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DESIGN AND ANALYSIS OF A TRUCK CHASSIS FRAME USING CATIA AND ANSYS

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Abstract— The chassis design, in general, is a complex methodology and to arrive at a solution which yields a good performance is a tedious task. Since the chassis has a complex geometry and loading patterns, there is no well defined analytical procedure to analyze the chassis. So the numerical method of analysis is adopted, in which 'Finite Element Technique' is the most widely used method.

Index Terms: Chasis, Finite Element Technique, Ansys Work Bench, complex geometry, analytical, numerical method, truck, natural frequency, mode shape, frequency response function.

INTRODUCTION

The truck industry has experienced a high demand in market especially in Malaysia 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 Malaysia are currently much relying on foreign technology and sometime not fulfill the market demand in term of costs, driving performances and transportations efficiency.

LITERATURE REVIEW

The literature review of the truck chassis was carried out to obtain the basic understanding of the project. Information like typical natural frequency values of truck chassis, excitation sources and mode shape of truck chassis were searched and reviewed. Then the dimension of an existing truck chassis was measured. The chassis chosen was a Suzuki Jeep model of mass approximately 75kg. The type of chassis was known as parallel ladder type frame with box section as shown in Figure 3.1. The next step was the chassis structural preparation and set up for measurement purposes. The measurement of Frequency Response Function (FRF) data was performed and there were 22 measurement points through out the chassis structure. The FRF data were then transformed into ME's Scope software for further analysis on Modal Analysis

PROBLEM STATEMENT

The vehicle models that have been developed almost the same appearance since the models developed in 20 or 30 years ago. This is a major challenge to truck manufacturers to improve and optimize their vehicle designs in order to meet the market demand and at the same time improve the vehicle's durability and performance. Since the truck chassis is a major component of the vehicle system, therefore, it is often identified for refinement and improvement for better handling and comfort.

The frame of the truck chassis is a backbone of the vehicle and integrates the main truck component systems such as the axles, suspension, power train, cab, and trailer. The typical

Chassis is a ladder structure consisting of two C channel rails connected by cross-members as illustrated in Figure 1.6. Almost all the chassis development is varying in design, weight, complexity, and cost. However, the effects of changes to the frame and cross-members are not well understood in term of vehicle response during riding especially on bumpy and off road conditions.

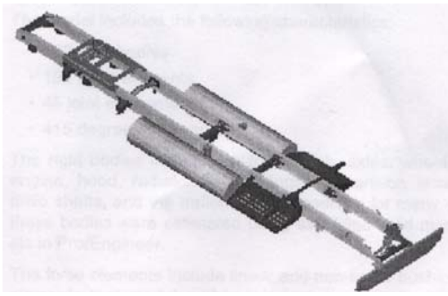


Figure 1.6: Sample of the Truck Chassis

On an overall, this research study is really requiring attention to improve the existing condition for a betterment of riding quality and comfortable. There are major areas need to be established in the study to come out with the proper investigation on truck chassis especially research methodology on experimental and computational analysis.

OBJECTIVE

i) To determine the torsion stiffness and static and dynamic mode shape of the truck chassis by using torsion testing, modal analysis, and finite element method.

ii) To improve the static and dynamic behavior of the truck chassis by changing the geometrical dimension and structural properties.

iii) To develop a new truck chassis.

SCOPE OF WORK

a. Literature review associated with truck chassis development, design and analysis to the commercial truck chassis.

b. This study will concentrate on truck chassis of not more than 2-ton

c. Simulation and experimental work on the existing truck chassis

d. Correlation of simulation and experimental results.

e. Model updating process, which includes parameters adjustment in order to obtain a good model of truck chassis

f. Improvement of truck chassis characteristic by changing the geometry, material, and structure to the existing model.

g. Development of new truck chassis.

EXPECTED RESULT.

a. To improve the existing chassis performance such as the torsion stiffness, strength and dynamic behavior due to a dynamic load. The result shall be able to present the static and dynamics motion of the truck chassis which include the natural frequency, mode shapes, and damping value.

b. The experimental data will be used to validate a finite element model and the updated model shall represent the real structure of the chassis.

c. The improvement of structures and supports shall be done to the existing chassis in order to fulfill the customer's requirement such as cost, reliability, conformability and better performance.

3.1 IDENTIFICATION OF PROBLEM

For this project, the truck chassis is categorized under the ladder frame type chassis. Figure 3.1 shows a typical ladder frame chassis for the commercial vehicle. A ladder frame can be considered structurally as grillages. It consists of two side members bridged and held apart by a series of cross members. The side members function as a resistance to the shear forces and bending loads while the cross members give torsion rigidity to the frame. Most of the light commercial vehicle chassis have sturdy and box section steel frames, which provide this vertical and lateral strength and resistance to torsion stress.

Parallel ladder type frame

OVERVIEW OF CHASSIS TYPE

The chassis used for this analysis was Suzuki Truck Chassis as shown in above fig. and it was described as a space frame chassis with ladder type structure. It was constructed from mild steel Rectangular Hollow Section (RHS) and its cross section was supported by mild steel sheet. The majority of the RHS has dimension of 100 x 50 mm with a 2.0mm wall thickness. The detail specifications are as follows:

Test Sample: MAN Truck Chassis

- Material: Steel
- Young Modulus (GPa) : 2E+11
- Density (kg/m3): 7850
- Poisson's Ratio:0.30

PROBLEM FORMULATION

NEED FOR THE WORK:

In the present scenario, the automotive industry has been one of the rapidly growing industries. Today there are increased demands on trucks, not only on the cost and weight aspects but also on the improved complete vehicle features and overall work performance. In addition to this the number of variants that are possible due to different types of design, material compilations, and modularization, calls for several design iterations arrive at a suitable combination.

OBJECTIVES:

The main objective of this work is to evaluate the static characteristics of a truck chassis under different load conditions. In order to minimize the memory requirements and to simplify, the analysis is carried out on an equivalent beam model. Static analysis is carried out on 4 different models of the chassis with variations in depth of longitudinal or cross members or both. The loading pattern remains same and analysis is carried out in all 4 models.

Out of the four models, two models whose static performance is better than the others are chosen.

SCOPE OF WORK:

Solid modeling of chassis parts and estimation of their section properties.Static analysis of chassis frame for different load conditions.Modal analysis to find the Natural Frequencies. In order to cover the scope of work outlined above, a detailed finite element analysis is proposed to be carried out on a beam model of a truck chassis to determine the deflections and stresses in static conditions when the vehicle is on a bump using the analysis software ANSYS.

MODELING OF CHASSIS

GEOMETRIC MODEL OF CHASSIS:

Geometric modeling of the various components of chassis has been carried out in part mode as 3-D models using SolidWorks. The properties, viz. cross-sectional area, beam height, area moments of inertia of these 3-D modeled parts are estimated in SolidWorks. These properties have been used as input while performing the finite element analysis using ANSYS software.

PARTS OF CHASSIS FRAME:

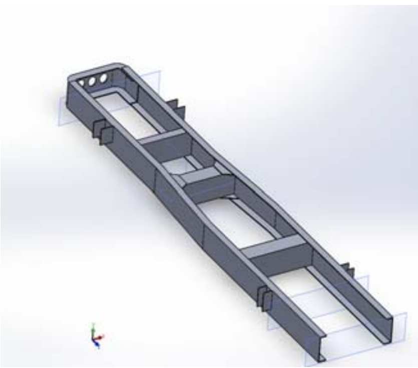
The chassis under study consists of following parts, whose 3-D models have been created:

1. Longitudinal member
2. Cross member 1
3. Cross member 2
4. Cross member 3
5. Front bracket

MODELING SOFTWARE:

SolidWorks is an interactive Computer- Aided Design and Computer Aided Manufacturing system. The CAD functions automate the normal engineering, design and drafting capabilities found in today's manufacturing companies. The CAM functions provide NC programming for modern machine tools using the SolidWorks design model to describe the finished part.

Solidworks is fully three dimensional, the double precision system that allows to accurately describing almost any geometric shape. By combining these shapes, one can design, analyze, and create drawings of products.



The 3-D model of truck chassis as shown in figure 5.1.

FEM MODELING

This chapter consists of modeling of the chassis and applying loading conditions and then solving the problem with the help of ANSYS Workbench software.

ANSYS Workbench is a common platform for solving engineering problems. Typical
tasks you can perform in Workbench are:

- Importing models from a variety of CAD systems.
- Conditioning models for design simulations using the Design Modeler.
- Performing FEA simulations using Simulation.
- Optimizing designs using Design Xplorer or Design Xplorer VT.

The underlined words above are the names of different processors within ANSYS
Workbench . Basically, you will use the Design Modeler to create the geometry and the
Simulation to set up the materials, FE-mesh, loads and boundary conditions, solve the
problem and analyze the results. The standard interface ANSYS Classic (used in the first
computer workshop) is still the core of ANSYS. ANSYS Workbench is a new modern interface with more up to date functions such as, for example, the integration of CAD geometries.

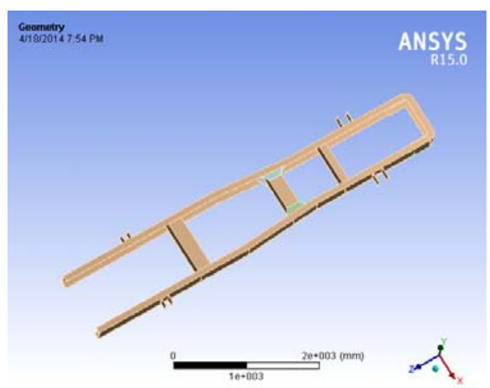
DESIGN MODELER

Design Modeler is designed to be used as a geometry editor of existing CAD models.

Design Modeler is a parametric feature-based solid modeler designed so that you can
intuitively and quickly begin drawing 2D sketches, modeling 3D parts, or uploading 3D
CAD models for engineering analysis preprocessing.

SIMULATION

Use the Workbench Simulation module to define your model's environmental loading
conditions, solve the simulation and review results in various formats depending on the
type of simulation.



➢ **Figure 6.1: Truck chassis**

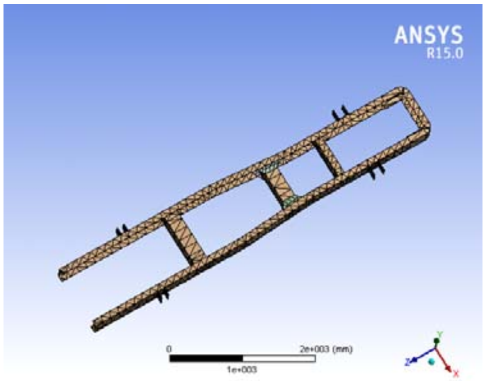


Figure 6.2 Truck chassis model meshed with tetrahedral 10 elements

FINITE ELEMENT MODEL

The truck chassis was modeled by using 10-noded tetrahedral (Tet-10) solid elements. Experimental and numerical studies on a simple hollow rectangular straight beam suggested that Tet-10 element can mesh the truck chassis geometry as shown in Fig 6.2 and give accurate results of the natural frequencies and the mode shapes. There are two types of analysis carried out; normal mode analysis to determine the natural frequencies and the mode shapes, and the linear static stress analysis to look into the stress distribution and deformation pattern of the chassis under static load. For normal mode analysis, the chassis model was meshed with 15648 Tet-10 elements and 32846 nodes, while for linear static analysis, 37014 Tet-10 elements and7548 nodes were used.

RESULTS

7.1 Static Analysis for Structural Steel using Finite Element Analysis

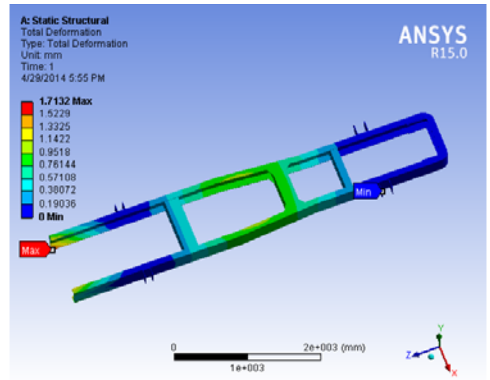


Figure 7.1 (a) Total Deformation

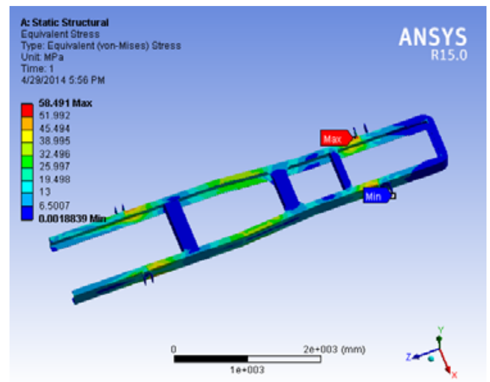


Figure 7.1 (b) Equivalent (Von Mises)Stress

7.2 Static Analysis for Duralumin using Finite Element

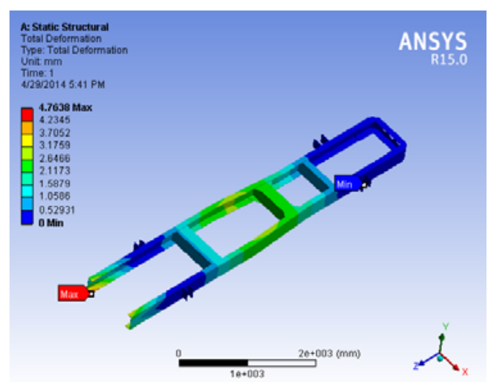


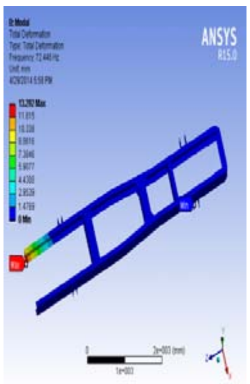
Figure 7.2(a) Total Deformation

MODAL ANALYSIS RESULTS

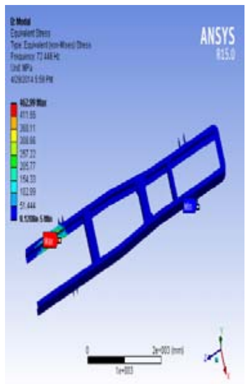
Modal analysis is a kind of linear analysis technology, used to determine the structure of the natural frequency and vibration mode. In normal mode analysis, the natural frequencies obtained are used to relate to the operating conditions of the truck while the mode shapes are used to determine whether the mounting locations of components on the truck chassis are suitable. A preliminary study was carried out in determining the suitable boundary conditions for the chassis. A free-free boundary condition was chosen as it is much simpler to test experimentally in this condition if required. Thus, two types of free-free boundary conditions were tested. The first type is without any constraint and the other type is applying spring boundary condition (by default, K = 10-13 N/mm) to the truck chassis. It was shown that both boundary conditions gave identical values of the natural frequency.

7.3 MODE SHAPES OF STRUCTURAL STEEL

MODE 1:

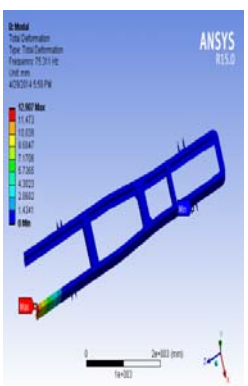


Total Deformation

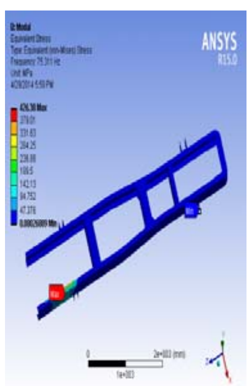


Equivalent Stress

MODE 2:

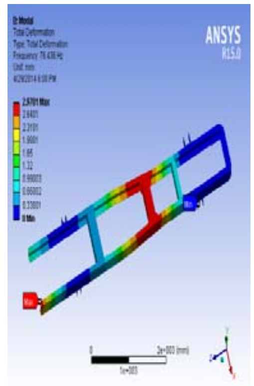


Total Deformation

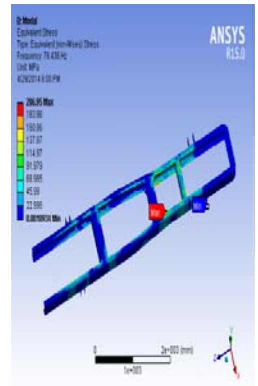


Equivalent Stress

MODE 3:

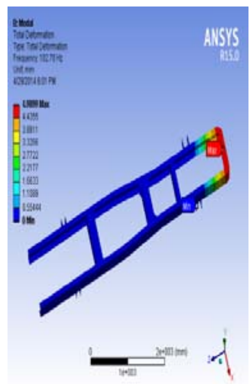


Total Deformation

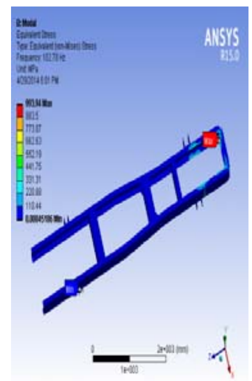


Equivalent Stress

MODE 4:

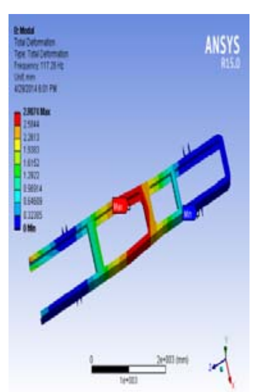


Total Deformation

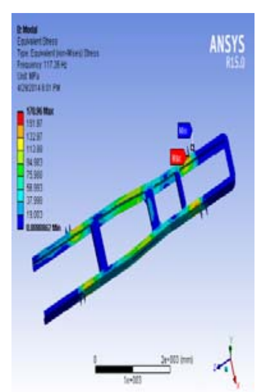


Equivalent Stress

MODE 5 :

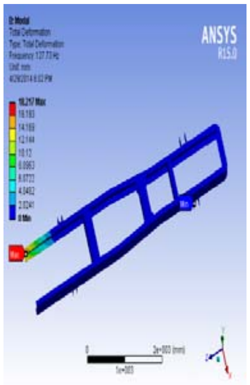


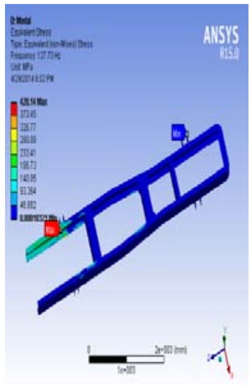
Total Deformation



Equivalent Stress

MODE 6:

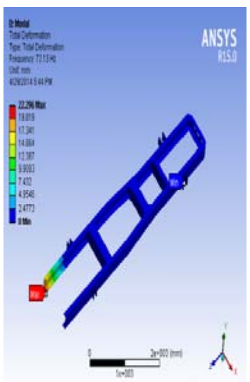


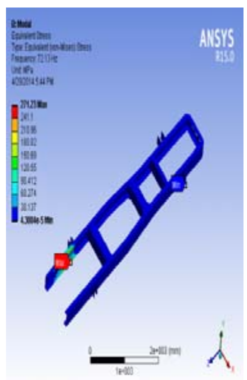


Total Deformation Equivalent Stress

7.4 MODE SHAPES OF DURALUMIN :

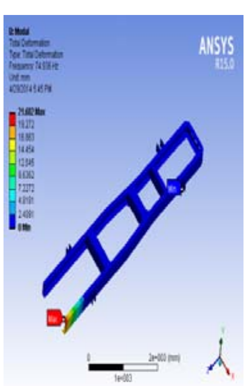
MODE 1:

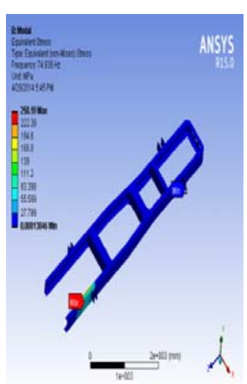




Total Deformation Equivalent Stress

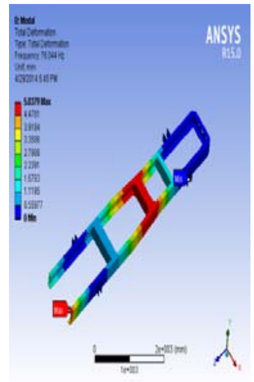
MODE 2:

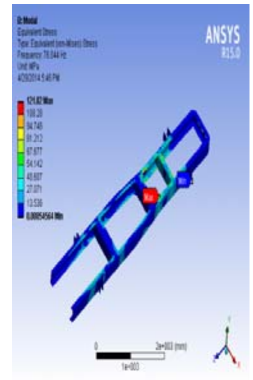




Total Deformation Equivalent Stress

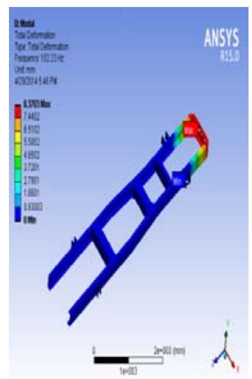
MODE 3:

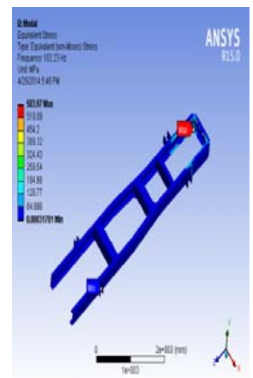




Total Deformation Equivalent Stress

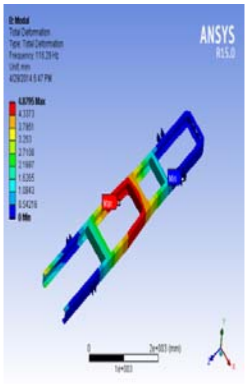
MODE 4:



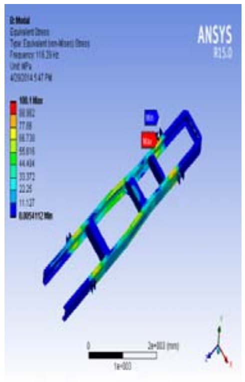


Total Deformation Equivalent Stress

MODE 5 :

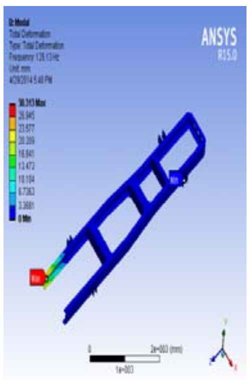


Total Deformation

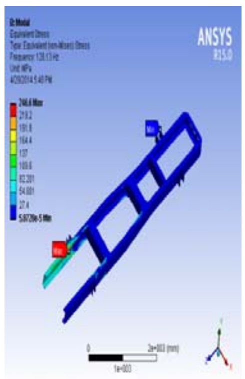


Equivalent Stress

MODE 6:



Total Deformation



Equivalent Stress

Material properties of Stainless steel and Duralumin

properties	Stainless steel	Duralumin
Young modulus, Pa	2E+11	7E+10
Poisson Ratio	0.3	0.33
Density, Kg/m3	7850	2790
Yield Strength, MPa	250	450

In the static analysis, the deformation of Duralumin is more than the steel and von-Mises stress in Stainless steel is more than the Duralumin.

CONCLUSIONS

1. The finite element analysis of Truck Chassis Frame is carried out using 10 noded brick element. The static and Modal analysis is carried out.
2. The Static analysis has a significant effect on the overall stresses in the Chassis Frame.
3. By using Stainless steel and Duralumin materials Static and modal analysis was done to see stress and mode shapes of a structure.
4. By comparing Results of Stainless Steel and Duralumin. Finally, we can say Duralumin is better than Structural Steel
5. Chassis designed now is capable of withstanding to the loads up to 18 tons with minimum weight by using Duralumin.
6. 6 . From tabular column, Duralumin is better than Structural Steel.
7. 7. . From the above table, it can be understood that though the deformation is more for . duralumin it is stronger due to its higher factor of safety.
8. . As Duralumin is a light weight material the weight of the chassis decreases and therefore. the vehicle efficiency increases.

MATERIAL	DEFORMATION (mm)	STRESS (Mpa)	Factor of safety
STRUCTURAL STEEL	1.71	58.491	4.2
DURALUMIN	4.76	58.1	7.7

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