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Design and analysis of heavy duty vehicle truck chassis.

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Abstract: This paper presents a design of an off road vehicle YJ3128 –type dump truck chassis. In mining areas the road is uneven because of this one or more tires are moving up and down so usually 3 to 5 months the chassis should get bad condition and fatigue failure is occurs. So, lift the frame and set at particular height for 50 mm and 20 mm, and analyze the stresses for manganese steel. Static and modal analysis is performed on the dump truck chassis frame modal using Ansys work bench 16.0 software. At 50 mm height the frame gets failure because of at front frame the number of beams are lesser than the end frame so add the beam and calculate the stress and then observe stresses for frame using different materials i.e. Aluminum, structural steel and carbon –carbon composite. For this design is done in creo parametric 2.0 and analysis is done in Ansys work bench 16.0 software.

I. INTRODUCTION

The dump trucks are generally used to transport the materials such as sand, gravel, or demolition waste in mining areas and construction areas. A typical dump truck is consists of an open –box type bed, and which is hinged at the rear end and having with hydraulic piston in the bed it will be deposited ("dumped") on the land as shown in Fig .1.The commercial average dump truck holds 10 to14 yards of dirt.

Now a day's Transportation industries have a one of the major role in the economy of modern industrialization and also develop the countries. Heavy duty trucks are carries the total and relative volumes of goods are increasing perilously. Logistics, factories, agricultures and other industries are using this type of heavy duty vehicles for dump the material from place to another place.

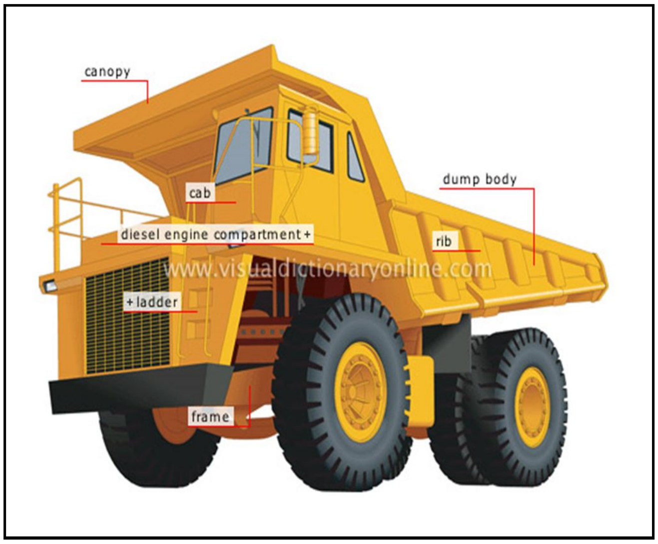

Fig.1Dump truck

Irregular roads in mining areas due to the fatigue life and working condition of the dump truck chassis should be reduced. Dump truck consists of the main-frame, sub-frame, Cab, suspension system, the hydraulic lifting mechanism, engine, and gears. The sub-frame connected to the main frame, the strength and stiffness of the main frame should have high because it distribute the all the load forces to the entire frame. Sub frame is one of the important parameter for increase quality and service life of the main frame so, the design of sub frame is considered. Generally in mining areas the roads are uneven, because of this while driving on these roads the tires are moving up and down that's why the chassis usually get bad condition in 3 to 5months, there will be fatigue failure occurred at mostly welding areas and front frame.

From literature review, various studies have been done in trucks. Various techniques [2, 3] are used to reduce the stresses acting upon it. Mainly studies on stress developed in chassis frame and deformation of chassis frame of EICHER 11.10[4, 5]. The maximum equivalent stress and total deformation are also compared for the different cross section [6, 7]. Using polymeric composite heavy vehicle chassis is lighter and more economical than the conventional steel chassis with similar design specifications [8, 9] The maximum stress is observed more at the joints where the weld are present [10, 11].

II. THE STRUCTURE OF THE FRAME

The YJ3128-type dump trucks frame is formed by the main-frame and its length is 4700mm, forth-width is 901mm, and the back-width is 761mm. The8mm thick V-beam is trough, all its section is the same. It consists of six beams in the sub-frame, those are a cylindrical beam at the back of it, a square beam in the middle, and four trough beams, Which are showed in Fig.2 All parts of the chassis are made from ―C Channels with 210mm x 95mm x 8mm and cross member 190mm x 190mm and circular member with 40mm radius.

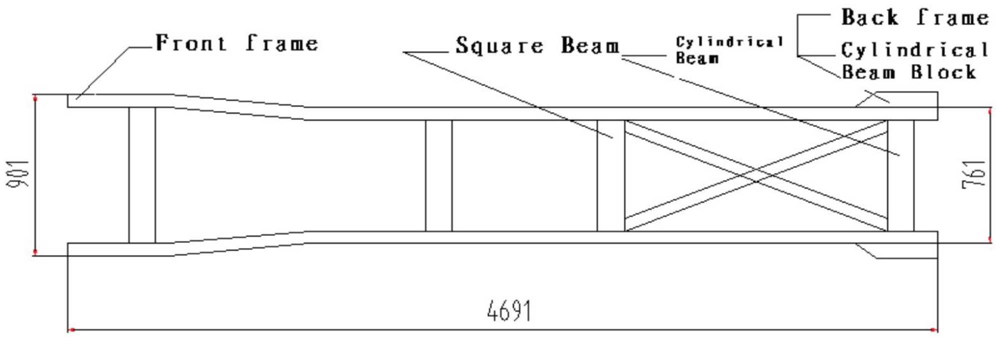

Fig.2 Structure of the frame

III. MODELLING

The 3D model of dump truck chassis frame as shown in Fig.3. Model is created in Creo parametric 2.0

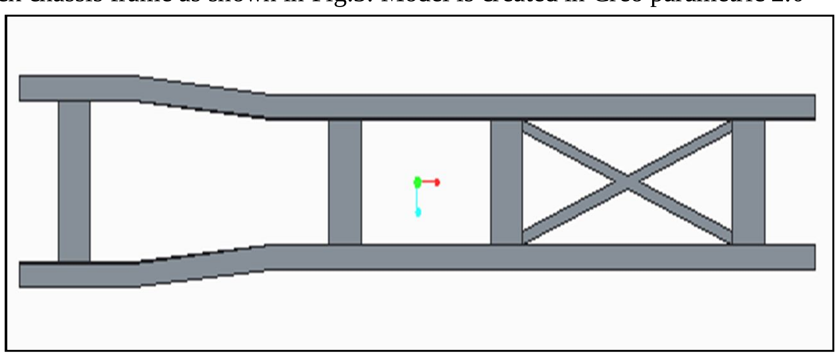

Fig.3 Creo model of chassis frame

A. Material of chassis frame

Table.1Properties of 16MN material

S.no	Material	16 MNL
1	Young's modulus	210 G pa
2	Poisson ratio	0.3
3	Density	7.8×10^3 g/mm^3
4	Yield strength	345 M pa
5	Tensile strength	510 M pa
6	Safety factor	0.2
7	Allowable stress	287.5 M pa

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IV. STATIC ANALYSIS

A. Meshing of chassis frame

The meshing is done on the model with 59960 No. of nodes and 30120 No. of elements show in Fig.4.

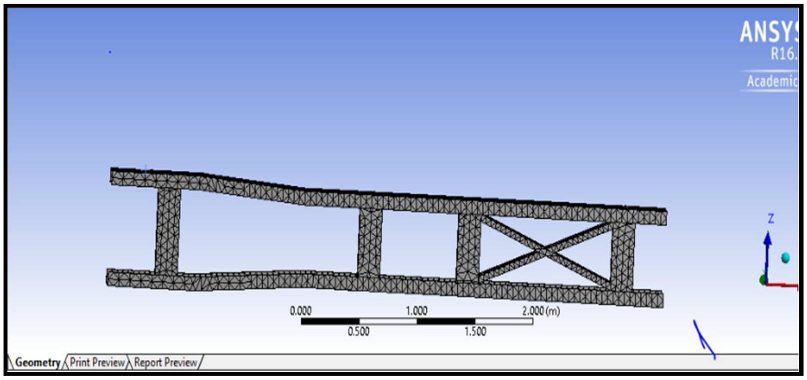

Fig.4 Meshed model of the dump truck chassis frame

B. Boundary Conditions

The boundary conditions for the dump truck chassis frame is as shown in the Fig.5.Every part of chassis frame is made of C-Channel with dimensions of 210mm x 95mm x 8mm and circular member with 40 mm radius and cross members are 190mm x 190mm. Each Truck chassis frame has two beams. So load acting on each beam of the frame is half of the Total load acting on the chassis frame is 121266.3 N/Beam and Load acting on entire span of beam is 121266.3N. Length of the beam is 4700 mm.

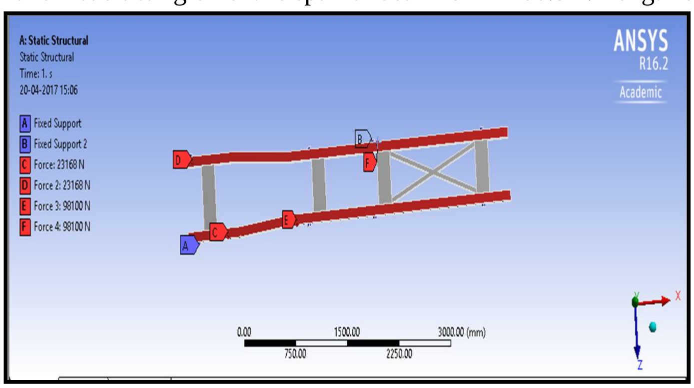

Fig.5 Boundary Conditions of the dump truck chassis frame

V. RESULT OF STATIC ANALYSIS

The deformation and equivalent stress of manganese steel are 5.15 mm and 331 M Pa obtained from static analysis of frame. The obtained deformation and stresses are in allowable limit. It can with stand the above loads shown in Fig.6and Fig.7.

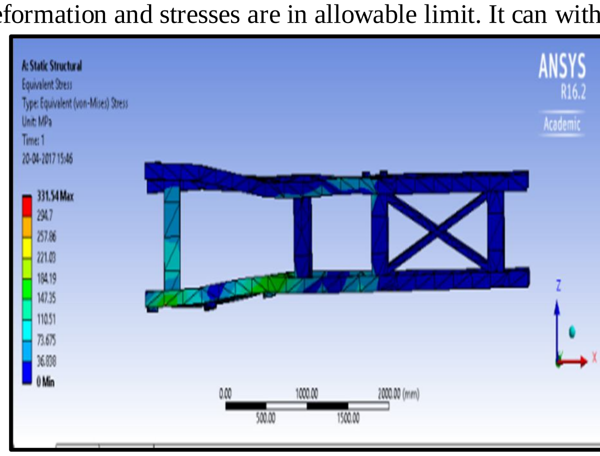

Fig.6 Stress of the chassis frame

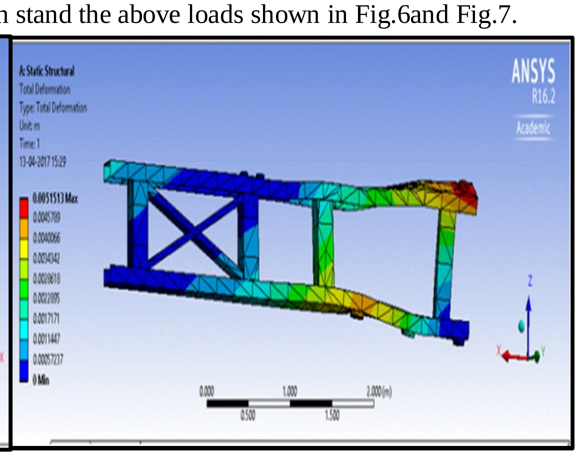

Fig.7 Deformation of the chassis frame

A. Natural frequencies of chassis frame

The natural frequencies of the chassis are shown in figures when 16MN steel is used:

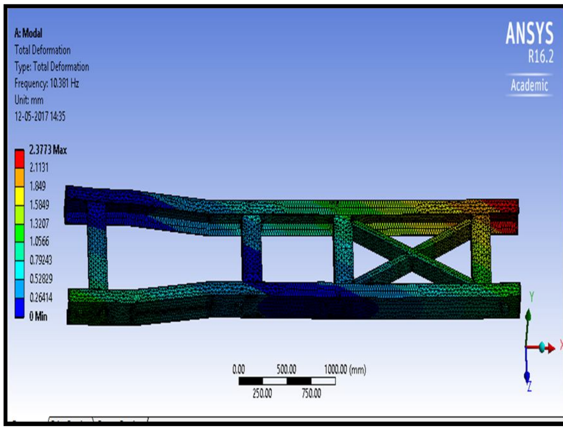

Fig .8 First mode shape at10 Hz

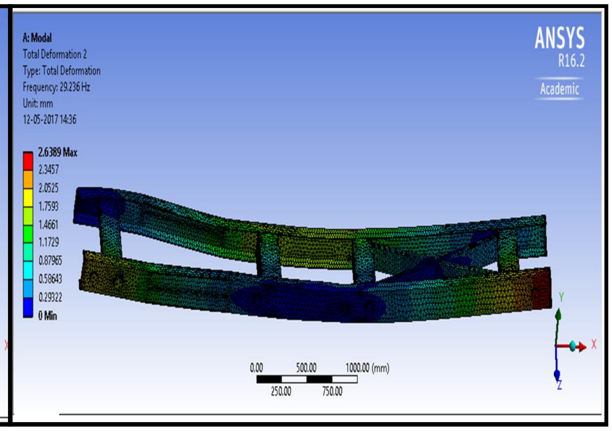

Fig.9 second mode shape at 23Hz

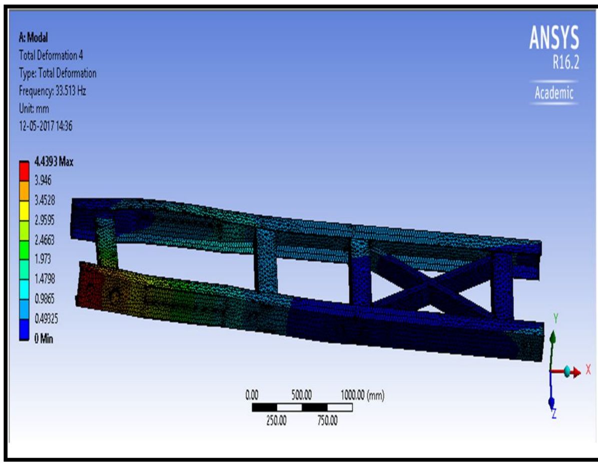

Fig.10 Third mode shape at 32Hz

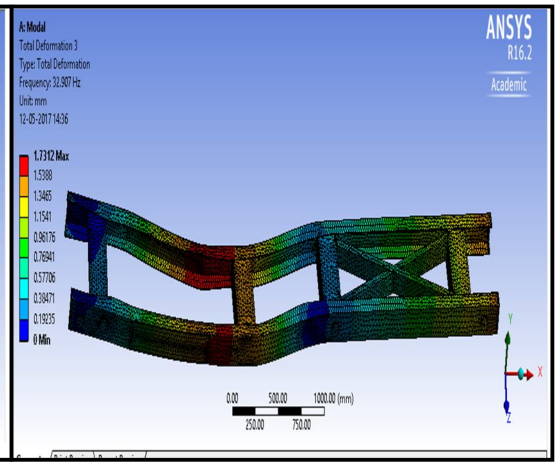

Fig.11 Fourth mode shape at 33H z

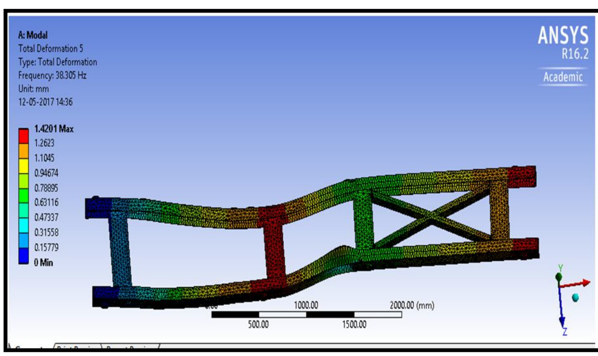

Fig.12 Fifth mode shape at 38Hz

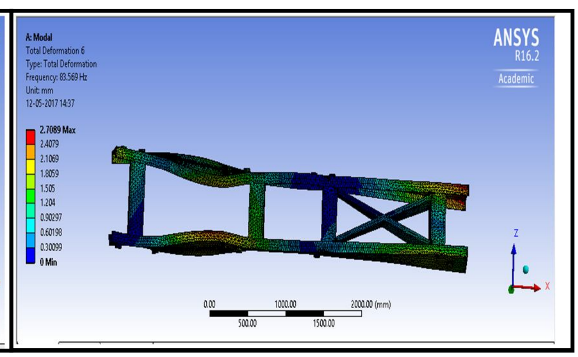

Fig.13 Sixth mode shape at 83 HZ

B. The load case's size and analysis

Generally in mining areas the roads are uneven, because of this while driving on these roads the tires are moving up and down that's why the chassis usually get bad condition in 3 to 5months, there will be fatigue failure occurred at mostly welding areas and front frame.

Generally in mining areas the roads are uneven, because of this while driving on these roads the tires are moving up and down because of this the fatigue failure is occurred. So lift the frame and set at particular height for 50 mm and 20 mm, and analyze the stresses.

C. The finite element static analysis of the sub-frame

1) *The up-rising of tire is 20mm:* In this condition observed three maximum stresses the first stress occurred at final end of the frame that is 323 M Pa it is exceeds the maximum allowable stress of the material. Because of this the crack will be appeared and breaks are observed mostly at welding places. The second stress occurred at square beams of right side of the frame that is 179 M Pa it is in allowable stress of the material. And finally third stress occurred at turning points of the beam that is 143 M Pa as sown in Fig.14. Second and third stresses have lesser than the allowable stress.

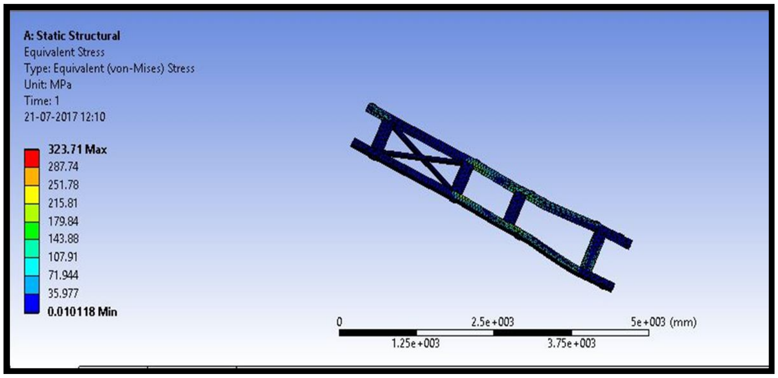

Fig.14 The equivalent stress contours for 20mm

2) *The up-rising of tire is 50mm*

In this condition observed three maximum stresses the first stress occurred at final end of the frame that is 958 M Pa as shown in Fig.15. It is exceeds the maximum allowable stress of the material. Because of this the crack will be appeared and breaks are observed mostly at welding places. The second stress occurred at square beams of right side of the frame that is 426 M Pa it is in allowable stress of the material. And finally third stress occurred at turning points of the beam that is 532 M Pa. Second and third stresses have lesser than the allowable stress.

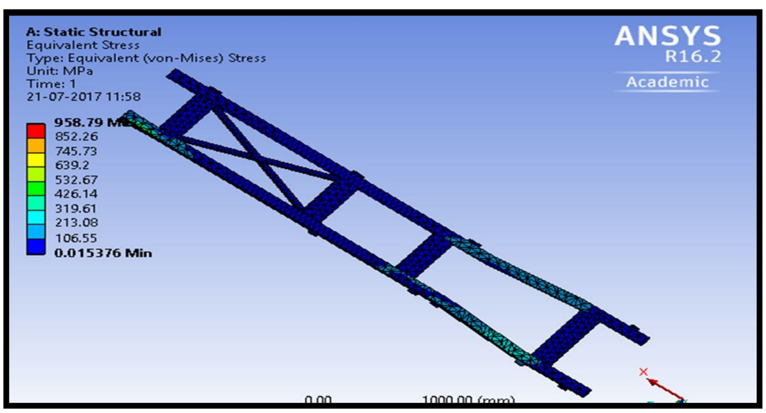

Fig.15 The equivalent stress contours for 50mm

D. The sub-frame's structural modified and finite element analysis

In frame fatigue cracks are observed generally due to lack of torsional stiffness. The number of beams present at front frame is very less compared to end frame so, one beam is added to the front frame. The modified frame is considered as shown in Fig.16.

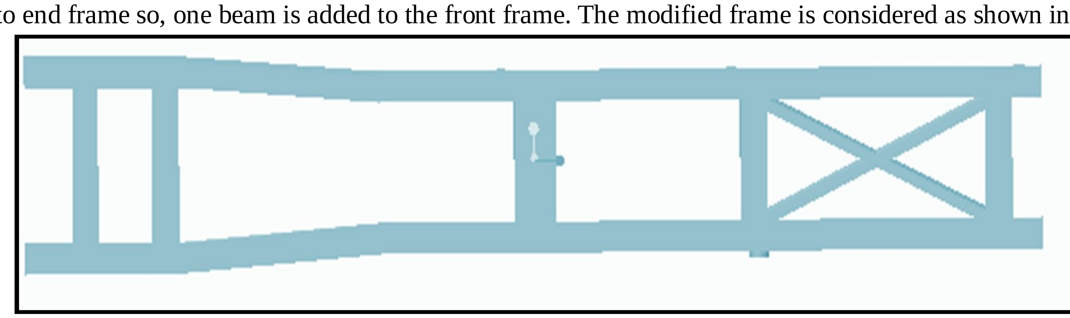

Fig.16 The modified sub-frame

1) *The finite element static analysis of the modified frame:* Truck chassis frame is damaged at 50 mm rising condition. So modification of the frame occurs. For this modified frame calculate the maximum stress at same rising condition and compare it as is shown in Fig.17. The max Von-Misses stress for modified frame is 237M Pa. The stress is within allowable stress limit, and maximum stress occurred at front beam.

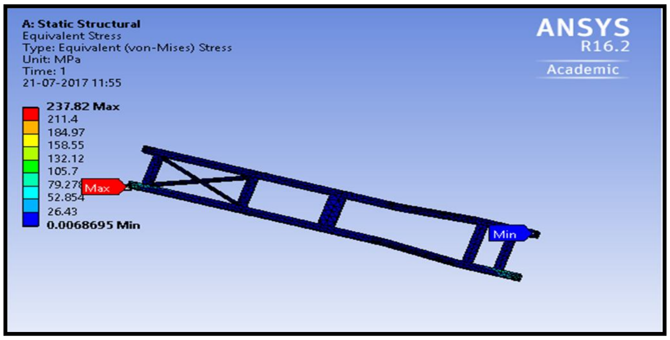

Fig.17The equivalent stress contours for modified one

2) *The static analysis of modified sub frame using different materials*

Table.3 Different materials used and their properties

Property	Structural steel	Aluminium	Carbon–carbon composite
Young's modulus	2e5 M pa	7.1e4 M pa	95e3 M pa
Density	7850 Kg /m^3	2770 Kg /m^3	1.7 g /Cm^3
Poisson ratio	0.3	0.33	0.32
Shear modulus	7.69e4 M pa	2.66e4 M pa	36e3 M pa

3) *Aluminium material*

Using aluminum material at 50 mm rising condition the frame gets fatigue failure so, find out the maximum stress for modified frame at 50 mm rising condition as shown in Fig.18.The maximum Von-Misses stress observed is 259MPa.It is exceeds the allowable stress limit. Mostly the maximum stresses are observed at the front frame because the number of beams are having less than the end of the frame.

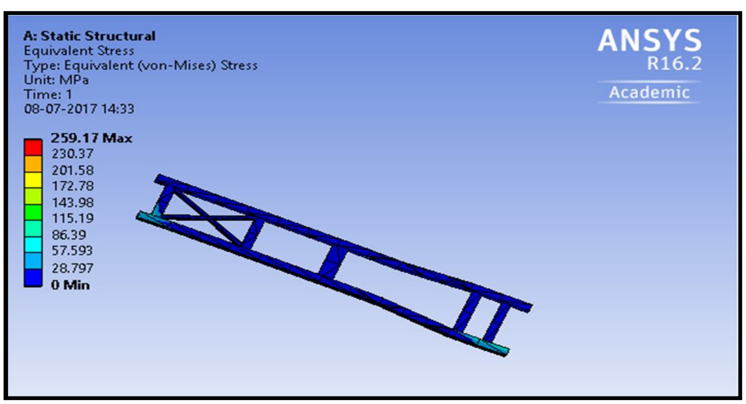

Fig.18 The equivalent stress contours 50 mm for aluminum

4) *Structural steel*

Using structural steel material at 50 mm rising condition the frame gets fatigue failure so, find out the maximum stress for modified frame at 50 mm rising condition as shown in Fig.19. The maximum Von-Misses stress observed is 241MPa.It is in allowable stress limit. Structural steel and manganese steel both materials have an equal strength and these are with stand the loads. Both the materials obtained maximum stresses that are in allowable stress.

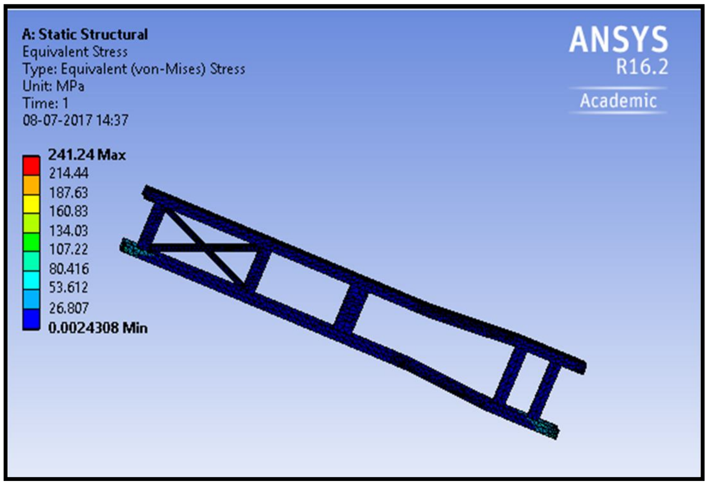

Fig.19 The equivalent stress contours 50 mm for structural steel

5) Carbon –carbon composite material

Carbon –carbon composite material have high strength compared to steel and aluminium. At 50 mm rising condition using steel and aluminium material, the frame gets fatigue failure so replacing the material of modified frame with composite material observe the maximum von-missies stress that is obtained value is 212 M Pa as shown in Fig.20. It is in allowable stress limit.

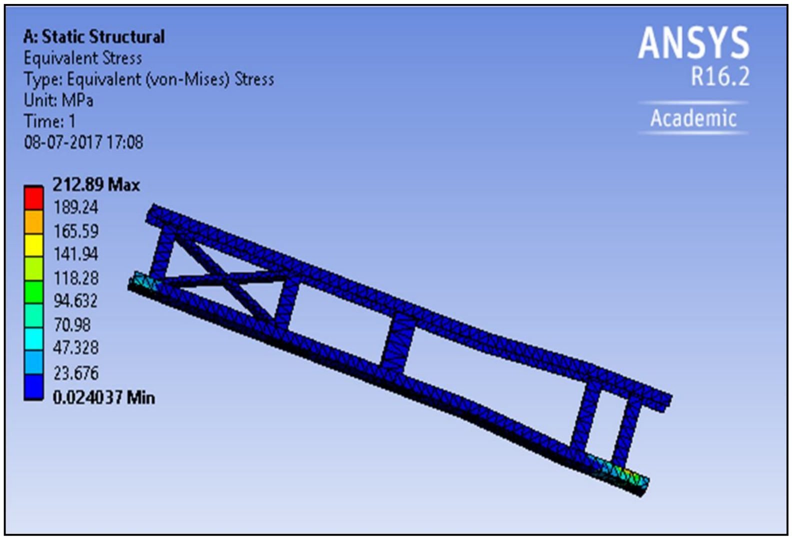

Fig.20 The equivalent stress contours 50 mm for carbon –carbon composite

VI. CONCLUSIONS

In this project a improved sub frame is proposed which is very useful in dump trucks and off road vehicles. In this project proposed model is created using Creo parametric 2.0 software. Static analysis is done for the proposed model and static analysis results showed that there is need for optimization to reduce its stress. After design optimization the maximum von misses stress are reduced drastically. After optimization again static and modal are done and the results are listed.

In this project, after design modification the maximum von -misses stress of model for structural steel is 241M Pa it is in allowable limit so using this material the frame should be with stand in off roads.

1) By replacing Mn steel with aluminum the maximum von –misses stress is 259 M pa. Aluminum material is not in the allowable stress.
2) By replacing manganese steel with carbon – carbon composite the maximum von misses stress is 212M Pa.
3) By comparing both the conventional and composite materials, shows the better results obtained in composite materials.
4) So the composite materials can be replaced by the conventional materials, as they have the better results.

VII. FUTURE SCOPE

In a future, to work is done on effect of dynamic load like vibration and load due to external factors such as air resistance, suspension effect, cornering, brake dip etc. By considering all and some above loads, the analysis of chassis can be made to meet actual life situation. Impact analysis of the frame can be carried out. Using polymeric composite materials for heavy duty vehicle chassis reduced weight approximately73%~80% having same load carrying capacity and also 66~78% stiffer than the steel chassis.

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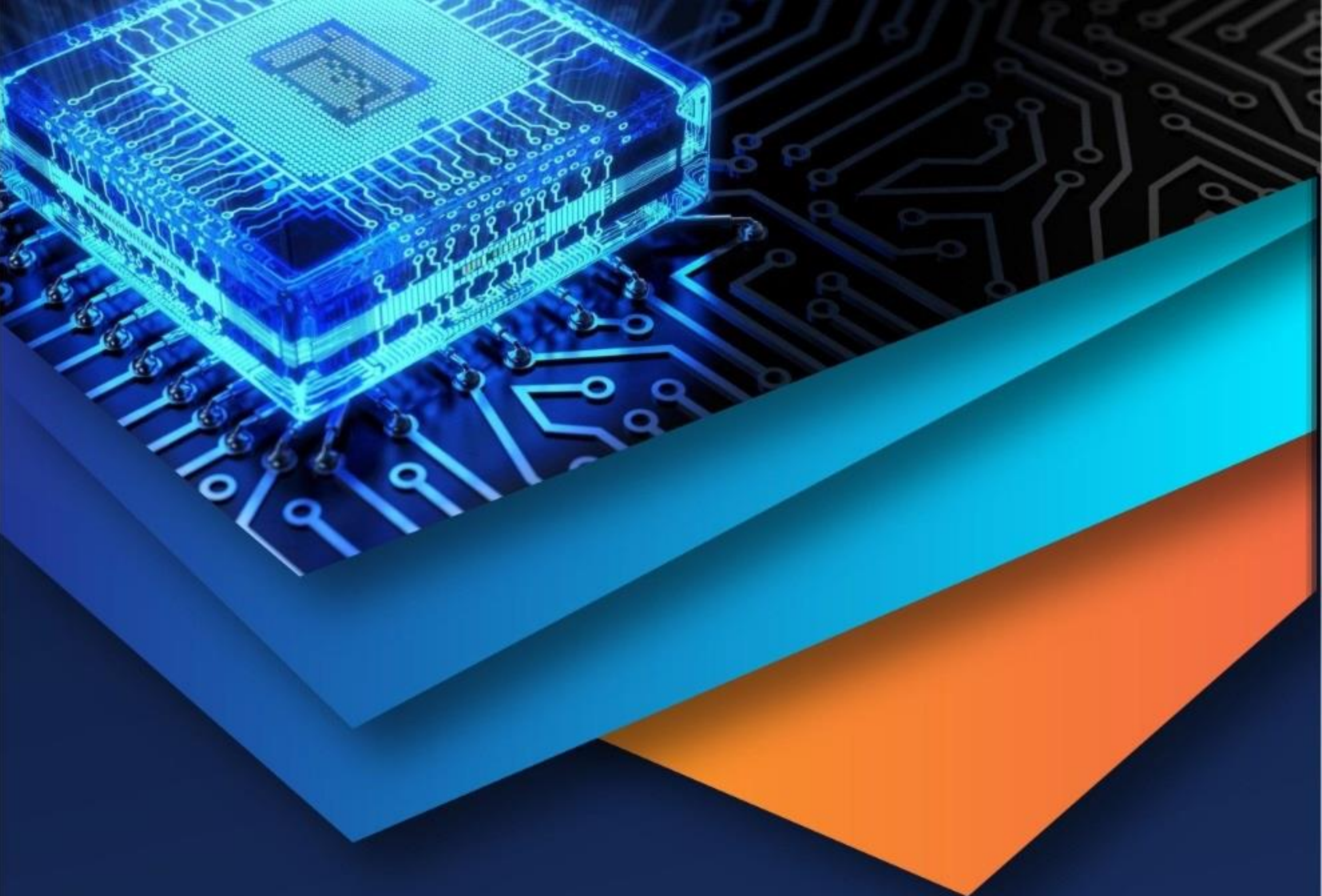

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