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OPTIMIZATION OF HEAVY TRUCK CHASSIS DESIGN PARAMETERS USING FEM

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Abstract: Truck chassis is a backbone component in a vehicle system, as it carries the entire load of the vehicle. So it should be strong enough and on the other hand, the weight of the chassis should be as least as possible to improve the efficiency. This can be achieved in this work by doing static and dynamics analysis to determine key characteristics of a truck chassis (TC). Stress analysis using Finite Element Method (FEM) can be used to locate the critical point which has the highest stress. This critical point is one of the factors that may cause the fatigue failure. The magnitude of the stress can used to predict the life span of the truck chassis. In this study, the stress analysis is accomplished by the commercial finite element package COSMOS. The constraints to be considered in this work are factor of safety. During optimization, either the addition of material or removal of the material, the factor of safety should not be reduced beyond the specified limit

Keywords: Sisal fiber, Epoxy resin, Treated and Untreated fiber, mechanical testing, weight percentage

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INTRODUCTION

The truck industry has experienced a high demand in market especially in India whereby the economic growths are very significantly changed from time to time. There are many industrial sectors using this truck for their transportations such as the logistics, agricultures, factories and other industries. However, the development and production of truck industries in India are currently much relying on foreign technology and sometime not fulfill the market demand in term of costs, driving performances and transportations efficiency.

Basic Frames

Below is some basic technique in developing the frame commonly used by truck chassis manufacture in the world since it was introduced in 1977.

a. The frame rails start as 1/8'' flat steel. Side rails, boxing plates, top and bottom lips are plasma cut to shape and fully jig welded. The sample plate is shown in the figure 1.

b. The top and bottom lips are then full length welded on the inside as well as the outside as illustrated in Figure 1. The reason is to make the rails stronger so that crack will not occur at the weld seams.

c. The rails are fully ground and smoothed.

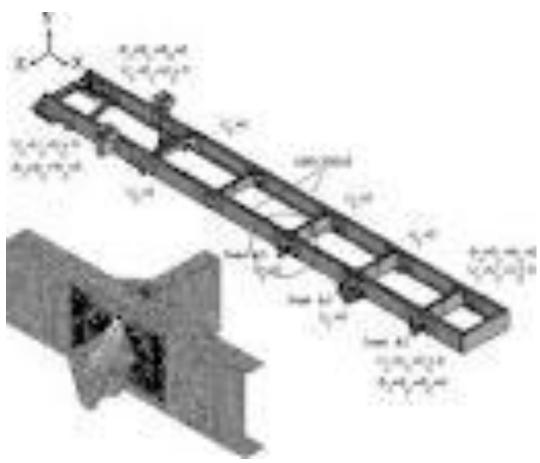

Figure 1.

Final assembly

d. Finally, the rails are clamped back into fixture, ready for the cross members to be welded into place. The final assemble of the chassis is shown in the figure 1.8.

Identification of Problem

The chassis frame forms the backbone of the truck and its chief function is to safely carry the maximum load wherever the operation demands. Basically, it must absorb engine and axle torque and absorb shock loads over twisting, pounding and uneven roadbeds when the vehicle moving along the road. For this project, the truck chassis is categorized under the ladder frame type chassis. Figure 2 shows a typical ladder frame chassis for commercial vehicle.

The next step was the chassis structural preparation and set up for measurement purposes. The measurement data was performed and modeled in the Solid works software. The model of the truck is shown in the figure 2.

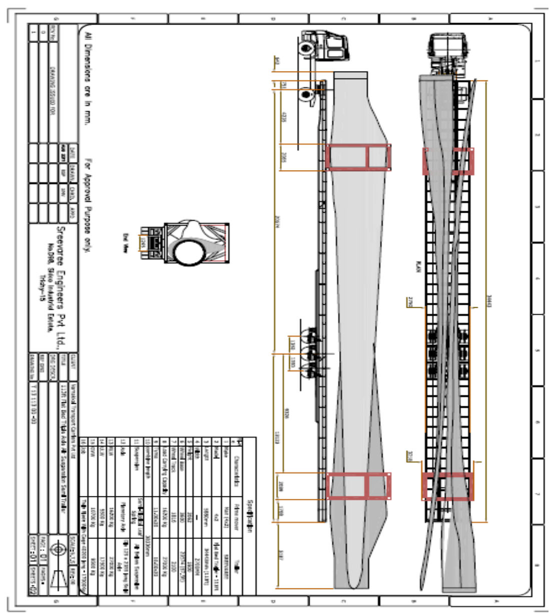

Figure 2. Truck Elevation, Plan and side view

Then the model was imported to the COSMOS software for further analysis of finite element analysis. Then, the result from the analysis was interpreted. Based on the results obtained, the addition and subtraction of the materials of the chassis should be done. Then the model should be redesigned and the procedure is repeated until the optimal design obtained.

TEST SAMPLE I

Test Sample: 113 feet flat bed spring suspension semi trailer

Material : Mild Steel

Dimension (LxBxH), mm: 34443 X 2700 x 1600

Young Modulus (GPa): 200

Density (kg/m3) : 7850

Poisson's Ratio : 0.30

Wheel base : 20574 mm

Wheel Track : 2100 mm

Load carrying capacity: 27 Tones

No of tyres : 10

RLW : 27 tones

ULW : 18 tones

GVW : 9 tones

Stress Distribution Test using FEM

The theoretical analysis has been carried out using the finite element analysis to obtain the stress distribution value of the truck chassis. The objectives of this analysis are to evaluate and optimize the results.

Step I:

The truck chassis structure was modeled using SOLIDWORK software to create the model as shown in figure 3 and 4. The chassis structure are closed rectangular profile longitudinal rails and tubular section cross members.

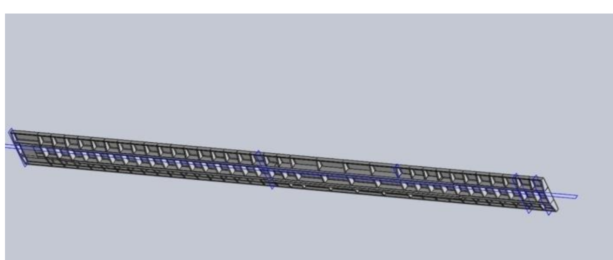

Figure 3. 113 feet flat bed spring suspension semi trailer – Solid works Model

Step II:

The drawing was then exported to the Solid works – COSMOS software.

Step III:

The neutral format is again imported into the COSMOS software simulation system.

Step IV:

The material and element properties of the chassis structure were then defined. The chassis properties were listed as below:

a. Modulus of Elasticity, E = 200Gpa

b. Coefficient of Poisson, ν = 0.30

c. Mass density, ρ = 7850 kg/m cubes and other required details as given in the specification.

Step V:

The tetrahedral-10 element was used in the meshing procedure because of 3D and solid modeling of truck chassis and was meshed on auto meshing (Fine). General overview finite element mesh of the truck chassis with 31,489 elements/ 52788 nodes and 30,489 elements/ 62788 nodes respectively. These results were based on the element set-up on the testing parameter.

Step VI:

The free-free boundary condition was adopted. Therefore, neither constraints nor loads were assigned in attempt to stimulate the free-free boundary condition which means all the brackets and support such as absorbers, spring leafs and engine were removed from the chassis.

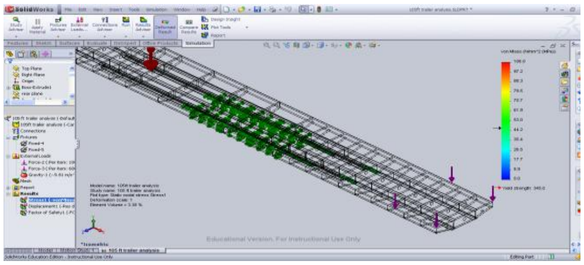

Figure 4. High Stressed Area of the Truck chassis

STRUCTURAL MODIFICATION

105 Feet Truck Analysis on Existing Frame

Study Properties

Study name	105 ft trailer analysis
Analysis type	Static
Mesh Type:	Solid Mesh
Solver type	FFEPlus
In plane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Thermal Effect:	Input Temperature
Zerostrain temperature	298.000000
Units	Kelvin
Include fluid pressure effects from Solid Works Flow Simulation	Off
Friction:	Off
Ignore clearance for surface contact	Off
Use Adaptive Method:	Off

Units

Unit system:	SI

Fixture

Restraint name	Selection set	Description
Fixed-4 <105ft trailer analysis>	On 1 Edge(s), 11 Face(s) fixed.	
Fixed-5 <105ft trailer analysis>	On 1 Face(s) fixed.	

Load

Load name	Selection set	Loading type	Description
Force-2 <105ft trailer analysis>	on 1 Face(s) apply normal force 90000 N using uniform distribution	Sequential Loading	

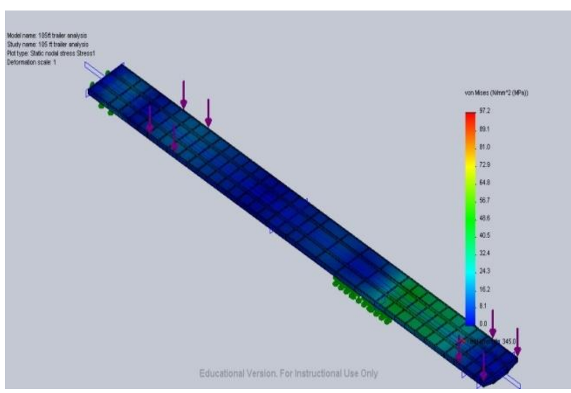

Figure 5. 105 ft trailer analysis-105 ft trailer analysis-Stress-Stress

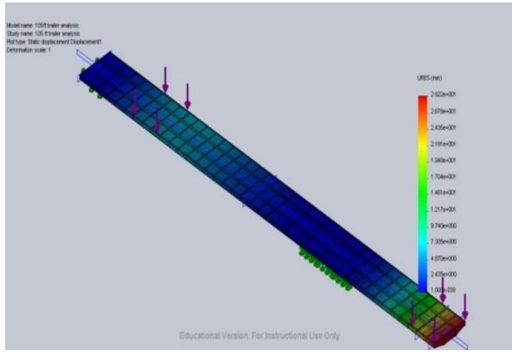

Figure 6. 105 ft trailer analysis-105 ft trailer analysis-Displacement-Displacement

Mesh Information

Mesh Type:	Solid Mesh
Mesher Used:	Curvature based mesh
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	387.08 mm
Tolerance:	9.5663 mm
Quality:	High
Number of elements:	29585
Number of nodes:	55328
Time to complete mesh(hh;mm;ss):	00:00:18
Computer name:	CAD33

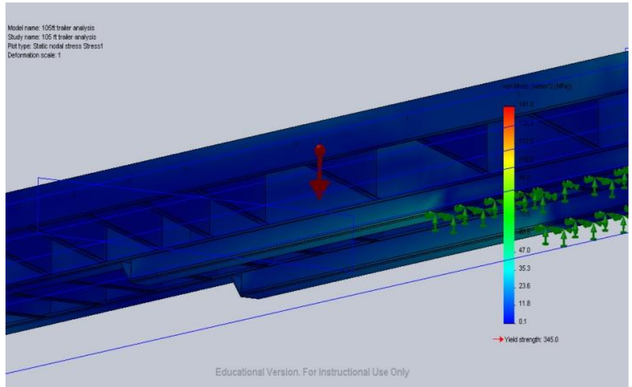

Figure 7. 105 ft trailer analysis-105 ft trailer analysis-Stress-Stress

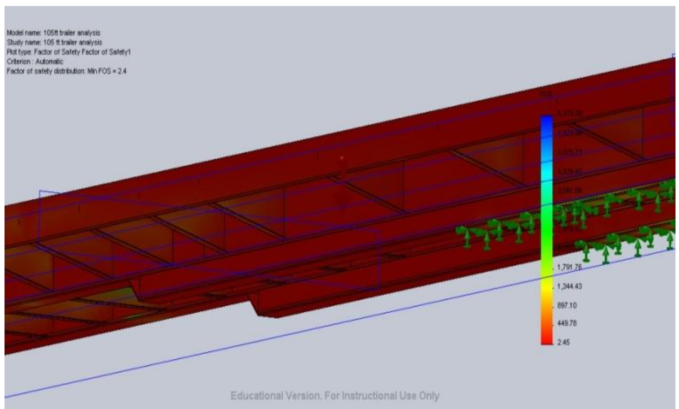

Figure 8. 105 ft trailer analysis-105 ft trailer analysis-Factor of Safety-Factor of Safety

Feet Truck Chassis Analysis – Holes on Side Frame

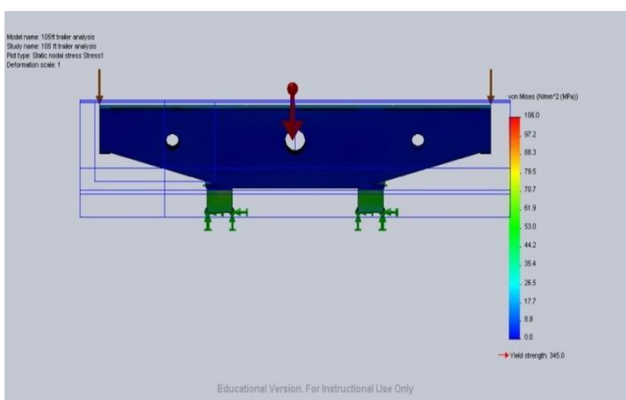

Figure 9 105 ft trailer analysis-105 ft trailer analysis-Stress-Stress

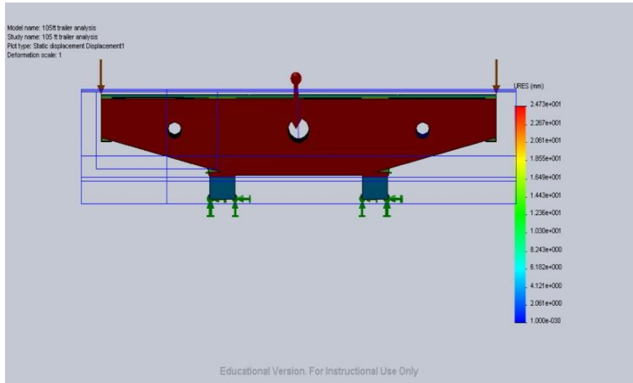

Figure 10. 105 ft trailer analysis-105 ft trailer analysis-Displacement-Displacement

CONCLUSION

Experimental results were used in conjunction with the finite element to predict the dynamic characteristic of truck chassis. Basically, the occurrence of the stress is the important parameters in chassis design.

The overall torsion stiffness was significantly improved by 25% over the base line model. The total deflection also reduced by 16%. There were seven total number of test variables conducted to the existing chassis and it was shown that the combination of increasing the wall thickness by 2 mm and adding plate on the center cross member gave optimum results.

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