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DESIGN AND VIBRATION ANALYSIS OF HEAVY DUTY VEHICLE (TRAILER) CHASSIS THROUGH FEM SOFTWARE

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***Abstract*-Modern heavy duty vehicles are designed to sustain the large amount of loads and carry out best performance on that load. Due to the running condition of vehicle as well as engine, the deformation of chassis produces over the time which causes the failure and needs maintenance. Vibration is the major cause of deformation in chassis, as it always undergoes vibrations due to the shocks from road also the engine vibration. In this study, the vibrations due to the loading as well as running condition is studied so as to understand a range of defect free loading for chassis. A model analysis is performed on virtual truck chassis frame and the ranges of vibrations are found for five different modes of frequencies. It can help for the analysis of frame in vibration point of view. Study explains how the vibrations are set in the chassis and in what range due to applied load and running condition with the help of FEA model bases on FEM (Finite Element Method). A frame of 4 axle, standard truck has been studied and analyzed. On the basis of the studies conducted pre-existing design has been changed taking rectangular and T section as cross bearer and then deign has been analysed using ANSYS package software. The results show important points of stress concentration on chassis. Also, vibration modes have been analyzed during the loading conditions.**

***Keywords:* chassis; rectangular section; Heavy Duty Vehicle (Trailer) Chassis, FEA, ANSYS.**

I. INTRODUCTION

The chassis structure is the bigger component in the any automobile vehicle. The vehicle shape dependent on this chassis, It provides a means of absorbing energy from frontal, side and rollover impacts. The greater the energy absorbed by the chassis on impact the lower the energy levels transmitted to a vehicles occupants and surroundings, so that lowering the chances of injury. The main function of the chassis is not only support the components and payload mounted upon it including engine, body, passengers and luggage, but also to maintain the desired relationship between the suspension and steering mechanism mounting points. Along with a vehicle chassis provides safety to occupants of the vehicle and outside parties. The chassis is subjected to stress, bending moment and vibrations due to road roughness and components that mounted on it.

When the truck travels along the road, Stress acting on chassis is varies with the displacement, the behaviour of the chassis that always subjected to stress (moving or not),to overcome this failure chassis requires appropriate strength, stiffness and fatigue properties of the components to be able to stand these loads or stresses. modal updating technique also important in order to create a good model for analysis. From the global torsion analysis, it has been found that the torsion load is more severe than bending load. In order to overcome this problem, a cross bar and material selection are very important to consider during design stage

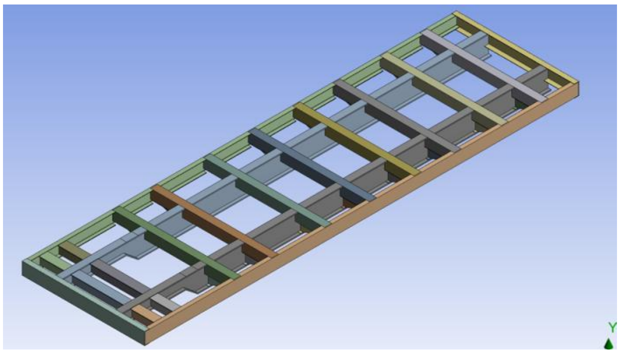


Figure 1 New design model

II. LITERATURE REVIEW

Ashif Iqbal, S. M. Oak et al. [4] (2013) has reviewed a design and analysis study that reduces chassis mass with also minimizing the cost impact. Considering the same material ST 52-3U for design of chassis and altering certain dimensions in cross sections used in chassis deign considerable amount of weight reduction have been achieved. Typical analytical method is being used for analyzing the results.

N.Lenin Rakesh K.Gowtham Kumar et al. [5] (2014) has modelled chassis in CATIA software using actual dimensions. Material used here is Glass Fibber Reinforced Plastic. Steel Bedford's fiber glass reinforced plastic is highly corrosion resistant The main process involves with the both design and analysis of the model. At first all the possible design calculations are performed as per its physical specs, which later is used to convert the same into a 3D model so that it is easily perceptible. Once when done with the design process, structural analysis in which parameters like stress, strain and total deformation are applied ,calculations are performed and all the properties are compared and represented graphically

III. OBJECTIVE

The objective of the study is to reduce the weight of pre existing chassis design . This weight reduction should not be compensated by reduction in strength of chassis. Therefore based on the vast literature review and having a look an analysis result objective being finalised as reducing the weight of chassis without reducing strength of chassis showing through analytic calculations and then analysis the new chassis design in FEM software to validate the result

IV. CASE CONSIDERATION TECHNICAL SPECIFICATION

1 Type of trailer	Three axle, six wheeler [12 wheeled] ,benzo type sprung chassis, horse tractor drawn , semi trailer [articulated] with open box
2. Chassis	Sprung 9200×1125 mm size, st 42
a) long bearers	Composite I-section of 450/250×140mm Cross section fabricated from 20mm thick plates
b) Crossed bearers	8 hollow rectangular section ISMC 200 and 2 T section ISST 250
3. Axle	3 no. of 120 mm dia from 40 ni2cr1 mo28 [en24 }
4. Brakes	6 no. Of air operated internal expanding shoe type of standard ASHOK LEYLAND system
Size	420 mm diameter and 150 mm width
Capacity	748 kgm
5. Tyres	12 no, of 10.00×20, 16 PLY
6. Body	Open box body
Size	9200 mm × 2600 mm × 1250 mm Length width height of box
7. Overall size of the platform	9200 mm × 2600 mm × 3400 mm Length width height from ground

V. WEIGHT CALCULATIONS

1. MAIN CHASSIS LONG AND CROSS BEARERS:

(a) Weight of long bearers :

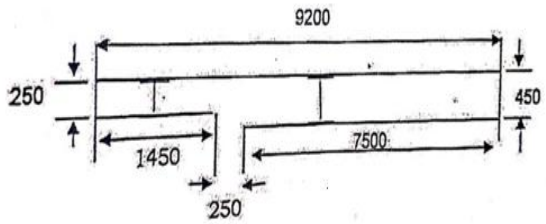
It is built up of composite I beam of 450/250×140 mm size from 20 mm thick plates as shown **fig**

Specific weight 450 × 140 × 20 mm I beam
$= [(0.45\times0.14) - (0.14\times0.120)] \times7860 = 108.47$ kg/m
Specific Weight of 250×140×20 mm I- beam
$= [(0.25\times0.14) - (0.21\times0.120)] \times7860 = 77.03$ kg/m

Weight of two composite sections 9200 mm long bearers :

= 2 ×[(1.45×77.03) + (7.50×108.47) + 0.25 (77.03 +108.47) / 2]

= 1896.74 kg/m



b. Weight of cross bearers

Specific Weight of standard hollow rectangular beam as per given standards for ISMC 200×150 is 22.1 kg/m

Specific Weight of standard T- section beam as per given standards for ISST 250 180×250 is 37.5 kg/m.

c. *Weight of cross bearers:*

= [no. of section used × length of section × specific weight]

= [8×2.6×22.1] + [2×2.6×37.5]

= 654.68 kg

Weight of main chassis:

= total weight of two main long bearers + cross bearers

= 1896.74 + 654.68 = 2551.42 kg ,say 2552 kg.

2. WEIGHT OF CHASSIS FRAME:

(a) Long bearers (side bearers)

Size ISMC 250 sp. Wt= 37.3 kg/m ,

Length = 9200 mm

Weight = [no. Of section used × length of section × specific weight]

= 2×9.2×37.3 = 686.32 kg

(b) Riggers C-section

Size 250/ 50/150 mm in length 745 mm fabricated from 5 mm plate.

Specific Weight = [(0.25 + 0.05) / 2 + 2× (0.15)] ×0.005×1860 = 17.685 kg/m

Weight = (16× 0.745× 17.685) = 210.805 kg

Weight of chassis frame : 686.32+210.805 = 897.152 kg or 898 kg

3 WEIGHT OF FRONT AND REAR CROSS CHANNEL:

Size ISMC 200 Specific Weight = 22.2 kg/m

Weight = 2× (2.60×22.2) = 115.44 kg

a. Vibration analysis of truck chassis

To perform Vibration/Model analysis of chassis we have first imported IGES file into the FEA package. Here ANSYS 14.0 FEA package is used to carry out Vibration Analysis. 3.1 Assigning properties of metal. In FEA package defining material is very important which directly affect the results. For truck chassis mostly steel and its alloys are widely used and for the frame structures, wide variety of alloy materials, composite materials are used. For model analysis we are using St 42 steel as chassis material.

Density = 7.85e-006 kg/mm^3

Poisson Ratio = 0.30

Symmetry = Linear isotropic

Young Modulus = 200 Gpa

Above properties are used to carry out model analysis of truck chassis frame. A set of frequency range will give chassis natural frequency. More the frequency, safer will be the object.

b. Meshed model of truck chassis.

Fine meshing provides a better approximate solution of FE model. Meshing or discretisation of CAD model is initial step towards obtaining solution. This will form small pieces of an object called element which are connected to each other by means of points called nodes. To perform Vibration Analysis meshing of chassis is required. CAD model is completely discretised according to area of loading and constraining.

Tetragonal element is used for discritisation. While at some places where the stresses may induce, the fine meshing is applied. This will form a meshed section which is shown in bellow. It is also indicating the points where the chassis is fixed. Means its displacement at that position is restricted.

Meshed model of truck chassis is given bellow in Figure 2.

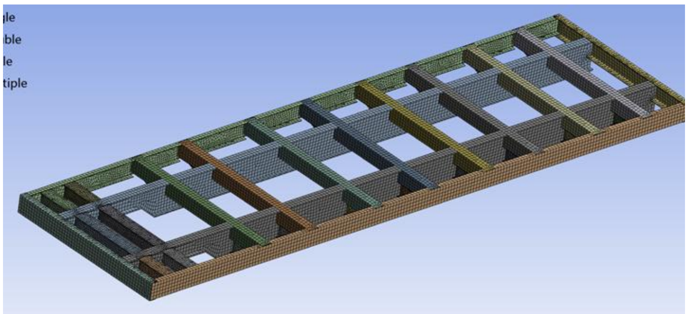


Figure 2 meshed model

c. Obtaining Solution

In Vibration Analysis, the loads applied on chassis are not considered as we want its natural frequency so that we can understand how many vibrations it can sustain and at what frequency level chassis may bend. Applied loads do not affect the results. Therefore the solution is obtained for five different sets of frequency. Each set will give its own chassis displacement value with area of displacement. Complete result obtained using FEA package is discussed bellow.

VI. RESULTS AND DISCUSSION

By obtaining analysis result we got various frequency ranges for various modes. The maximum frequency obtained is 105.84 Hz. Vibration in the truck chassis are allowed up to 105 Hz frequency level. Bellow table shows the frequency values for each mode.

Mode	Frequency [Hz]
1.	29.056
2.	40.023
3.	41.304
4.	54.62
5.	104.94
6.	105.84

First mode of vibration: Vibrations in the first mode will carry the displacement in side members of chassis. This displacement is due to the vibrations of frequency level 29.056 Hz. This mode shows that the at the frequency value 74.32 Hz the chassis will have the deformation up to 1.532 mm

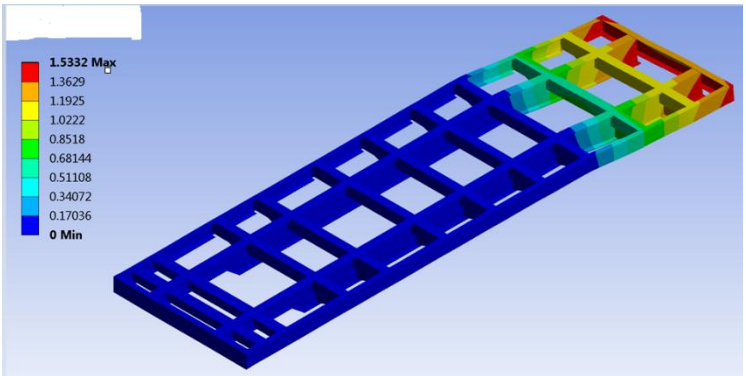


Figure 3 First frequency mode

Second mode of vibration: At second mode the frequency value slightly increased with increasing deformation. Here deformation is in the cross member of a chassis. Due to vibrations frequency value 40.032.14 Hz will setup in the members of chassis and the maximum deformation is 2.5289 mm. Figure 4 shows the second mode of vibration with frequency value.

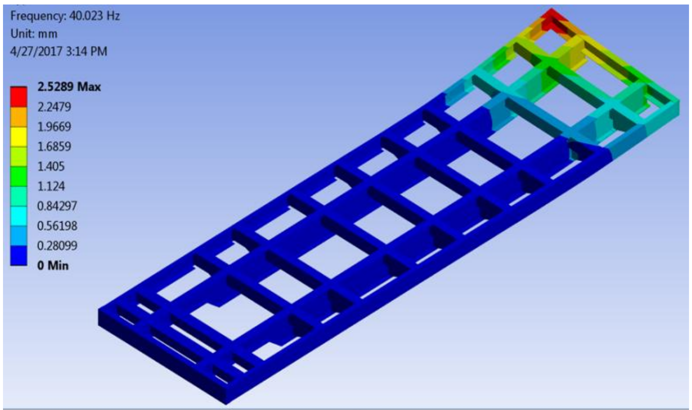


Figure 4 Second frequency mode

Third mode of vibration: Third mode of vibration gives frequency value 41.304 Hz with maximum deformation 3.0327 mm.

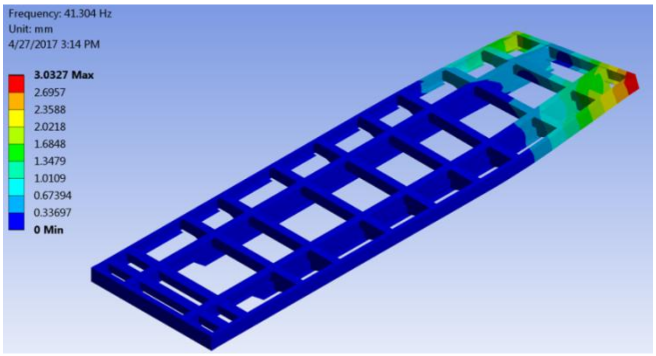


Figure 5 Third frequency mode

Fourth mode of vibration: fourth mode of vibration gives frequency value 54.62 Hz with maximum deformation 1.3548 mm.

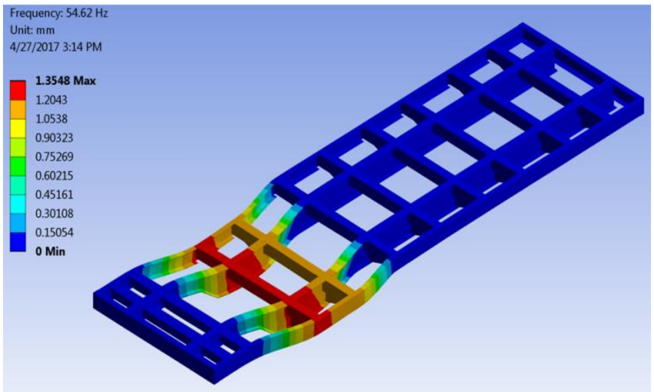


Figure 6 Fourth frequency mode

Fifth mode of vibration: fifth mode of vibration gives frequency value 104.94 Hz with maximum deformation 1.4611 mm.

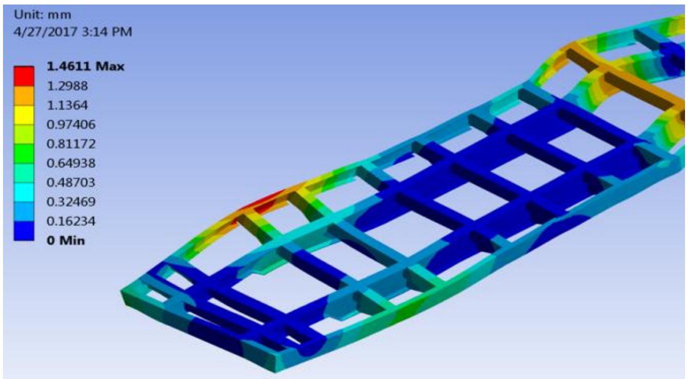


Figure 7 Fifth frequency mode

Sixth mode of vibration: sixth mode of vibration gives frequency value 105.84 Hz with maximum deformation 2.3251 mm.

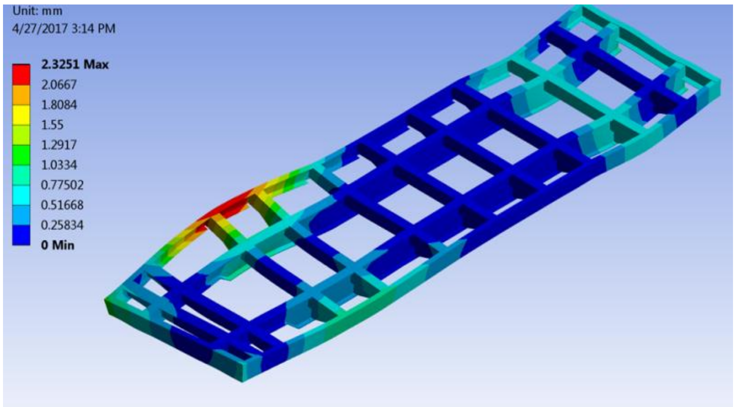


Figure 8 Sixth frequency mode

Results

Object Name	***Total Deformation***	***Total Deformation 2***	***Total Deformation 3***	***Total Deformation 4***	***Total Deformation 5***	***Total Deformation 6***
Definition						
Type	Total Deformation					
Mode	1.	2.	3.	4.	5.	6.
Results						
Minimum	0. mm					
Maximum	1.5332 mm	2.5289 mm	3.0327 mm	1.3548 mm	1.4611 mm	2.3251 mm
Minimum Occurs On	I-SECTION\Solid					
Maximum Occurs On	I-SECTION\Solid	C-SEC2\Solid2		I-SECTION\Solid		C-SEC\Solid2
Information						
Frequency	29.056 Hz	40.023 Hz	41.304 Hz	54.62 Hz	104.94 Hz	105.84 Hz

VII. CONCLUSIONS

Model analysis is the optimised way to find out effect of vibration a chassis. As chassis always undergoes to continuous uniform loading, there is always need to have better chassis which must satisfy all requirements of truck chassis. Also it must have high natural frequency so that while working in vibrations it should no bend or deform permanently.

By above analysis results, it can concluded that Vibrations in chassis can cause deformation in chassis. Maximum frequency obtained by performing Vibration analysis is 105.84 Hz. Natural frequency of chassis needs to improve as more the frequency safer the object. Vibrations in chassis can be sustained by optimizing chassis design by means of Natural frequency.

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