 tonnes
8.	Shoulder Width	5.10 m
9.	Thickness of PQC	320 mm (main carriageway)
10.	Thickness of DLC	150 mm

11.	Top Width of Embankment	47.60 m (including 6.0 m wide Median)
12.	Vehicle underpass	70
13.	Minor bridges	41
14.	Interchanges	6
15.	Box Culverts	182
16.	Main Toll Plaza	3 (26 lanes at each location)
17.	Concrete	33.2 lakh cum
18.	Cement	12.0 lakh tonnes
19.	Steel	1.30 lakh tonnes
20.	Stone Aggregate	130 lakh tonnes
21.	Bitumen	7500 tonnes
22.	Admixtures	12500 tonnes

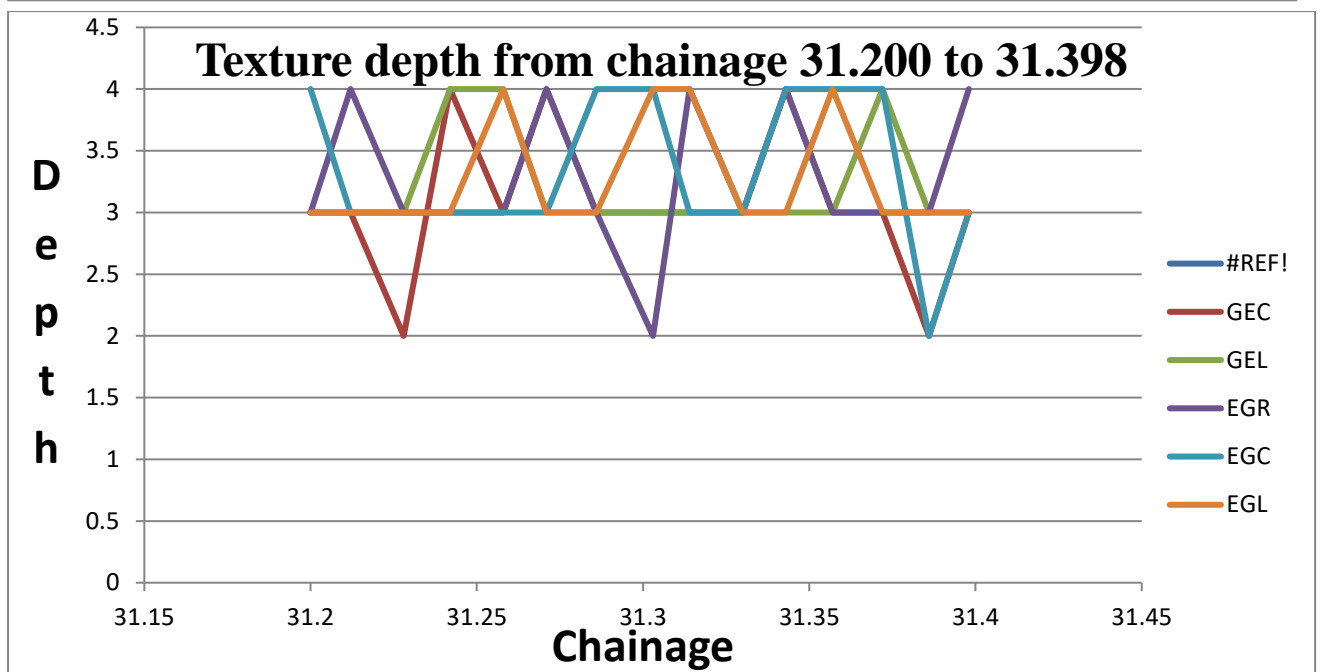
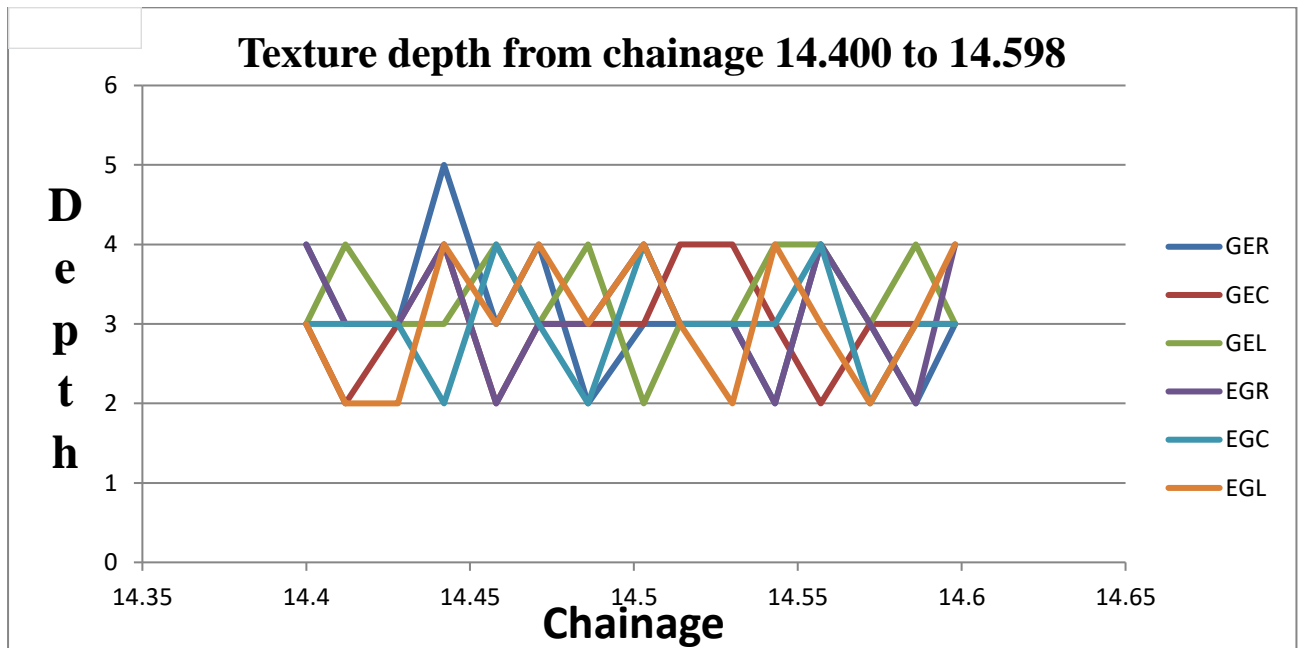
3.2. Experimental Investigation:

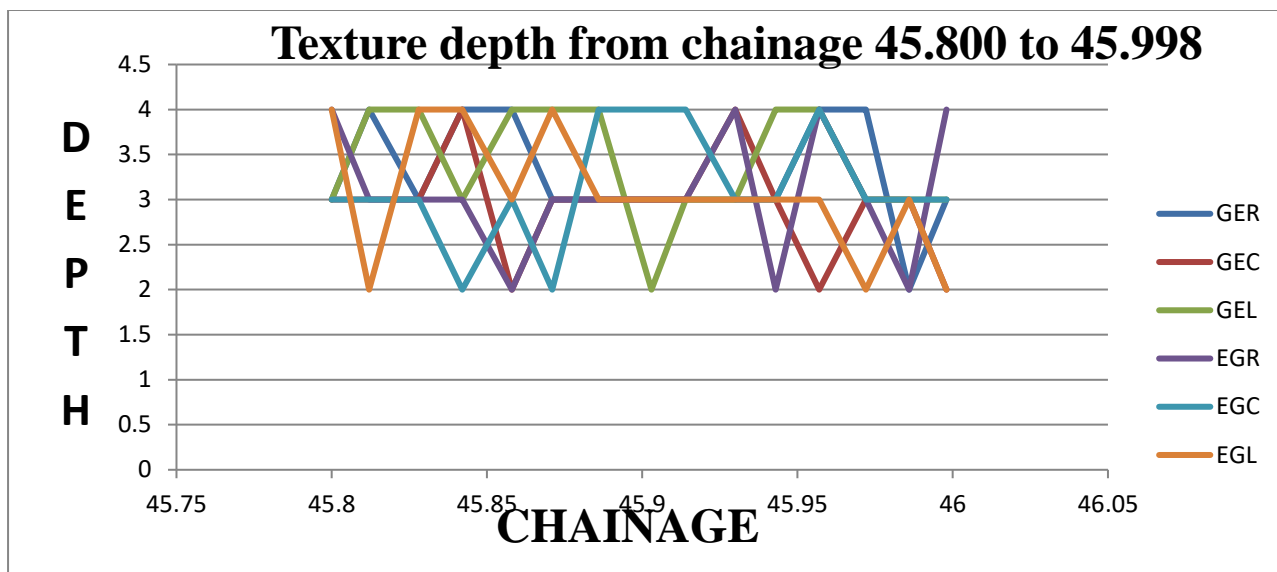
3.2.1 Measurement Of Texture: Texture has been measured by sand patch test(SPT).It is described in British standard(BS 598 part 105,1990) and also given in ASTM E 965.The SPT assesses macrotextural characteristics of pavement surface .Dry pavement surface away from wheel path is marked for texture measurement and cleaned properly with soft brush.50 ml sand of standard size of 0.6 to 0.15 mm is poured in heap over the surface .The sand heap is spread in a circular area by using wooden flat disc of 65 mm diameter in which hard rubber sheet of 1.5 mm thickness stuck to the bottom face of disc.It is ensured that the surface depressions are filled with sand to the level of the surface peak.Now four readings of patch diameter are measured at every 45° in mm and average value is calculated as D mean.

Mean texture depth,MTD(mm)=(volume of sand/area of patch)={ $50 \times 1000 / (\pi D^2)$ } and reported to nearest 0.01 mm.

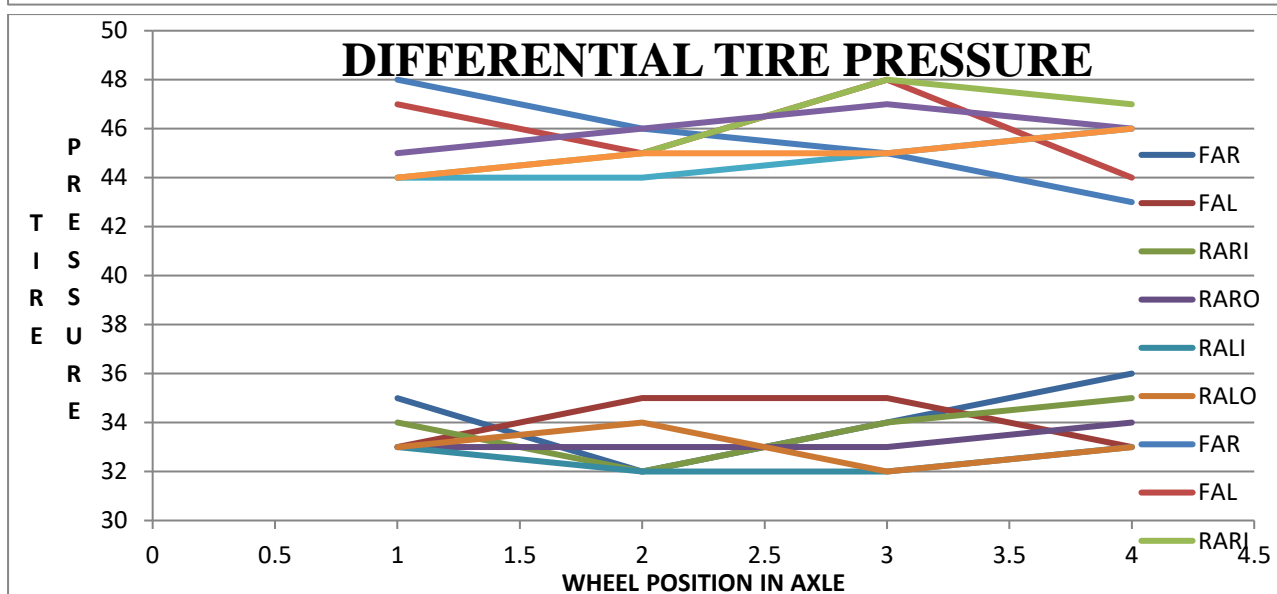
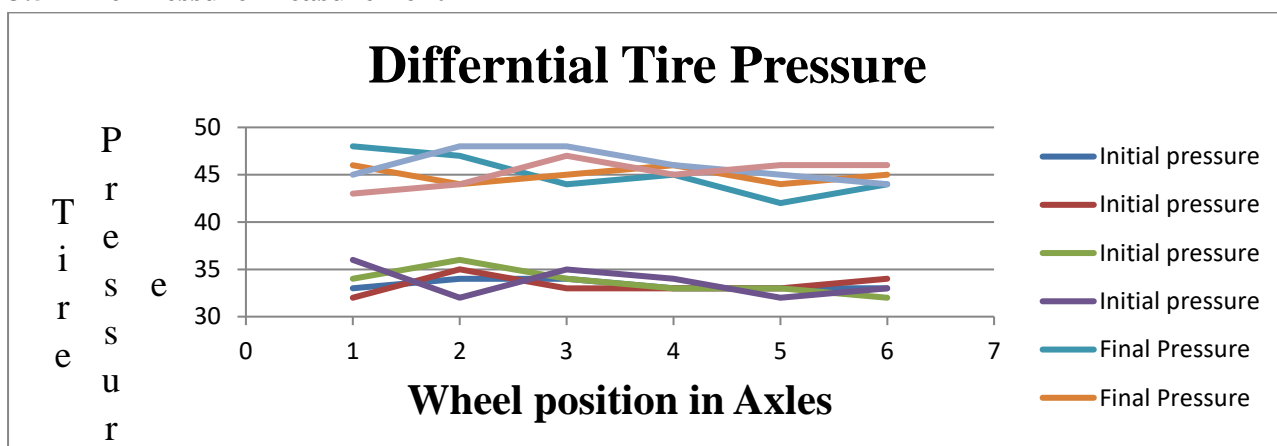
3.2.2 Measurement Pressure:Tire Pressure gauge is used to determine pressure in tire of the vehicles.since tires are design for specific load at specific pressure,so it is necessary to maintain the tire pressure at proper level as per manuals .Precision of gauge should be in range of ± 3 psi to ± 1 psi.

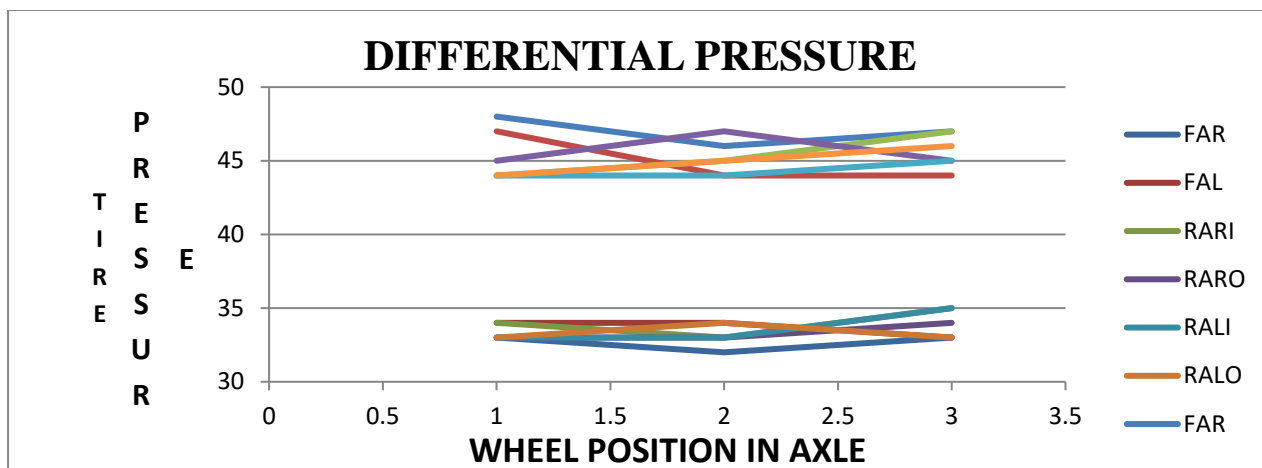
3.3. Texture Measurement –



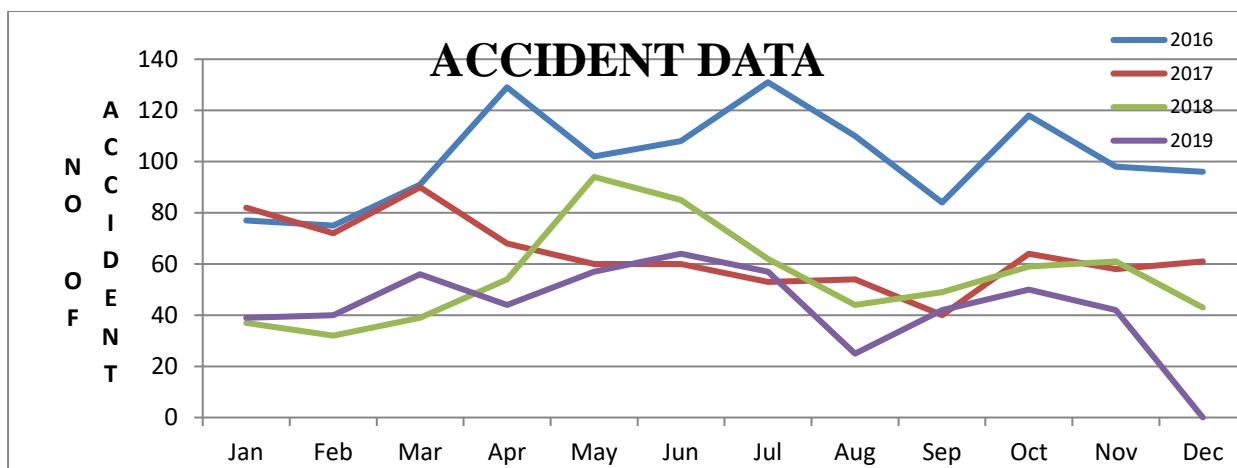


3.5 Tire Pressure Measurement

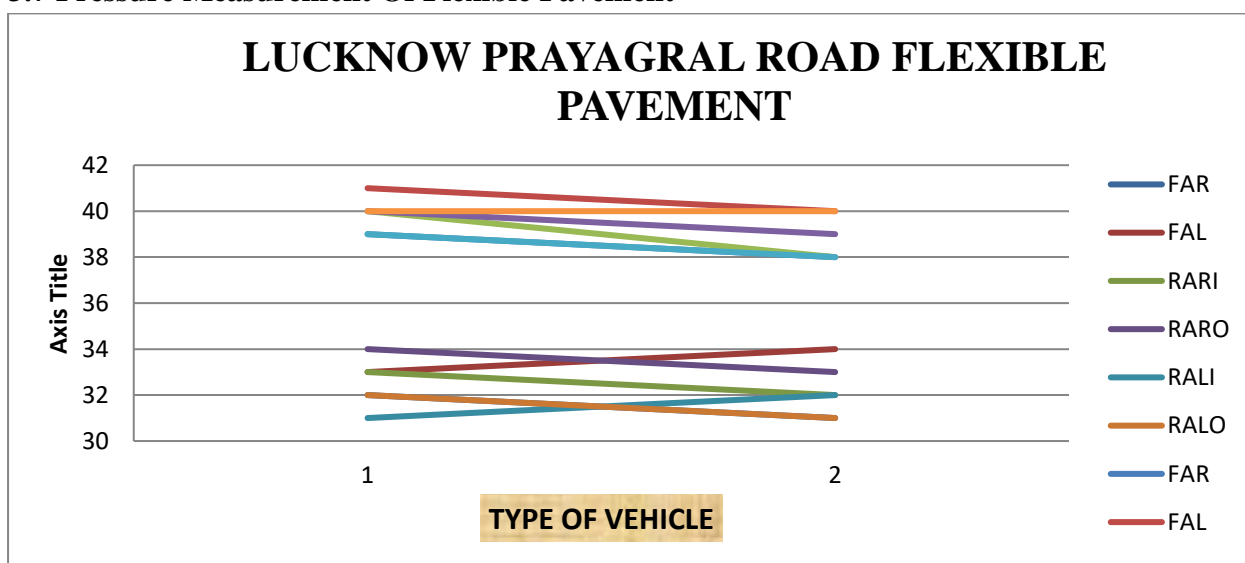




3.6. Accident Data



3.7 Pressure Measurement Of Flexible Pavement



3.8 Measurement Of Texture Of Flexible Pavement

Lucknow Prayagraj Road (Flexible Pavement)

Date – 29/05/2021

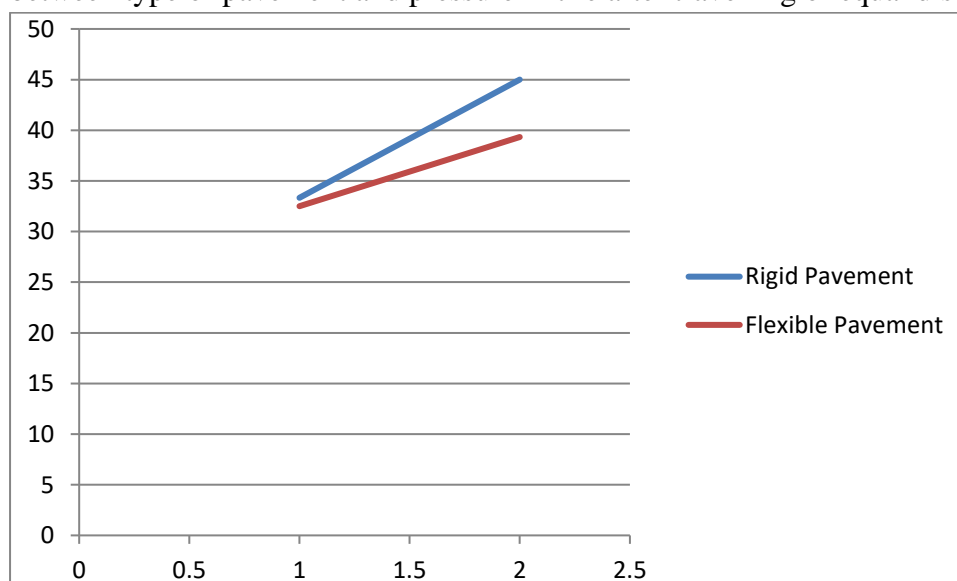
Day time Temperature – 36 0

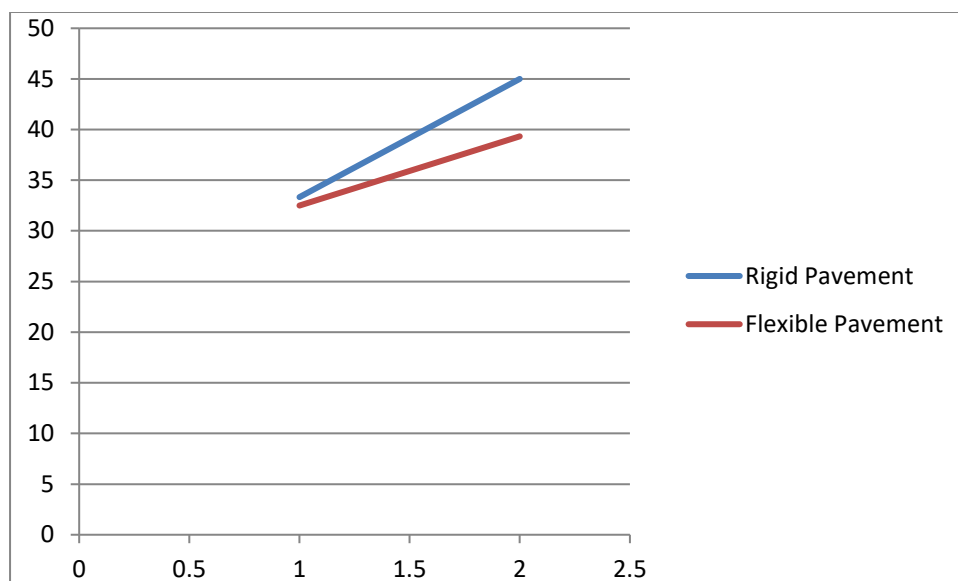
Length covered : 165 km

SN	CHAINAGE	Distance from base line	Lucknow to Prayagraj		Prayagraj to Lucknow	
			Texture Depth in mm		Texture Depth in mm	
			Right	Left	Right	Left
1	135.400	0	1	1	1	2
	135.410	10	2	1	2	2
	135.430	20	2	1	2	1
2.	105.200	0	2	2	1	2
	105.220	20	1	1	2	2
	105.260	40	1	2	1	1

9. Data Analysis :

It is assumption that gas filled in tire will behave like ideal gasses and under goes perfectly elastic collision. Concrete Pavement has better riding quality than flexible pavement. Frictional resistance is provided to the tire of the vehicle by coarse grains of the mix by which pavement has been constructed. Concrete pavement have very smooth riding surface which cause rear collision of the vehicles .To avoid this type of accident ,texture has been provided to overcome this type of demerit of the concrete pavement. Due to provision of texture, extra heat is generated which causes increase of temperature in side the tire. As per thermodynamics low, heat is proportional to pressure, hence pressure is increased in side the tire as temperature is increased in side the tire. Tire bursting phenomena occurs when pressure is increased beyond permissible limit of pressure for which tire is designed and it also depends on life of tire and distance covered by tire. This graph has been prepared between type of pavement and pressure in tire after travelling of equal distance of 165 km





In above graph , average mean texture depth for flexible pavement,Lucknow ----Prayagraj highway and Yamuna expressway are 1.54 mm and 2.88 mm respectively.Average initial tire pressure on flexible pavement and concrete pavement are 32.25 and 32.84 respectively and final pressure in tire after travel of 165 km (equal in both case) have been 40.26 psi and 45.35 psi respectively. So it is clear that texture depth is main factor for heat generation on pavement surface.

10 . **Conclusion** : Presently concrete pavement has edge over flexible pavement due to easily availability of raw material for cement industries and costly procurement of bitumen used in flexible pavement. Inflation pressure and age of the tire play a vital role in the dissipation of energy. If texture depth is reduced,pressure reduces but chances of rear collision may increase . If texture depth is increased,pressure in tire increases but chances of tire bursting may increase. So, optimization of texture depth is essential for safe journey on concrete pavement which depends on age of tire , speed of vehicles ,distance travelled and environmental condition.

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