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FEA Based Analysis of Dynamic Behaviour of Truck Chassis

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ABSTRACT
Chassis forms the structural backbone of a passenger vehicle. As the truck travels along the road, the truck chassis is excited by dynamic forces induced by the road roughness, engine, transmission and more. Under such various dynamic excitations, the truck chassis tends to vibrate. Whenever the natural frequency of vibration of a machine or structure coincides with the frequency of the external excitation, there occurs a phenomenon known as resonance, which leads to excessive deflections and failure. All the structural components in vehicles are subjecting to dynamic loading behaviour and fails due to dynamic loading. In the present work the modal analysis and frequency response analysis is carried out on existing designed chassis to determine the natural frequency of the structure and stress levels. From the FEA results are revealed that one of the natural frequencies of the existing chassis is aligned with operating frequency of the vehicle, this leads to resonance failure of chassis.

1. INTRODUCTION

The chassis is the truck's backbone. If a vehicle is to last a long time, its chassis must withstand all the stresses and strains it's subjected to every single day, both from the power it has to deliver while carrying a heavy load or when subjected to dynamic loading. The dynamic response of simple structures, such as uniform beams, plates and cylindrical shells, may be obtained by solving their equations of motion. However, in many practical situations either the geometrical or material properties vary, or the shape of the boundaries cannot be described in terms of known mathematical functions. Also, practical structures consist of an assemblage of components of different types, namely beams, plates, shells and solids. In these situations it is impossible to obtain analytical solutions to the equations of motion.

2. LITERATURE REVIEW

Today, there are many researches and development program available in the market especially by the international truck manufacturers, which are very much related to this study. Therefore, there are several technical papers from the 'Engineering Society for Advancing Mobility Land Sea Air & Space' (SAE) and some other sources which are reviewed and discussed in this chapter.

Dave Anderson and Greg Schade[1] developed a Multi-Body Dynamic Model of the Tractor-Semitrailer for ride quality prediction. The studies involved representing the distributed mass and elasticity of the vehicle structures e.g. frame ladder, the non-linear behaviour of shock absorbers, reproduce the fundamental system dynamics that influence ride and provide output of the acceleration, velocity and displacement measures needed to compute ride quality.

I.M. Ibrahim, et.al. [2] had conducted a study on the effect of frame flexibility on the ride vibration of trucks.

Romulo Rossi Pinto Filho, who analysed on the Automotive Frame Optimization. The objective of his study was basically to obtain an optimized chassis design for an off-road vehicle with the appropriate dynamic and structural behaviour. [3] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased

Izzudin B. Zaman [4] has conducted a study on the application of dynamic correlation and model updating techniques.

Lonny L. Thomson, et. al., had presented his paper on the twist fixture which can measure directly the torsion stiffness of the truck chassis. [5] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences. Elements and speed vectors were thought to be inaccessible, along these lines a NN eyewitness was intended to recoup the limitless states. At that point, a novel NN virtual control structure which permitted the craved translational speeds to be controlled utilizing the pitch and the move of the UAV. At long last, a NN was used in the figuring of the real control inputs for the UAV dynamic framework. Utilizing Lyapunov systems, it was demonstrated that the estimation blunders of each NN, the spectator, Virtual controller, and the position, introduction, and speed following mistakes were all SGUUB while unwinding the partition Principle.

Murali M.R. Krishna [6] has presented his study on the Chassis Cross-Member Design Using Shape Optimization.

Marco Antonio Alves [7], on the Avoiding Structural Failure via Fault Tolerance Control. There were two approaches or option used, firstly the structural modification and secondly by some active modification.

3. OBJECTIVE

To increase the dynamic stability of the chassis material by obtaining and analysing the modal analysis report and moving the natural frequency away from the operating frequency. The natural frequency band is considered as +/- 10 of maximum operating speed of the vehicle. As per ISO standards the natural frequency of the structure should align with this operating frequency band to avoid the resonance and its failure.

4. METHODOLOGY

The dynamic structural analysis is performed on the four wheeler truck chassis to evaluate the induced stress, deformation and displacement levels in the chassis for the vehicle speed of 90 Km/h.

The analysis steps followed are,

- Geometry clean up using Hypermesh V12
- Mesh generation using Hypermesh V12
- Apply loads, boundary conditions and obtain the solution in ANSYS V14.5.
- Review the results.

Geometry for the Analysis:

The vehicle mainly consists of chassis, engine, steering, cab, suspension system and wheel assembly. All these structural components are mounting on chassis. For the analysis only chassis is considered and all other structural elements are modelled as lumped mass element such as engine, steering etc. The geometry clean up like defeaturing of small fillets, chamfers etc., are carried out using hyper mesh. The geometry considered for the analysis is shown in figure 1

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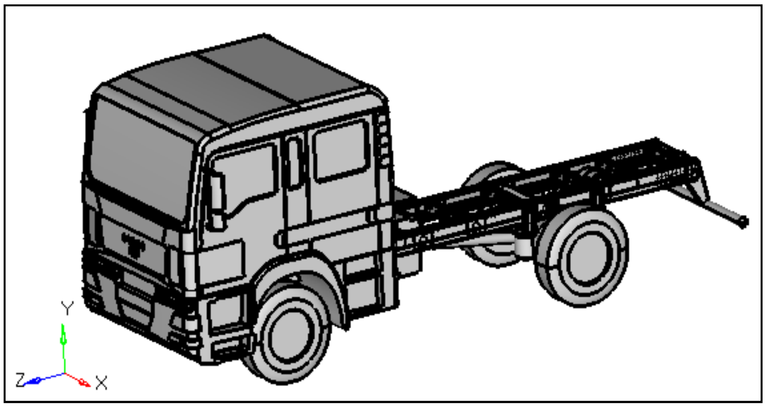

Figure 1: Full Vehicle Geometry

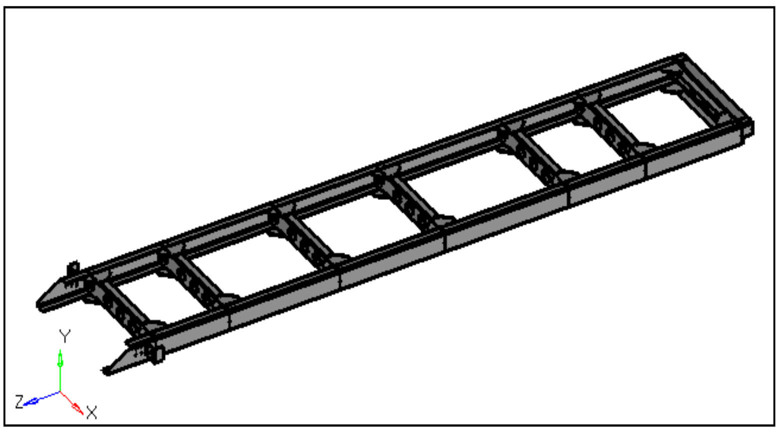

Figure 2: Chassis geometry

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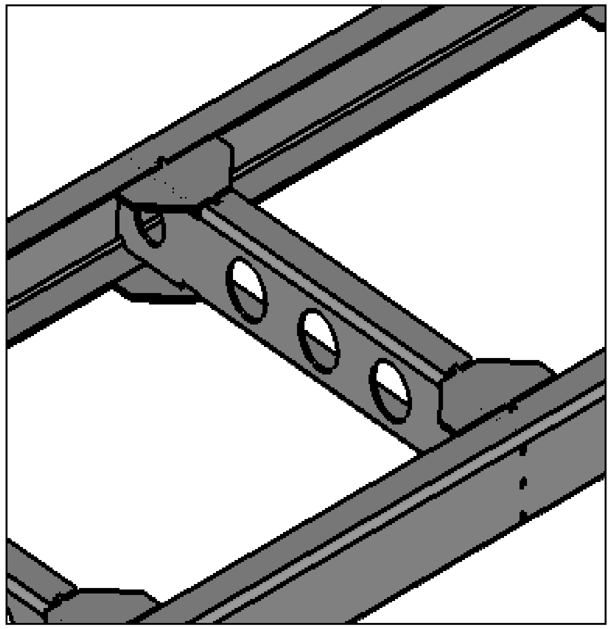

Figure 3: Zoom in view of Chassis geometry

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Generation of FE Model:

The Finite element model is generated using Hypermesh V12. The SHELL 181 2D shell element is used for meshing of chassis. The 2mm element size is selected for meshing. The BEAM 188, 1D beam element is used to connect the front sleeve assembly to the floor chassis. The COMBIN 14 elements are used for modelling suspension system. The MASS 21 is used to distribute the GVW (gross vehicle weight) of vehicle as lumped mass element. The FE model of chassis is shown in figure 4

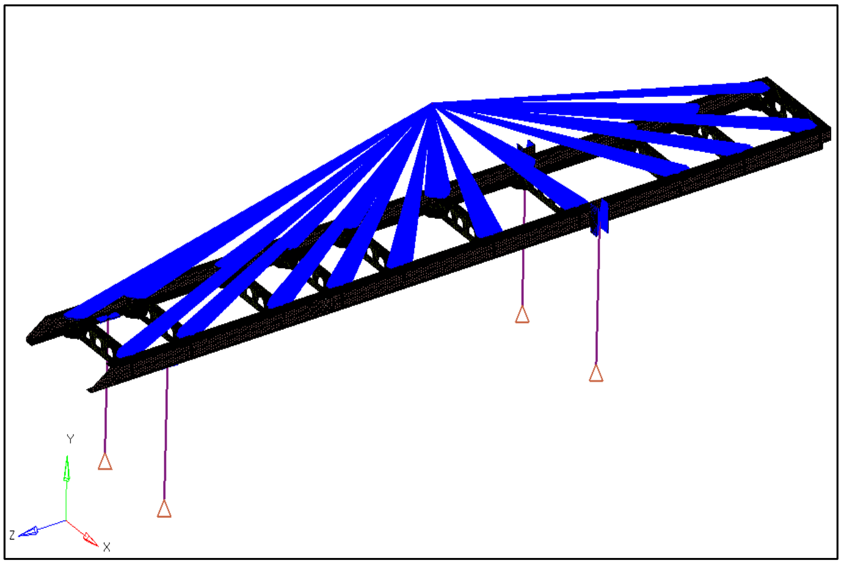

Fig 4: FE Model of Chassis

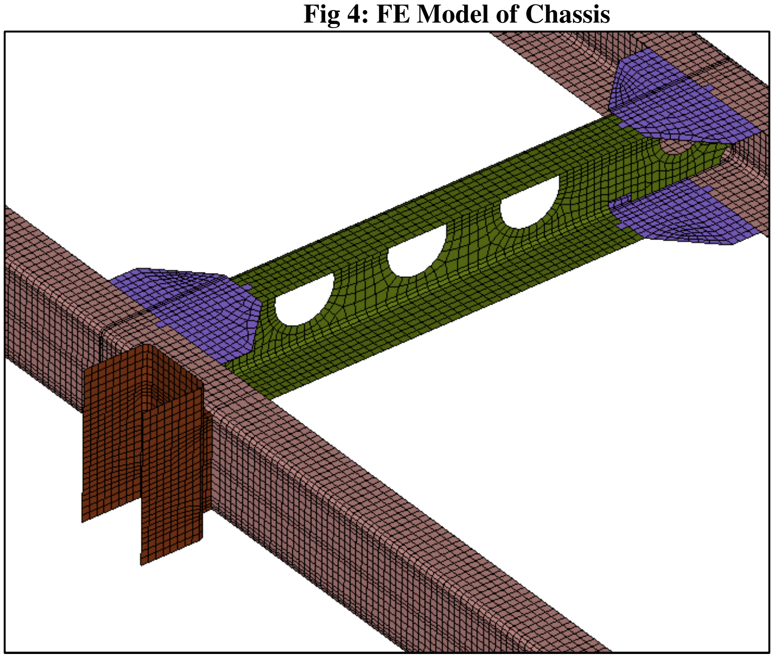

Figure 5: FE Model of chassis side rails

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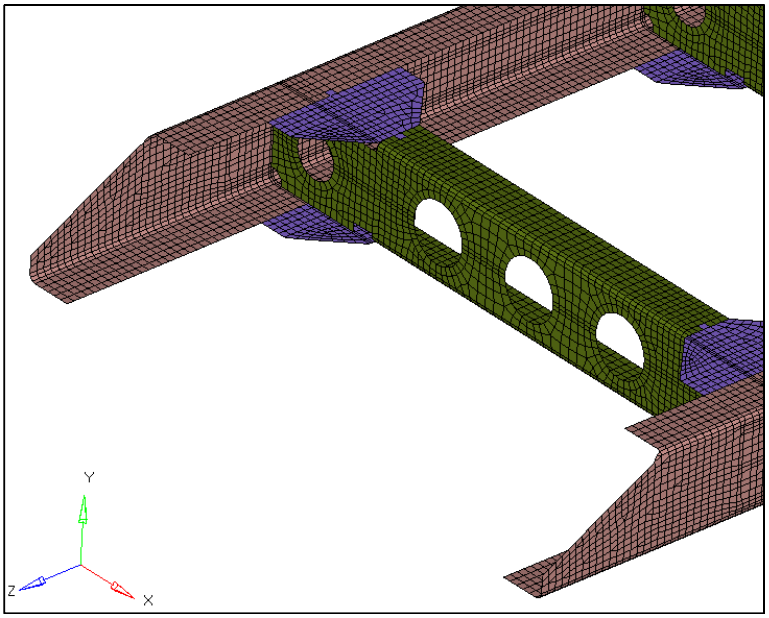

Figure 6: FE model of chassis bracket

Mesh Statistics:

Table 2.1: FE Model properties

Element Type	SHELL 181,BEAM188, MASS21,COMBIN14
Analysis Type	Modal Analysis, Harmonic Analysis
Total Nodes	125150
Total Elements	98520
Solver	ANSYS V1.5

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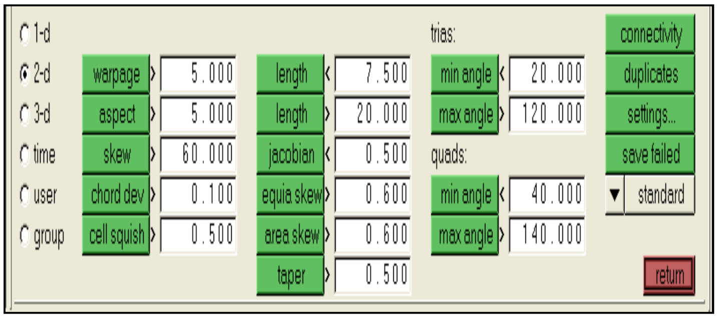

Figure 7: FE model quality parameters

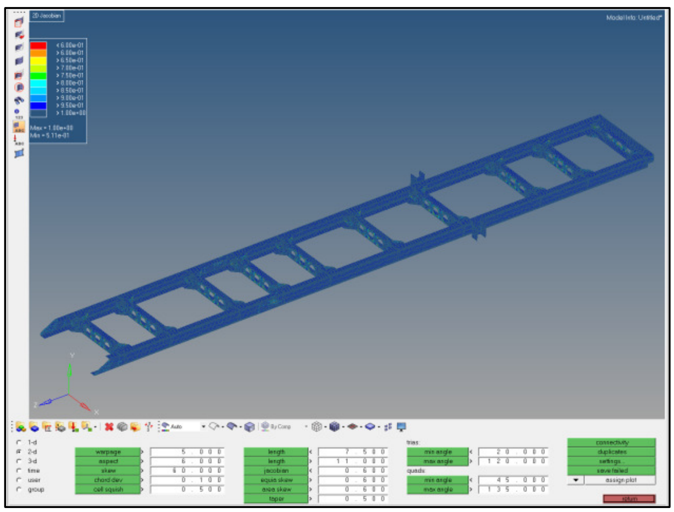

Figure 8: FE model

5. RESULT AND DISCUSSION

5.1 Modal Analysis

The maximum operating speed of the vehicle is 2800 rpm (from vehicle specifications) is considered for the analysis. It yields to the frequency of 46 Hz. The design target is that the natural frequency of the chassis shouldn't align with the +- 10 Hz of operating frequency as per industries standard. Hence the natural frequency of the chassis should not falls in the frequency range of 36 Hz to 56 Hz.

The chassis rear bracket beding mode is observed at 51 Hz and the displacement contour is shown in figure 9

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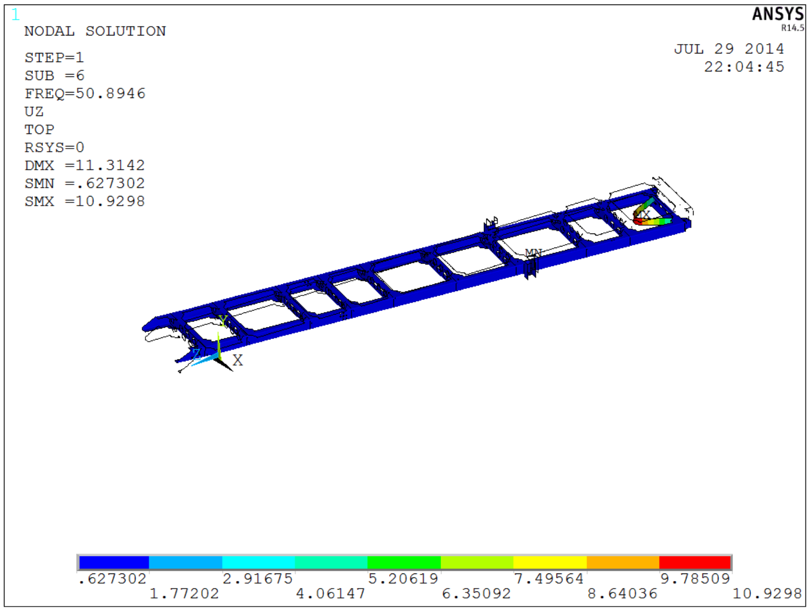

Figure 9: Displacement contour at 51 Hz Mode

The chassis rear bracket 2nd order beding mode is observed at 54 Hz and the displacement contour is shown in figure 10

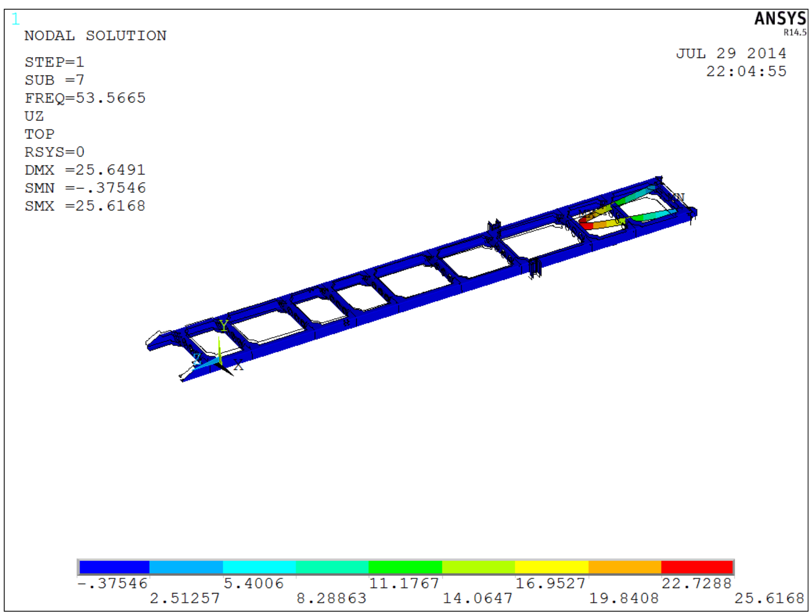

Figure 10: Displacement contour at 54 Hz Mode

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Summary of Modal Analysis:
From the FEA results are observed that the fundamental modes like fore aft, lateral roll, yaw, pitching and vertical modes of the chassis. The two natural frequencies of the chassis (51 Hz and 54 Hz) are aligned with the operating frequency range of 36 Hz to 56 Hz of the chassis. Hence it is preferable to move the mode above or below the operating frequency range.

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