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Crash analysis on a conventional type Chassis

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ABSTRACT

The phenomenon of a vehicle crash is a nonlinear transient dynamics phenomenon. This report presents, crash analysis of a conventional type chassis structure design of 252kg was performed by using FEM. During a chassis crash lot of the members will have a plastic deformation and would absorb a lot of energy, thus crash test analysis plays an important role in testing the vehicles safety. As the chassis is the Backbone of the Vehicle it should be able to withstand static and dynamic loads without much mechanical distortions. Crash analysis simulation used to determine better methods to design a chassis and also reduces the need of costly physical destructive testing programs. The Chassis has been designed in Solid works 2017 and the analysis has been done with the help of analysis software Ansys.

Keywords— *Chassis crash, Simulation, Ansys*

1. INTRODUCTION

The design of chassis is fully on conceptual basis and the objectives are to create conceptual design for an automotive chassis which will utilize standard components (inspired by Formula e racing vehicles). Conventional chassis frame, which is made of pressed steel members. The study of the mechanical behavior of the chassis and their welded or rivet joint are becoming a major concern in recent years. For this purpose, finite element analysis methods have been used extensively.

Car accidents causes lots of fatalities. Statistics show every year there are thousands to millions reports of fatal injuries and deaths due to Car accidents. Light weight of the chassis and crash worthiness of the vehicle are the two aspects of this design. During a chassis crash lot of the members will have a plastic deformation and would absorb a lot of energy. Structural Members of the chassis are designed to absorb as much as energy possible so that the energy transmitted to the driver is minimal by the time it reaches the driver.

2. OBJECTIVES

Crash Simulations are used to investigate the safety of the occupants during impact in a front end during a frontal impact, the lateral structure impact during a sideward impact and the rear end during a rear impact, however in this report the frontal impact has been only taken into account with the x axis velocity to be 150m/s. Crash Simulation is also used to assess the damage/injury to the object the car hits or the pedestrian the car hits, however the main objectives are as follows:

(a) Ensuring driver Safety
(b) Reduction of cost in actual car crash testing
(c) The result used to asses both the crash worthiness of the chassis and methods to improve the chassis safety design.

3. SCOPE

The main Purpose of the analysis is to observe how the vehicle would react to a frontal impact when it travels in a linear path at 150m/s. Chassis body's light weight and the crash worthiness of the chassis are the two aspects taken into consideration. The chassis forms the backbone of the vehicle. It should be able to carry maximum load for all operating conditions. This analysis is the part where the cost of actual physical testing can be cut off. This method has a great scope in Automobile industries as it is precise, efficient, fast, reliable and a cheaper method than an actual physical crash test. Hence most of the companies are relying on this form of analysis to improve their designs to withstand fatal impacts.

4. METHODOLOGY

A crash test requires a number of vehicles to be destroyed to achieve a desirable outcome which is both time consuming and uneconomical. The recent trend of computer aided simulations is gaining much popularity. Here instead of an actual physical test, an actual FE model is generated which is used to carry out those tests which were supposed to be tested physically. There are several

software packages to analyze a crash test however Ansys has gained the most popularity. We are using Ansys for our crash test report. A static as well as a dynamic analysis is done by this software. A chassis is designed and tested to assess the optimal results for maximum safety. The analysis of the chassis is done in its maximum achievable speed i.e. 150m/s, the speed might vary according to its design.

5. DESIGNING

5.1 Objective

Building a chassis to meet the optimum design parameters-

a) Keeping low weight of the frame as much as possible.
b) Have mounting structure for all subsystems that would withstand the load exerted by those subsystems
c) Withstand centrifugal force while cornering
d) Keeping the driver alive during a frontal impact
e) Withstand forces due to sudden acceleration and brake.

5.2 Methodology

Designed a space frame chassis. Most commonly used where a mannequin is taken as a reference and the other parameters are designed respectively. Safety and comfort factors are the two factors considered for the design. The 3d model is attached as follows-

5.3 3D Model

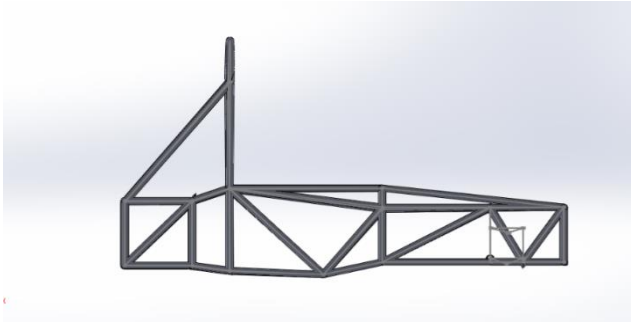

Fig. 1: Front view

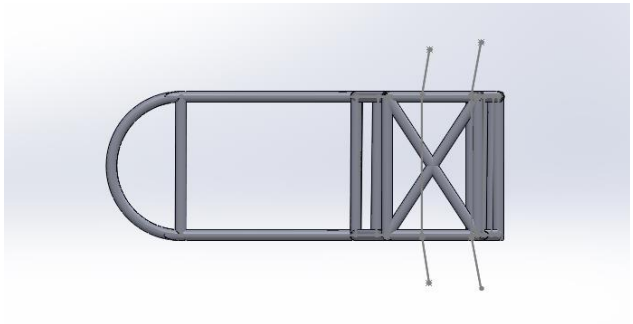

Fig. 2: Side view

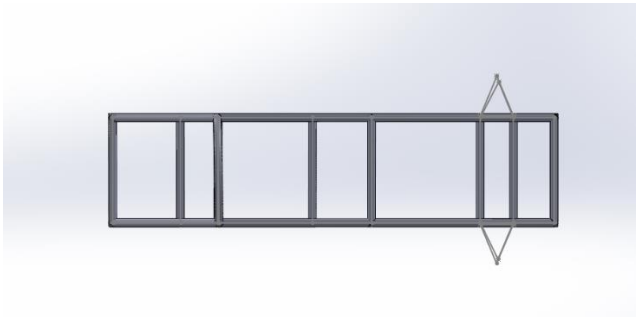

Fig. 3: Top view

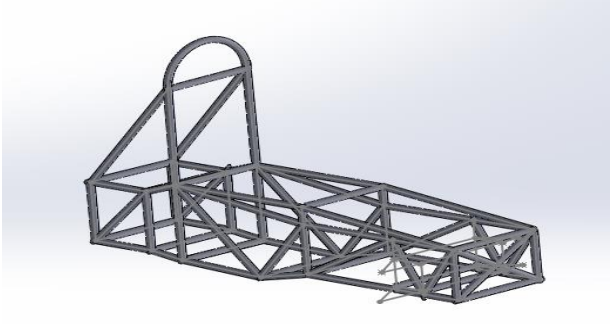

Fig. 4: 3d View

5.4 Materials

There are different materials today used to design a chassis. Different vehicles have different demand of quality. The materials are chosen according to the demand of the vehicle. Heavy duty vehicles demand high strength materials however light duty vehicles have no such need. One important need is sustainability. There are few aspects and properties to be taken into consideration:

(a) Light weight
(b) Anti Rust
(c) Economic Effectiveness
(d) Safety
(e) Recyclability

There are a number of materials available in the market however steel is used in majority of the applications as it has good qualities to manufacture chassis frame. Other than steel aluminum is used for its light weight. Carbon fiber is light as well as stronger however not economical. Other materials like titanium are not used as they are expensive. Some of the important materials are listed below:

AISI 1018

- Density= 7.9g/cc,
- Ultimate tensile strength= 440 MPa,
- Tensile yield strength =370 MPa
- Young's modulus =205 GPa
- Poisons ratio =0.29
- Major application – manufacturing of chassis, fixtures, mounting plates and spacers, used to prevent cracking in severe bends.

AISI 4130

- Density = 7.85g/cc
- Ultimate tensile strength = 560 Mpa
- Tensile yield strength = 460 Mpa
- Young's modulus = 190-210 GPa
- Poisons ratio = 0.27-0.3
- Major application – Aircraft engine mounts, welding tubing etc.

Al 6061

- Density = 2.7g/cc
- Ultimate tensile strength = 310 MPa
- Tensile yield strength = 276 MPa
- Young's modulus = 68.9 GPa
- Poisons ratio = 0.33
- Major application – Aircraft fitting, camera lens mount, coupling, marine fitting, brake pistons, hydraulic pistons, bike frame etc.

We have used Structural steel in the preparation of our design.

Density	7850 kg m^-3
Isotropic Secant Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat Constant Pressure	434 J kg^-1 C^-1
Isotropic Thermal Conductivity	60.5 W m^-1 C^-1
Isotropic Resistivity	1.7e-007 ohm m

6. RESEARCH METHODOLOGY

- Finite element analysis is a numerical Technique to handle complex geometries, boundary conditions, loading conditions and material properties.
- Mathematical model of any geometry is described as behavior of the geometry by boundary conditions and differential equations.
- Mathematical model is dividing the object of interest into finite number of elements
- The term degree of freedom is used for Physical objects
- If the number of dof is finite, the model is called discrete or finite.
- When the physical object is divided into discrete parts, then the infinite number of dof is converted to finite number of dof.
- Each part of discretized element is called element.
- Every element consists of one or more nodes.
- Elements are connected to each other through these nodes.
- Displacement Boundary conditions and surface loading conditions are the constraints.
- The chassis is allowed to move in a linear path only
- The x axis velocity is given to be 150m/s(the average maximum speed achieved by formula e vehicles)
- The wall is set to be a fixed support
- End time is set to be 7.e-004

6.1 Analysis Outcomes

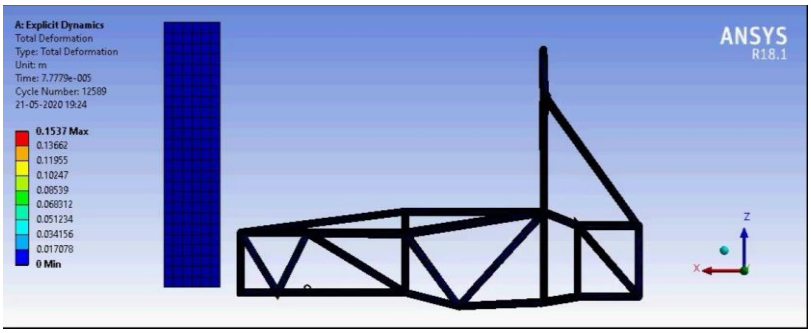

Fig. 5: Frontal impact (side view)

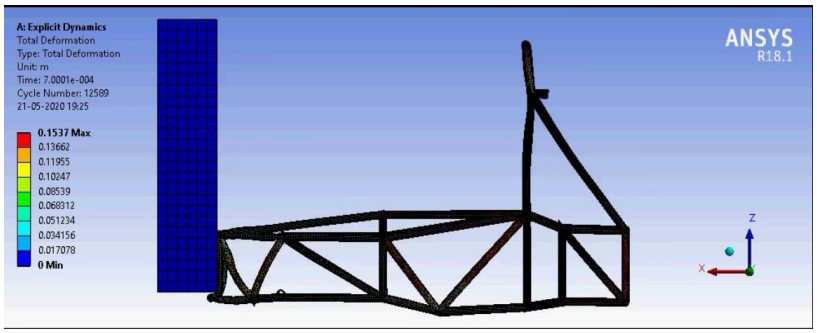

Fig. 6: Frontal total deformation

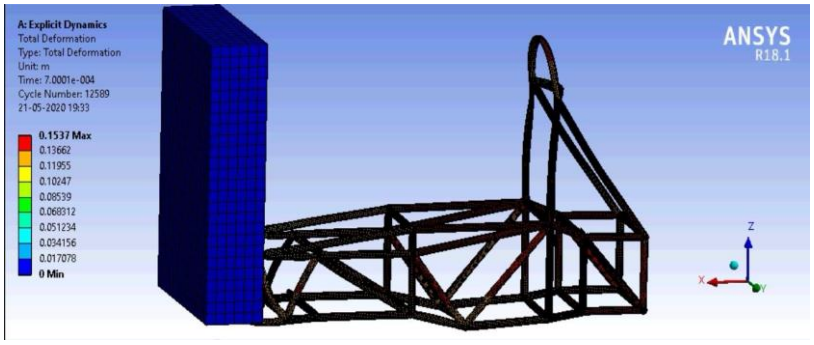

Fig. 7: Frontal total deformation 3D view

Fig. 8: Cost affected area in total deformation

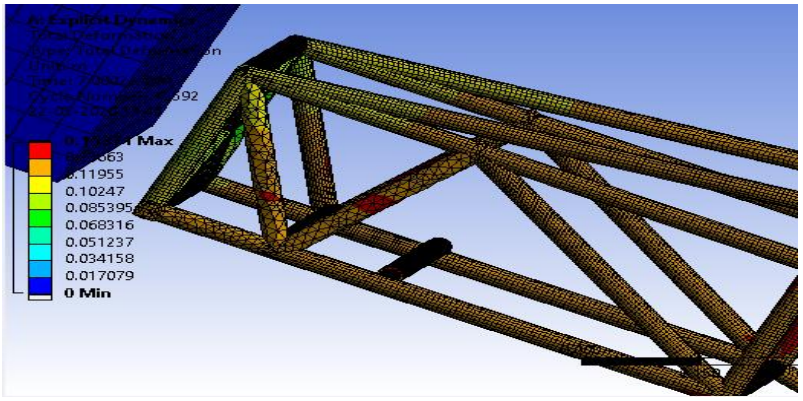

Fig. 9: Frontal impact

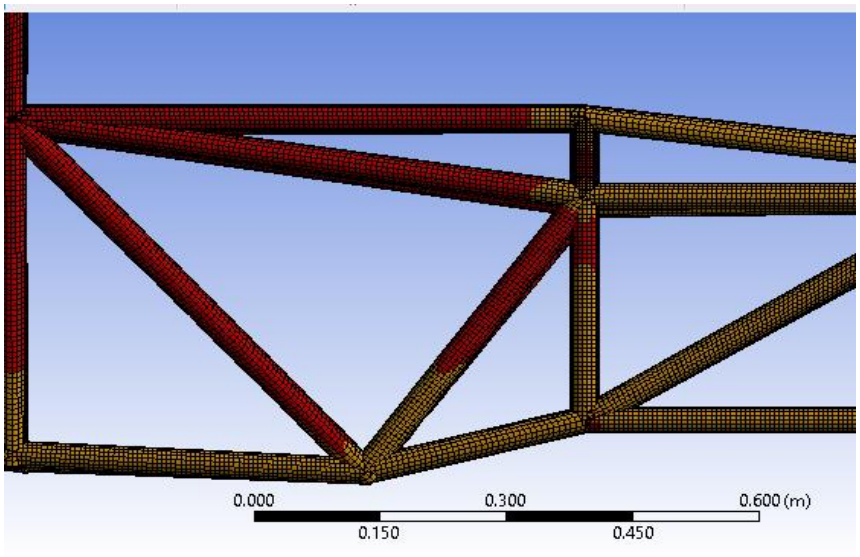

Fig. 10: Mid-section impact

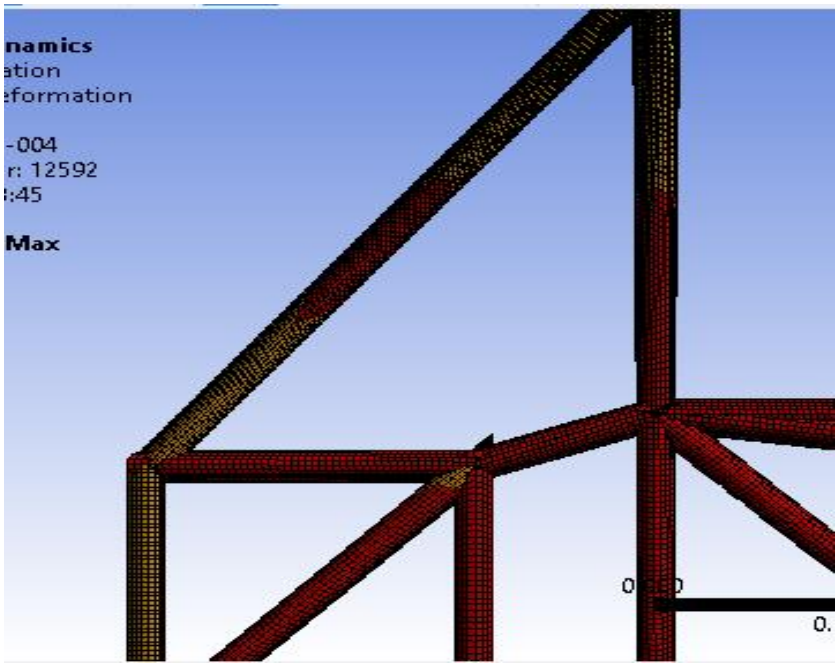

Fig. 11: Rear impact

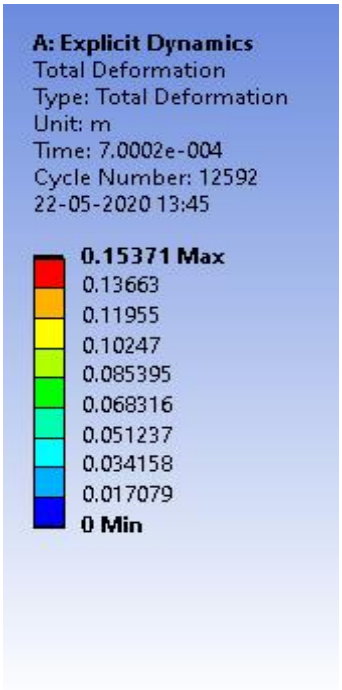

Fig. 12: Total deformation

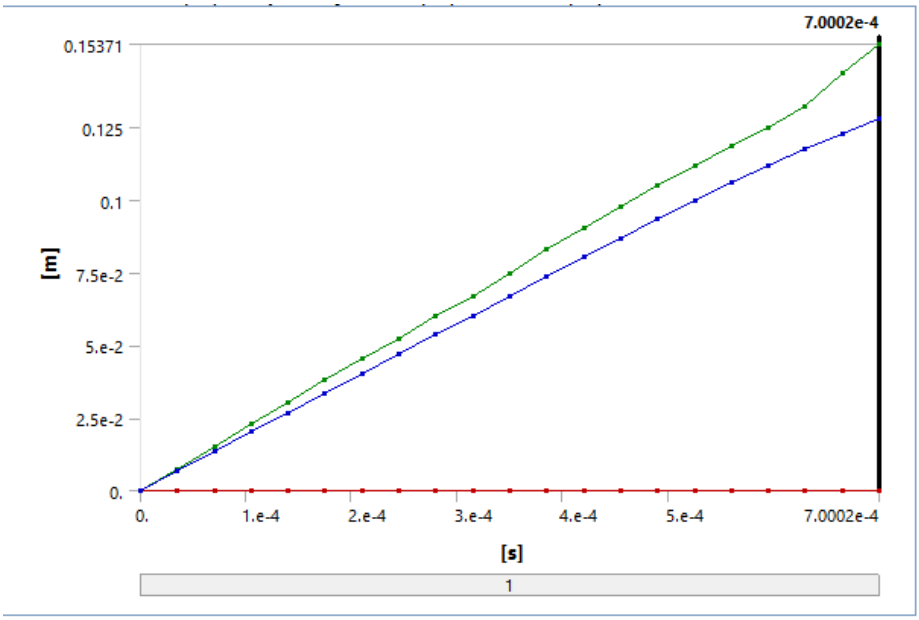

Fig. 13: Total deformation in m vs time in seconds

	Results
Minimum	0. m
Maximum	0.15371 m
Average	0.12831 m
Minimum Occurs On	SYS\Solid
Maximum Occurs On	SYS\Solid31

Fig. 14: Total deformation details

The Impact Force Is Given By The Formula

$$F = m * v^2 / (2 * d)$$

Where,

- F is the average impact force,
- m is the mass of an object,
- v is the initial speed of an object,
- d is the distance traveled during collision.

7. ADVANTAGES

(a) The actual Destruction of the chassis has been avoided.
(b) The crash test using simulation has been economical
(c) The crash test using simulation has saved time.
(d) A variety of model can be tested
(e) Result can be used both to inspect the crash worthiness of the chassis and can be used to investigate further designs.

8. CONCLUSION

Human life is of utmost importance. For the driver and passenger safety the vehicle should be safe against the various impacts on the vehicle. The chassis being the backbone of the vehicle must withstand design load and provide support for mounting different systems of the vehicle. The aim of this project was to design a safer, lighter and economical chassis using iterations for the safety of the vehicle in analysis software. The design is optimized and the weight factor along with the safety consideration is kept in view while designing the chassis. Material selected in accordance to the chassis demand. The actual cost of crash testing has been saved; hence the overall costing has been reduced. It has been noticed that the maximum deformation is to be 0.15371 m when the vehicle travels in a linear path at 150m/s, most of the impact energy is being absorbed in the frontal area of the chassis before transmitting it to the driver, claiming it to be a satisfactory design. For furthermore safety airbags should be installed which would act as a shock absorber to the driver's body during an unforeseen impact which would create a sudden jerk causing fatal injuries.

9. FUTURE SCOPE

Bumper systems should be applied to transmit minimum energy to the driver during a crash. The bumper can be made as a sandwich model or a spring. Analysis of this design can be done which may yield to better safety, lesser weight and fuel efficiency. FEA has a great future in upcoming automobile and manufacturing industries. The various software involved can be used for various findings in the industries. Separate analysis done for finding defective parts. Various other materials can also be analyzed in FEA model. The endurance limit of the model can be also tested. FEA models considers Dynamic analysis too, hence real time forces can be considered for testing endurance limit. Life and Fatigue failure can also be determined. Hence, adopting the FEA method a reliable and a good quality product is being manufactured.

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