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STUDY ON ASPHALT PAVEMENT WITH CONTACT STRESS DISTRIBUTION FOR SKID RESISTANCE

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Abstract: - According to the world health organization, road traffic accident results in the death of over 1.2 million people, each year and 50 million more are injured. The figures are on the increase in many countries, and if proper measures are not taken, by the year 2030, road traffic accidents will be listed as the fifth cause of death in the world, resulting in the death of about 2.4 million people annually.

The factors affecting the road traffic accident are Drivers, vehicle and the road. Therefore, highways have great effect on traffic accidents. A number of studies show that precipitation in the form of rain and snow generally results in more accidents compared with dry conditions. Studying the effect that different asphalt concrete mixes have on skid resistance is very essential in order to provide the general public with safer roads and to help relevant authority's select best materials for pavement surfaces. The objective of the study is to compare the skid resistance of six different asphalt concrete mixes. In our analysis, ANSYS was used and the model was developed.

Keywords: - Pavement, Skid Resistance; Skid Number; Superpave; Stone Matrix Aggregate; Slag; Micro Texture.

1. INTRODUCTION

Objective of the Work

The main objective of the current work is

1. Validation of the ANSYS models by comparing the present simulated results with Bo Chen et.al (Author of Base Paper).
2. To predict shear stresses.
3. To define normal stress and area mean pressure for the different mesh size.
4. We take two type of SBS and SMA asphalt materials
5. Comparison of SBS and SMA asphalt material w.r.t different mesh sizes
6. The contact stress along the modified asphalt pavement

Advantage of FEM

- Nonlinear issues simply solved.
- Easy formulations enable many various varieties of drawback to be solved.
- Advantages of the finite component methodology over area unit as follows.
- The methodologies are often used for any irregular-shaped domain and every one variety of boundary conditions.
- Domains consisting of over one material are often analyzed.

2. MODELING AND ANALYSIS WITH RESULTS AND DISCUSSION

The procedure for solving the problem is

- Modeling of the geometry.
- Meshing of the domain.
- Defining the input parameters.

Simulation of domain

Contact Stresses and Pressure along the modified asphalt pavement with different mesh size and an effect of tire load on pavement.

The static structural analysis was carried out to analyze pressure on pavement with different mesh size and contact stresses are determine by the effect of shear stresses and normal stresses during the contact of tire and pavement, the two types of materials are considered in present simulation i.e. styrene-butadiene styrene (SBS) modified asphalt and stone matrix asphalt is used and mesh size is varied from (7.5 to 18.5 mm) and contact stresses were evaluated to determine the skid resistance effect. The contour plot obtains for determination of contact stresses are shown below in figure.

Validation of base paper result Styrene-Butadiene styrene (SBS) modified asphalt with mesh size 18.5

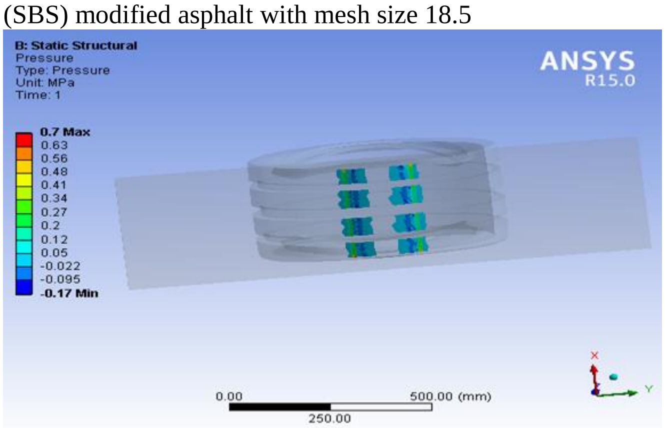

Figure No.: 5.1 Contour plot of contact pressure between tire and pavement (SBS) of mesh size 18.5 .

Above contour plots shows area mean pressure onpavementon exertion of tire pressure in it, the value of pressure varies from 0.05mm (minimum) to 0.7mm (maximum) at the surface of the pavement.

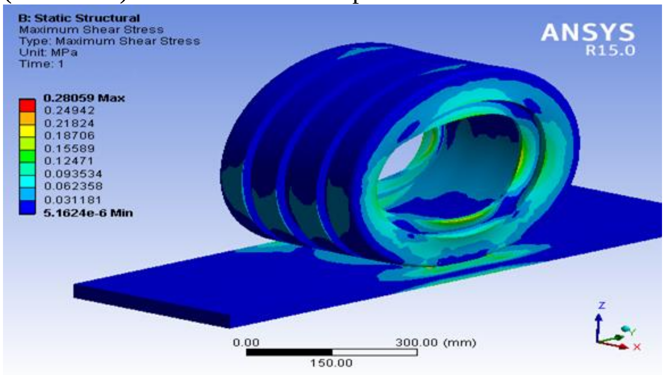

Figure No.: 5.2 Contour plot of shear stress on pavement block (SBS).

Above contour plots shows shear stress onpavementon exertion of tire pressure in it, the value of pressure varies from 0.031181mm (minimum) to 0.28059mm (maximum) at the surface of the pavement.

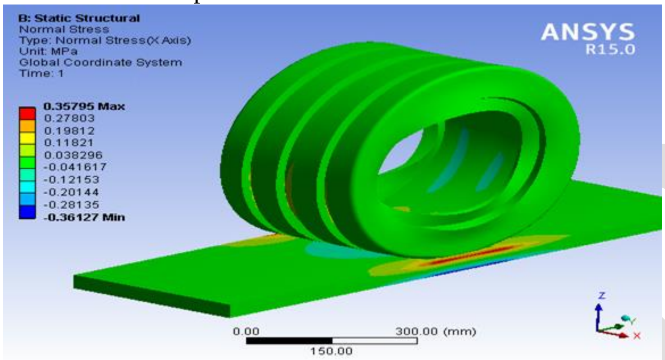

Figure No.:5.3 Contour plot of normal stress of pavement block (SBS).

Above contour plots shows normal stress onpavementon exertion of tire pressure in it, the value of pressure varies from -0.036127mm (minimum) to 0.35795mm (maximum) at the surface of the pavement.

Table No.: 5.1 Comparison of area mean pressure with base paper.

	Area mean pressure (MPa)	
Mesh size	Base paper	Simulation
18.5	0.465	0.48
13.4	0.550	0.58
10.3	0.583	0.57
8.5	0.602	0.65
7.75	0.632	0.64

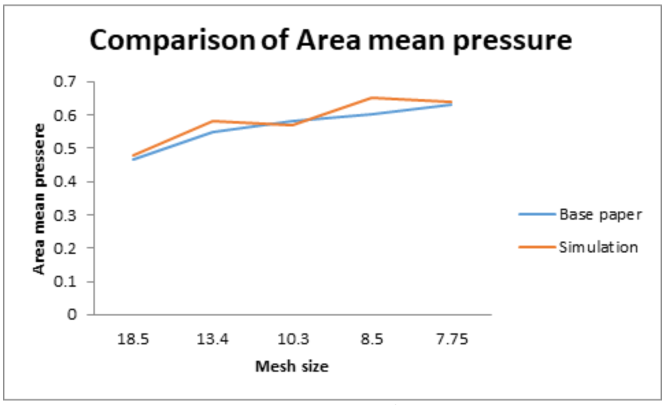

Figure No.:5.16 Graph shows Comparison of area mean pressure with base paper.

The above table & graph shows the comparison of area mean pressure of base paper and simulation with respect to different mesh size. We found the simulation values are converging in base paper value.

Table No.: 5.2 Contact stresses with different mesh size.

Mesh size	Contact stresses
18.5	0.89709
13.4	0.89707
10.3	0.89706
8.5	0.89706
7.75	0.89706

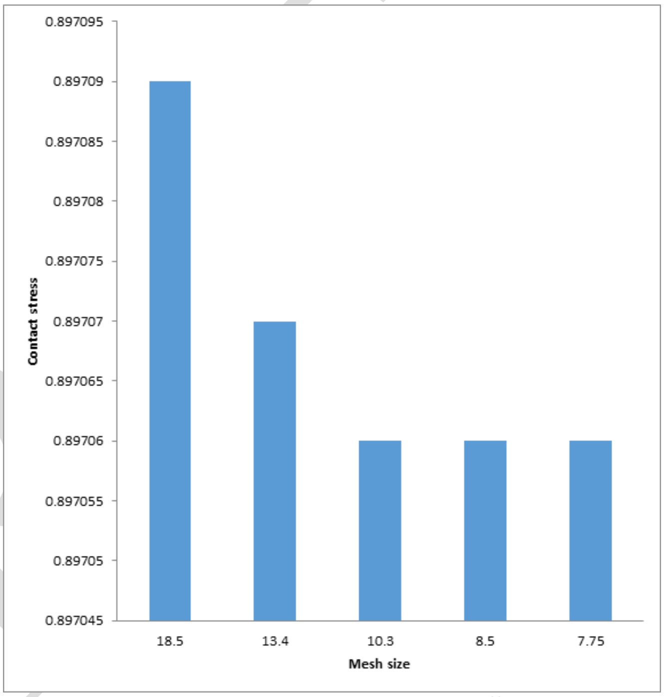

Figure No.:5.17 Graph shows Contact stresses with different mesh size.

The above table & graph shows the contact stresses value on SBS asphalt pavement with respect to different mesh size.

Optimization results of Stone matrix asphalt with variable mesh size.

Stone matrix asphalt (SMA) with mesh size 18.5

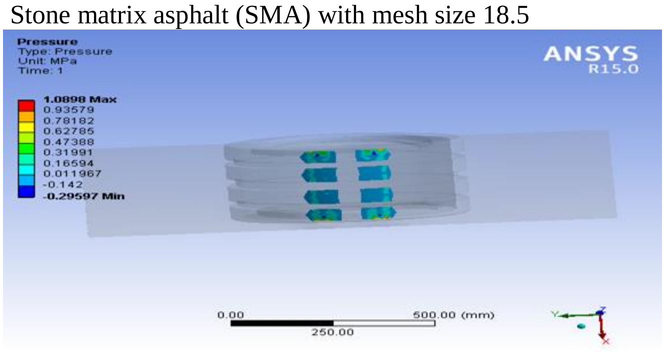

Figure No.: 5.18 Contour plot of contact pressure between tire and pavement (SMA) of mesh size 18.5.

Above contour plots shows area mean pressure onpavementon exertion of tire pressure in it, the value of pressure varies from -0.29597mm (minimum) to 1.0898mm (maximum) at the surface of the pavement.

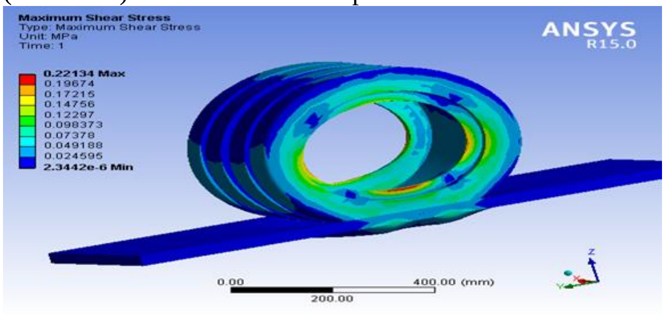

Figure No.: 5.19 Contour plot of shear stress on pavement block (SMA).

Above contour plots shows shear stress onpavementon exertion of tire pressure in it, the value of pressure varies from 0.024595mm (minimum) to 0.22134mm (maximum) at the surface of the pavement.

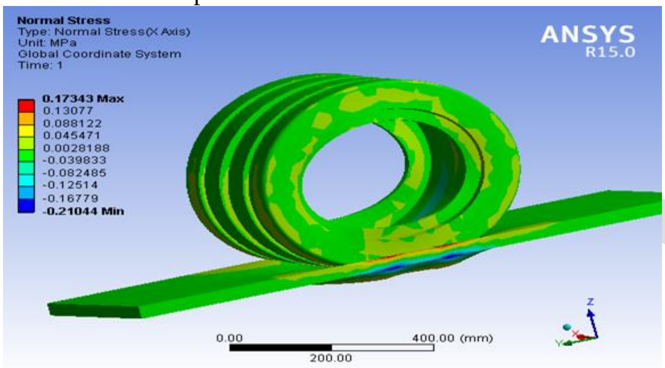

Figure No.:5.20 Contour plot of normal stress of pavement block (SMA).

Above contour plots shows normal stress onpavementon exertion of tire pressure in it, the value of pressure varies from -0.21044mm (minimum) to 0.173343mm (maximum) at the surface of the pavement.

$$\mu_s = \frac{\tau_{ult}}{\sigma_s}$$

Where, τ_{ult}= maximum shear stress

σ_s= vertical stress (Normal stress)

μ_s= Contact stress

$$\mu_s = \frac{0.19674}{0.13077} => 1.50447$$

5.10 Stone matrix asphalt (SMA) with mesh size 13.4

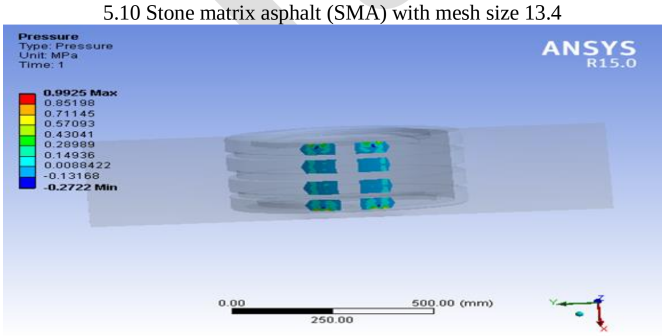

Figure No.: 5.21 Contour plot of contact pressure between tire and pavement (SMA) of mesh size 13.4.

Above contour plots shows area mean pressure onpavementon exertion of tire pressure in it, the value of pressure varies from -0.2722mm (minimum) to 0.9925mm (maximum) at the surface of the pavement.

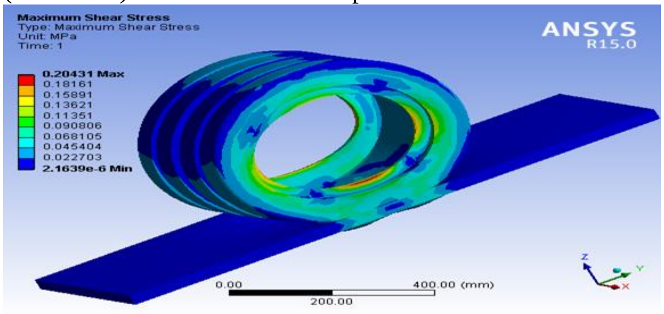

Figure No.: 5.22 Contour plot of shear stress on pavement block (SMA).

Above contour plots shows shear stress onpavementon exertion of tire pressure in it, the value of pressure varies from 0.022703mm (minimum) to 0.20431mm (maximum) at the surface of the pavement.

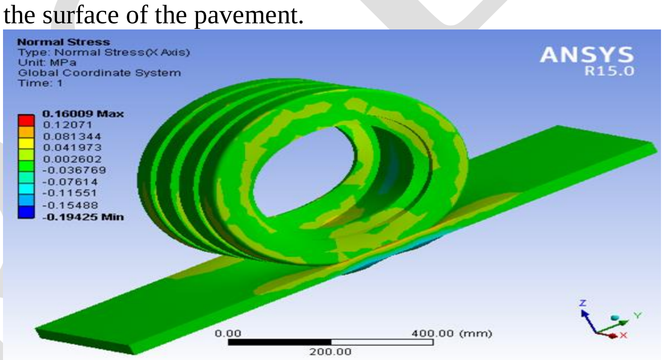

Figure No.:5.23 Contour plot of normal stress of pavement block (SMA).

Above contour plots shows normal stress onpavementon exertion of tire pressure in it, the value of pressure varies from -0.19425mm (minimum) to 0.16009mm (maximum) at the surface of the pavement.

$$\mu_s = \frac{\tau_{ult}}{\sigma_s}$$

Where, τ_{ult}= maximum shear stress

σ_s= vertical stress (Normal stress)

μ_s= Contact stress

$$\mu_s = \frac{0.18161}{0.12071} => 1.50451$$

Stone matrix asphalt (SMA) with mesh size 7.75

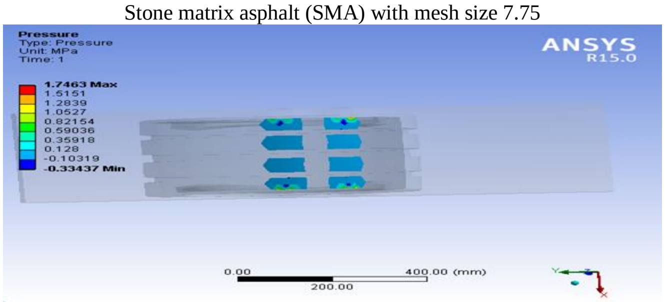

Figure No.: 5.30 Contour plot of contact pressure between tire and pavement (SMA) of mesh size 7.75.

Above contour plots shows area mean pressure onpavementon exertion of tire pressure in it, the value of pressure varies from -0.33437mm (minimum) to 1.7463mm (maximum) at the surface of the pavement.

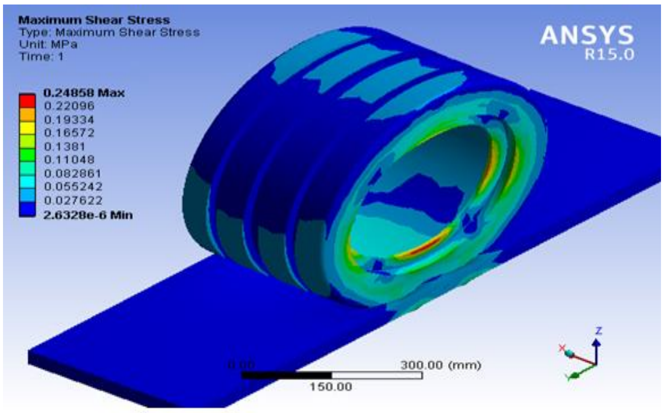

Figure No.: 5.31 Contour plot of shear stress on pavement block (SMA).

Above contour plots shows shear stress onpavementon exertion of tire pressure in it, the value of pressure varies from 0.027622mm (minimum) to 0.24858mm (maximum) at the surface of the pavement.

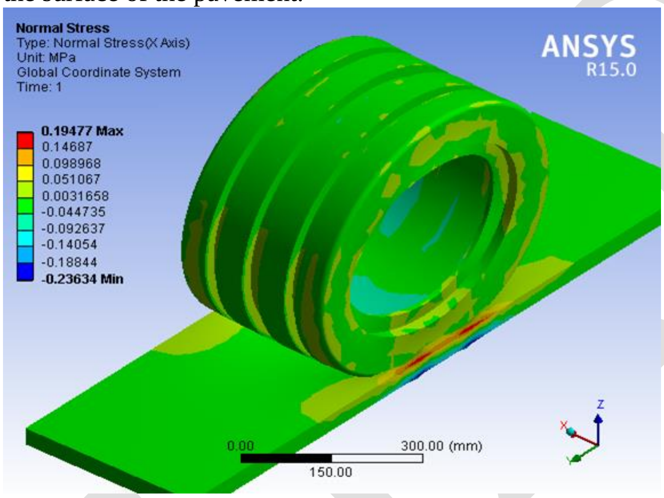

Figure No.:5.32 Contour plot of normal stress of pavement block (SMA).

Above contour plots shows normal stress onpavementon exertion of tire pressure in it, the value of pressure varies from -0.23634mm (minimum) to 0.19477mm (maximum) at the surface of the pavement.

$$\mu_s = \frac{\tau_{ult}}{\sigma_s}$$

Where, τ_{ult}= maximum shear stress

σ_s= vertical stress (Normal stress)

μ_s= Contact stress

$$\mu_s = \frac{0.22096}{0.14687} => 1.50445$$

Table No.: 5.3 Comparison of area means pressure with base paper.

Area mean pressure (MPa)		
Mesh size	Base paper	Stone matrix asphalt
18.5	0.465	0.62785
13.4	0.550	0.71145
10.3	0.583	0.75346
8.5	0.602	0.72487
7.75	0.632	0.82154

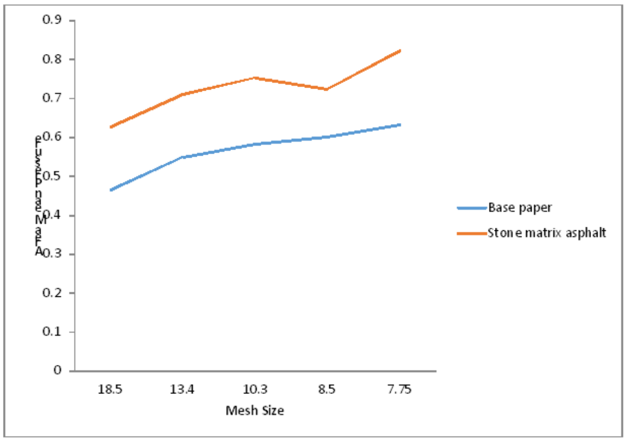

Figure No.:5.33 Graph shows Comparison of area mean pressure with base paper and stone matrix asphalt.

The above table & graph shows the comparison of area mean pressure of base paper and stone matrix asphalt with respect to different mesh size. We found the stone matrix asphalt values are increases as compared from base paper value.

Table No.: 5.4 Overall comparison of area means pressure with base paper.

Area mean pressure (MPa)			
Mesh size	Base paper	Styrene-Butadiene styrene	Stone matrix asphalt
18.5	0.465	0.48	0.62785
13.4	0.550	0.58	0.71145
10.3	0.583	0.57	0.75346
8.5	0.602	0.65	0.72487
7.75	0.632	0.64	0.82154

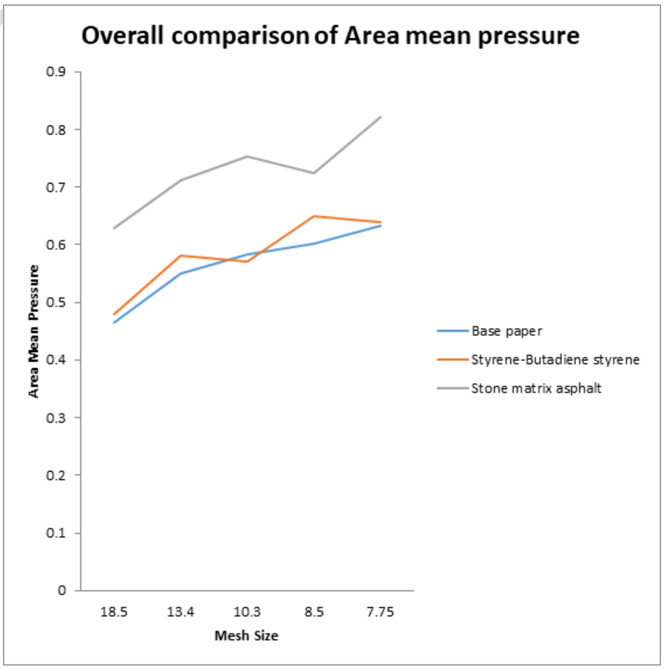

Figure No.:5.34 Graph shows Overall comparison of area mean pressure with base paper, Styrene-Butadiene styrene and stone matrix asphalt.

The above table & graph shows the comparison of area mean pressure of base paper, SBS and SMA with respect to different mesh size. We found the stone matrix asphalt values are increases as compared from base paper value and SBS.

Table No.: 5.5 Contact stresses with different mesh size of stone matrix asphalt.

Mesh size	Contact stresses
18.5	1.50447
13.4	1.50451
10.3	1.50445
8.5	1.50437
7.75	1.50445

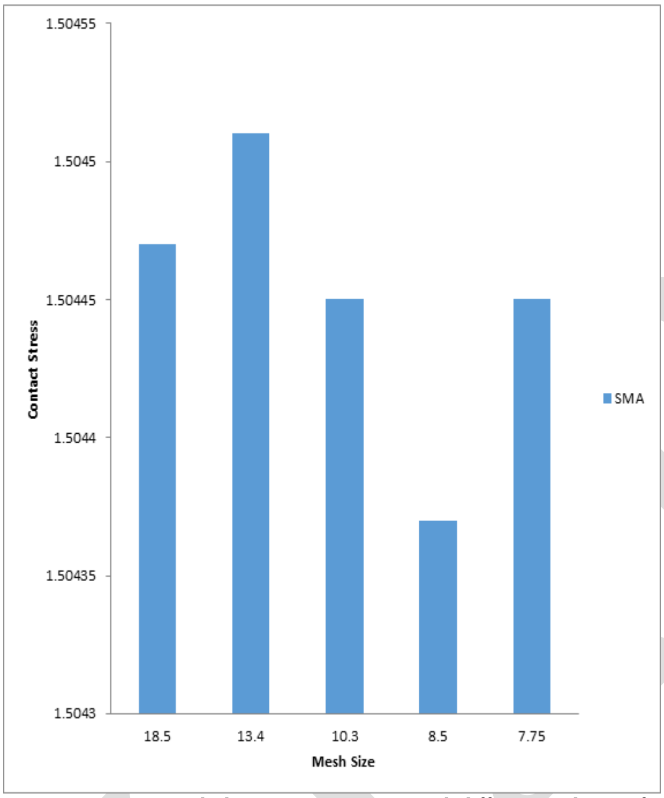

Figure No.:5.35 Graph shows Contact stresses with different mesh size of SMA.

The above table & graph shows the contact stresses of SMA with respect to different mesh size.

Table No.:5.6 Comparison of Contact stresses of SMA with SBS.

	Contact stress	
Mesh size	Styrene-Butadiene styrene	Stone matrix asphalt
18.5	0.89709	1.50447
13.4	0.89707	1.50451
10.3	0.89706	1.50445
8.5	0.89706	1.50437
7.75	0.89706	1.50445

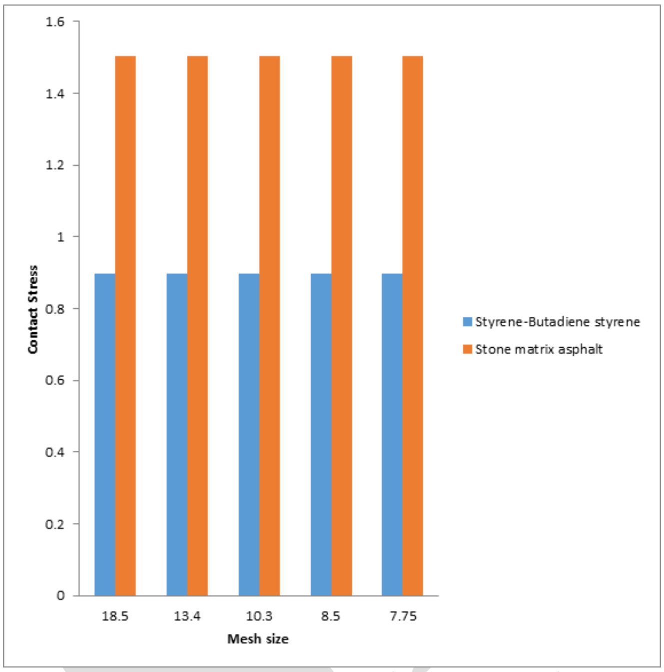

Figure No.:5.36 Graph shows Comparison of Contact stresses of SMA with SBS

The above table & graph shows the comparison of contact stress of SBS and SMA with respect to different mesh size. We found the stone matrix asphalt values are increases as compared from SBS contact stress value.

Comparison of Shear stress ofSBS with SMA

Table No.: 5.7 Comparison of Shear stresses of SMA with SBS

	Shear stress	
Mesh size	Styrene-Butadiene styrene	Stone matrix asphalt
18.5	0.24942	0.19674
13.4	0.26042	0.18161
10.3	0.25308	0.19069
8.5	0.25675	0.21490
7.75	0.25308	0.22096

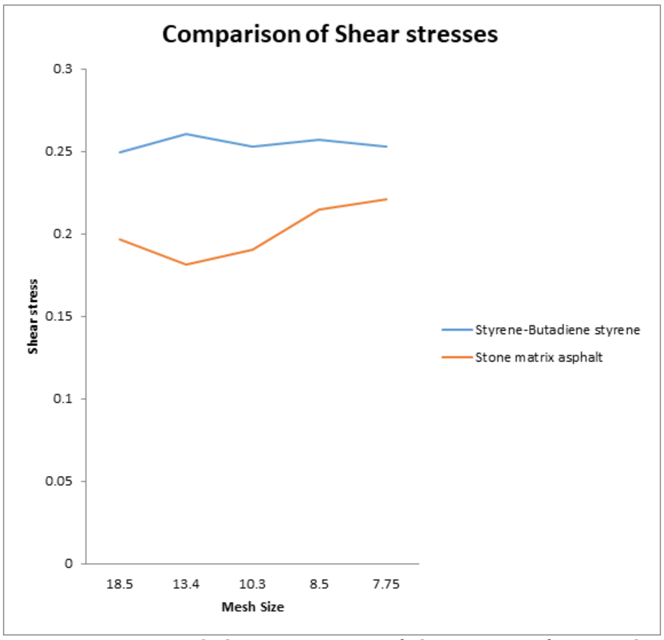

Figure No.:5.37 Graph shows Comparison of Shear stresses of SMA with SBS

The above table & graph shows the comparison of shear stress of SBS and SMA with respect to different mesh size. We found the stone matrix asphalt values are decreased as compared from SBS asphalt shear stresses value.

Comparison of Normal stress ofSBS with SMA

Table No.: 5.8 Comparison of Normal stresses of SMA with SBS.

Normal stress		
Mesh size	Styrene-Butadiene styrene	Stone matrix asphalt
18.5	0.27803	0.13077
13.4	0.2903	0.12071
10.3	0.28212	0.12675
8.5	0.28621	0.14285
7.75	0.28212	0.14687

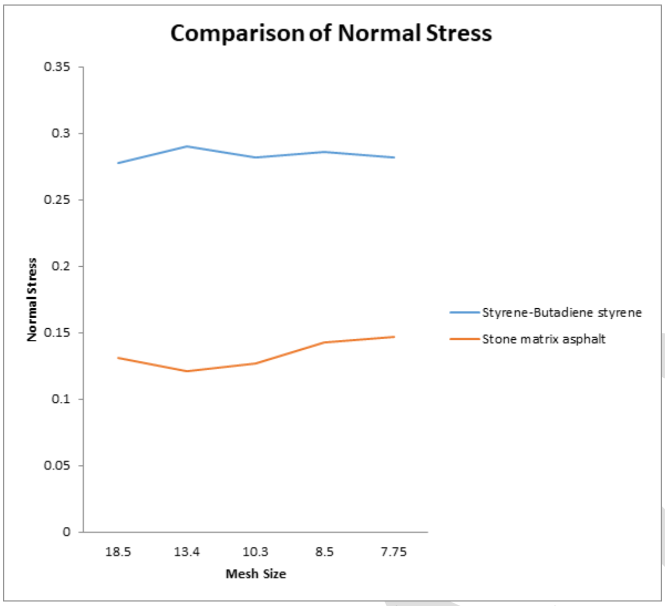

Figure No.:5.38 Graph shows Comparison of Normalstresses of SMA with SBS

The above table & graph shows the comparison of normal stress of SBS and SMA with respect to different mesh size. We found the stone matrix asphalt values are decreased as compared from SBS asphalt normal stresses value.

3. CONCLUSION

This work reports an investigation relating the contact patch properties of what may be regarded as a simple smooth treaded tire and how it is used to measure wet grip. It combines static laboratory measurement with dynamic on-site measurement. The current analysis has presented a study of contact stresses characteristics of a modified asphalt pavement of different mesh sizes. Static structural analysis was carried out on styrene butadiene styrene and stone matrix asphalt, from the analysis of the results, following conclusions can be drawn.

- The contact stress along the modified asphalt pavement profiles is found to be maximum for the stone matrix asphalt material profile with mesh size of 13.4mm varies along the contact area of the pavement. The pressure distribution along the area of contact between pavement and tire is maximum for SMA and mesh size for 13.4 shows maximum convergence.
- The shear stresses is minimum in case of stone matrix asphalt material profile with different mesh sizes i.e. 7.75 to 18.5mm. The nature of the shear stresses is maximum near the mesh size 8.5mm.
- The nature of the normal stresses is minimum in case of stone matrix asphalt material profile with different mesh sizes i.e. 7.75 to 18.5mm. The nature of normal stresses is maximum near the mesh size of 7.75mm and minimum near the mesh size of 13.4mm.
- In a comparison of SBS and SMAasphalt material w.r.t different mesh sizes. We found the results in contact stresses and area mean pressureis higher of SMA as compare to SBS asphalt pavement. So SMA pavement is better as compare to SBS asphalt pavement.\

4. FUTURE SCOPE

- Rigid pavement could be used to analyze contact stresses.
- Different mesh sizes can be used for analyzing area mean pressure for different types of pavements.
- Different load could be also analyzed for different mesh size to predict area mean pressure and contact stresses for pavement.
- Stiffness is also analyzed in different mesh size of pavement.

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