

Design and Analysis of Straight Frame over Fish Belly Frame

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ABSTRACT

The establishment primary engaged in manufacturing heavy commercial vehicles in India are using fish belly type of Frame assembly (Long member C section). The main aim of project is improve the design performance of the Fish belly frame by using design software and related analysis software. In this concept we are mainly comparison between straight frame and fish belly fresh is done by using the “C” section.

This project evaluates a use of straight “C” Frame assembly (Long member C section) to minimize the stress zone’s at various Frame location. The main aim of the thesis is found which one is highly strength and highly durable in the analysis point of view.

This project gives a brief idea about few advantage of straight C section over a fish belly section in the aspect of cost, weight, reliability, Manufacturability and easy of assembly consideration as the current situation in domestic market comparing the heavy commercial vehicles of Volvo, Scania and Actross as a benchmark.

I. INTRODUCTION

1.1. INTRODUCTION OF CHASSIS FRAME.

Chassis is a major component of a vehicle system. It consists of internal framework that supports man-made object. It is the under part of the vehicle which consists of frame and running gear like engine, transmission system, suspension system etc. The automotive chassis is tasked with keeping all components together while driving and transferring vertical and lateral loads, caused by acceleration, on the chassis through suspension and the wheels. The key to good chassis design is that further the mass is away from the neutral axis the more rigid it is. In this project, Pro/ Engineer is the software used for the modelling of the chassis.

The design and analysis of chassis is done by identifying the location of high stress areas. The chassis design used in this project is the ladder frame chassis. Ladder frame chassis is the simplest and oldest of the chassis design used in modern vehicular construction. It is originally adapted from the “horse and buggy” style carriages. as it provides sufficient strength for holding the weight of the components. Ladder frame has several members that cross link to hold frame rails together.

1.2.THEORY :

CHASSIS:

Chassis consists of the internal framework that supports man made object. It is an essential under part of the vehicle which consists of the frame and

- Running gear like engine
- Transmission system like clutch and gear
- Suspension system
- Fuel tank
- Brakes
- Steering system
- Road wheels

1.3. CLASSIFICATION OF CHASSIS FRAME.

CHASSIS are classified as on the utilization of space:-

- 1) **CONVENTIONAL CONTROL:** - in which engine is mounted in front of the driver's cabin. This type of arrangement avoids full utilization of the space.
- 2) **SEMI-FORWARD CONTROL:** - in which engine is so mounted that half of it is in the driver's cabin whereas the other half is in front, outside the driver's cabin.
- 3) **FULL-FORWARD CONTROL:** - in which the engine is mounted completely inside the driver's cabin. Obviously maximum utilization of space is achieved.

CHASSIS are classified on the basis of construction:-

- 1) **CONVENTIONAL CONSTRUCTION:** - in which separate frame is used. It is being used presently only for heavy vehicles.
- 2) **FRAMELESS CONSTRUCTIONAL:** - in which no separate frame is used. It is used for cars.

1.4. TYPES OF CHASSIS:

- 1) Ladder Frame Chassis
- 2) Multi tubular Chassis
- 3) Space Frame Chassis
- 4) Monocoque Chassis

1. Ladder frame chassis:-

It consists of two symmetrical rails and cross members connecting them. It is being used in trucks. It provides good beam resistance because of its continuous rails from front to rear, but poor torsion resistance if simple, perpendicular cross members are used

2. Space frame chassis:-

A space frame or space structure is a truss-like, light weighted rigid structure constructed from interlocking struts in a geometric pattern. Space frame usually utilize a multidirectional span, and are often used to accomplish long spans with few supports.

3. Monocoque chassis:-

Monocoque means mono means single and coque means shell. It is constructional technique that supports structural load by using an object's exterior, as opposed to using an internal frame or truss that is then covered with a non-load-bearing skin or coachwork. This technique is also called structural skin, stressed skin, uni body, unitary construction, or Body Frame Integral

1.4.1. Types of Cross Section used:

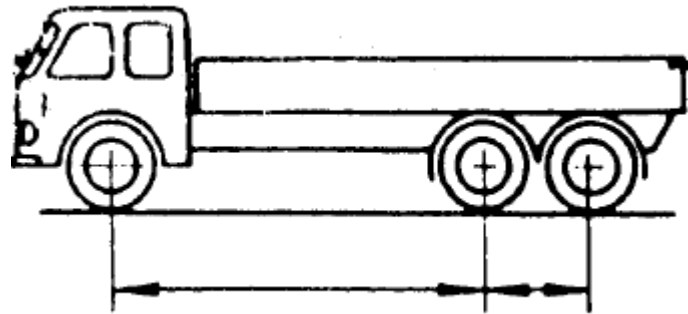
- a. Channel section
- b. I- Beam
- c. Hat section
- d. Rectangular tubular section
- c. Round Tubular section

1.5. TERMS ON CHASSIS FRAME:

- a. Wheel base (WB)
- b. Front Over hanging (FOH)
- c. Rear Over hanging (ROH)
- d. Frame width
- c. Overall length

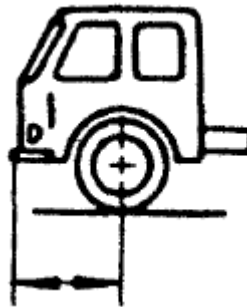
- a. Wheel Base:

The distance between the front and rear axles. Lengthening the wheel base provides a more comfortable ride and increases interior space, but at the same time, the convenience of a smaller turning radius is lost.



b. Front Over hanging (FOH) :

The distance between front end of the frame to the front axle centre line.



c. Rear Over hanging (ROH) :

The distance between the Rear axle centre line to the Rear end of the frame.

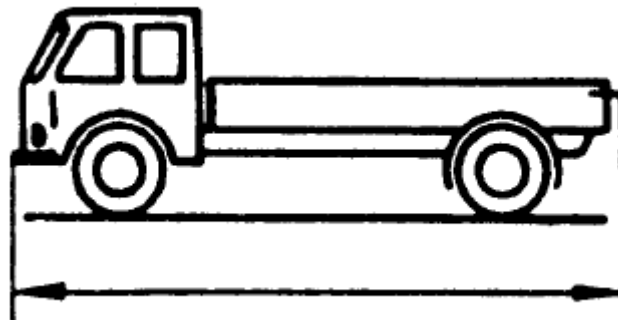


d. Frame width:

The distance between right side of the Long member Web to the left side of the long member Web.

c. Overall length:

The Sum of the wheel base, front over hanging & rear over hanging of frame is called Overall length.



1.6. BASIC TERMINOLOGY FOR CALCULATION OF CHASSIS FRAME:

1.5.1. TERMS RELATED TO STRENGTH:

- a. Section Modulus (Z)
- b. Bending Stress
- c. Resistance Bending Moment (RBM)

a. Section Modulus (Z) :

Section modulus is a measure of the frame strength based on the height, width, thickness, and configuration of the side rails (Long member). It is calculated at the point of the maximum stress, which is directly behind the cab.

b. Bending Stress:

Bending stress is the normal stress that is induced at a point in a body subjected to loads that cause it to bend. When a load is applied perpendicular to the length of a beam (with two support on each end). Bending moments are induced in the beam.

c. Resistance Bending Moment (RBM) :

Since the section modulus can only be used to compare frames of like material and yield strength can only indicate relative strength of identical frames. Some measurement is necessary to compare frames of different material and different sections. The RBM or Resistance bending moment, can be used for this comparison as it utilizes section modulus and yield strength.

1.6.1. TERMS RELATED TO DEFLECTION:

- a. Moment of Inertia (I)

1.6.2. TERMS RELATED TO APPLIED LOAD:

- a. Bending Moment (BM)

a. Bending Moment (BM) :

Summation of all moments acting on the beam (side-rails) at a given point.

II. LITERATURE REVIEW

The CC literature is dominated by a few authors and countries. Many of the papers study actual use and involve practitioners. This limits the places where the studies could have been carried out, as well as their generalizability. Studies from other countries and of specific services could offer valuable contributions to the literature.

Many methods are used to collect and analyze data, but two types of studies stand out; statistical analysis of survey data of citizens' CC, and case studies of MCM at the organizational level. The studies of CC appear more harmonized and coherent than those of MCM. Part of this may be because they are carried out by a small group of authors who cross-reference each other. However, these studies also revolve around one topic – individual's CC – use similar variance models and explicitly refer to the same theoretical frameworks to inform their analyses. There is a strong sense of progress and building on each other's work, and both empirical and theoretical contributions are offered. However, they are largely based on survey data from secondary data sets which the researcher cannot influence. Although a few studies use qualitative studies to inform the survey creation, CC scholars repeatedly state a need for supplementing surveys through qualitative methods [3, 4, 8, 40, 41, 47].

Methods of direct observation are time consuming to conduct, but they provide valuable contextual information and could inform areas which have only been slightly touched upon; situational constraints, habits and how the service in question and its importance to the citizens influence CC. Observations could study an entire service encounter from the citizens' point of view and the interplay that takes place between channels during such an encounter. This would enable CC scholars to explore citizen initiated requests and explain why these requests occur and gain insight into channel switching and supplementing behavior.

Data on channel traffic could update and supplement the existing knowledge on MCM. Longitudinal studies of channel traffic could be used to evaluate the effects of MCM instruments on citizens' channel

behavior. Most of the existing analyses of channel traffic are based on data which is a decade old, and it is unknown if the conclusions based on this data still hold up today.

Future CC studies could examine how citizens influence and help each other when interacting with government organizations. It is striking that the papers in this review focus at only the individual or organization level. There are no studies of CC at the group level, although both private and public intermediaries are mentioned at organizational level, and several studies mention that friends and family members can be intermediaries [25, 32, 44]. Teerling and Pieterse's process model seems suitable for this task as it illustrates external parties' influence on citizens' CC.

III. METHODOLOGY

3.1 FEATURES OF MODELING AND ANALYSIS SOFTWARES

3.1.1 Features of UG NX

UG NX also known as Unigraphics and it is software suit that developed by the Siemens PLM software. UG NX is a modern computer aided design (CAD) program. It allows the users to simulate their industrial design processes from initial concept to product design, analysis, assembly and also maintenance. In this software, it includes mechanical, and shape design, styling, product synthesis, equipment and systems engineering, NC manufacturing, analysis and simulation, and industrial plant design

UG NX provides suite of surfacing, reverse engineering, and visualization solutions in order to create, optimize, modify, and validate complex innovative shape design. For the mechanical engineering point of view, UG NX is good in creating 3D parts from 3D sketches, sheet metal, composites, moulded, forged or tooling parts and lastly up to the mechanical assemblies

✓ UG NX is one of the world's most advanced and tightly integrated CAD/CAM/CAE product development solutions.

✓ UG NX enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and moulded, forged or tooling parts up to the definition of mechanical assemblies.

✓ UG NX facilitates collaborative engineering across disciplines around its 3DEXPERIENCE platform, including surfacing & shape design, electrical, fluid and electronic systems design, mechanical engineering and systems engineering.

✓ UG NX provides a wide range of applications for tooling design, for both generic tooling and mould & die.

✓ UG NX uses parametric design principles for solid modeling. UG NX provides mechanical engineers with an approach to mechanical design automation based on solid modeling technology and following features.

3-D Modeling:

✓ The essential difference between UG NX and traditional CAD system is that models created in UG NX exist as 3-D solids. Other 3-D models represent only the surface boundaries of the model. Pro/E models the complete solid. This not only facilitates the creation of realistic geometry, but also allows for accurate models calculations, like that of mass properties.

✓ PARAMETRIC DESIGN:

✓ Dimensions such as angle, distance and diameter control Pro/E model geometry. Relationships can be created that allow parameters to be automatically calculated based on the value of other parameters. When the dimensions are modified, the entire model geometry will be updated according to the relation created.

✓ FEATURE-BASED MODELING:

✓ Models in UG NX are created by building features. These features have knowledge of their environment and adopt predictably to change. Each feature asks the user for specific information based on the feature type. For example, a hole has a diameter depth, and placement, while a round has a radius and edges to round.

ASSOCIATIVITY:

✓ UG NX is a fully-associative system. This means that a change in the design model any time in the development process is propagated through out the design, automatically updating all engineering delivers, including assembly, drawings, and manufacturing data. Associativity makes concurrent engineering possible encouraging change, with penalty; at any point in the development cycle. This enables downstream functions to contribute their knowledge and expertise early in the development cycle.

APPLICATIONS

UG NX can be applied to a wide variety of industries, from aerospace and defense, automotive, and industrial equipment, to high tech, shipbuilding.

3.1.2 Features of HYPERMESH

HYPERMESH software (made for meshing) from Altair is used mesh the solid model. Cad model which is in IGES format is imported to HYPERMESH. To mesh the geometry use the surface first and then solid. While meshing some of the quality parameters as to be maintained, those are aspect ratio, skew, jacobian, minimum element size, warpage.

Hyper Mesh is a market-leading, multi-disciplinary finite element pre-processor which manages the generation of the largest, most complex models, starting with the import of CAD geometry to exporting ready-to-run solver file.

3.1.3 CAD Interoperability

Hyper Mesh provides import and export support for industry-leading CAD data formats. Moreover, Hyper Mesh has robust tools to clean up imported geometry to allow for the efficient generation of high-quality meshes. Boundary conditions can also be applied directly to geometry for automatic mapping to underlying elements.

- UG NX and CATIA Composite Link
- IGES (import and export)
- Intergraph
- JT (import and export)
- Para solid (import and export)
- ProE and CREO
- Solid Works
- STEP (import and export)
- Tribon

FIGURE 3.1 shows hyper mesh shows importing .catpart to hypermesh

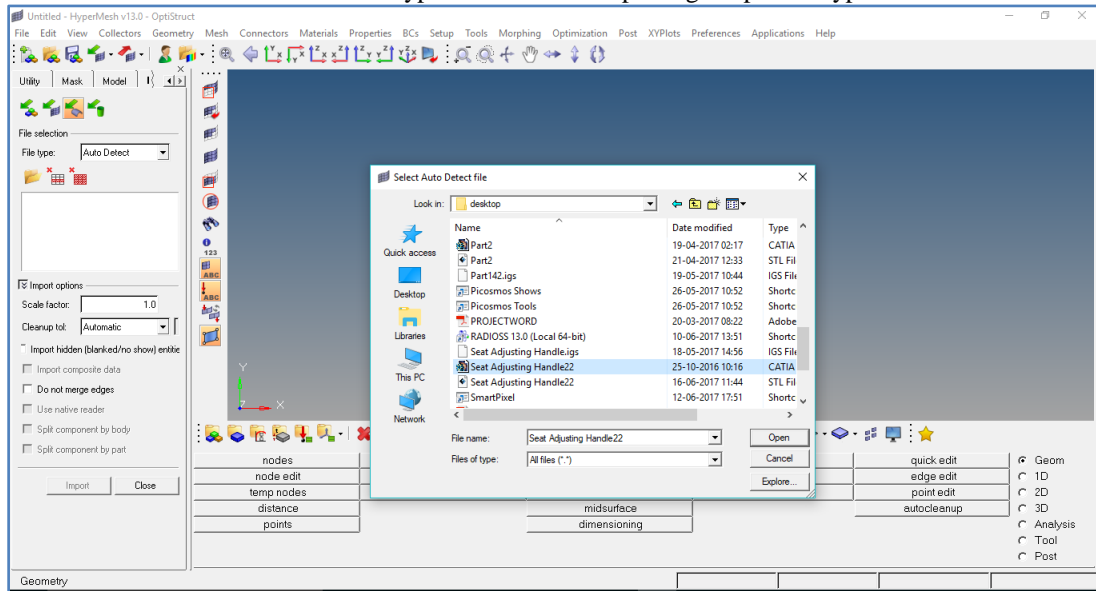


Figure 3.1 importing .Hypermesh

FIGURE 3.2 shows hyper mesh shows importing .catpart to hypermesh

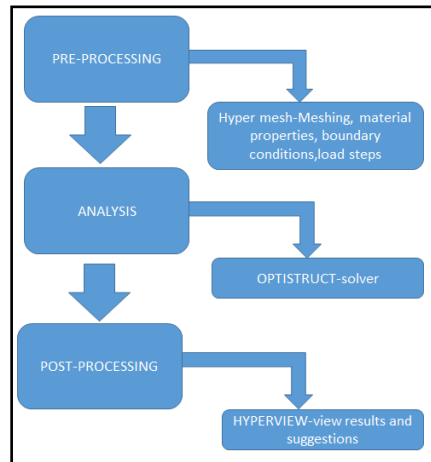


Figure 3.2 shows different stages in done in hyper mesh

Steps involved in pre-processing:-

- A) Importing Of Cad
- B) Geometry Clean Up
- C) Meshing
- D) Quality Checks
- E) MATERIAL PROPERTIES
- F) BOUNDARY CONDITIONS,LOADS

ANALYSIS: - OPTISTRUCt SOLVER

OptiStruct is part of the Hyper Works toolkit, as described earlier this is a finite element solver designed to solve linear and non-linear simulations. Along with the Hyper Works suite explicit solver, RADIOSS, Hyper Works can simulate structures, fluid, fluid-structure interaction, sheet metal stamping, and mechanical systems. (see picture below). To the user the integration is seamless through the run script provided. Based on the file naming convention, the right executable or combination of executable is chosen

OptiStruct is a full featured solver for linear structural analysis. It supports point (SPC) and multipoint (MPC) constraint boundary conditions as well as rigid elements and rigid bodies. Alternate coordinate systems based on the basic system or each other can be defined for easy grid location definition.

Loads can be distributed on the surface of shells and solids as well as along the length of beam elements. In addition, imposed displacements and inertia relief loading is available. Thermal loads include convection and heat generation.

OptiStruct supports a full set of elements including solids, shells, beams, rods, bushings, spot welds, seam welds, joints, point masses and single DOF mass, stiffness and damping. Beams can be defined by area and inertias, and also by cross sectional dimensions. Moreover, axisymmetric elements and loads are available.

Models can be specified as a collection of parts that are instanced, relocated, and connected. Additionally, sub-modeling is available for more accurate stress resolution in critical areas. Analysis results, such as stresses and strains, can be calculated at element centers, Gauss points, and corner points. Also available are grid point stresses and strains, element forces, and strain energy. Other output types include composite ply stresses and strains as well as interlaminar shear. Multiple composite failure models, such as Tsai-Wu, Hill, Hoffman, Applied loading, constrain forces, and rigid element forces can also be output. All output is available in the Altair H3d format as well as the .op2 and .pch file formats.

Figure shows hyper works solver- optistruct loading .fem file

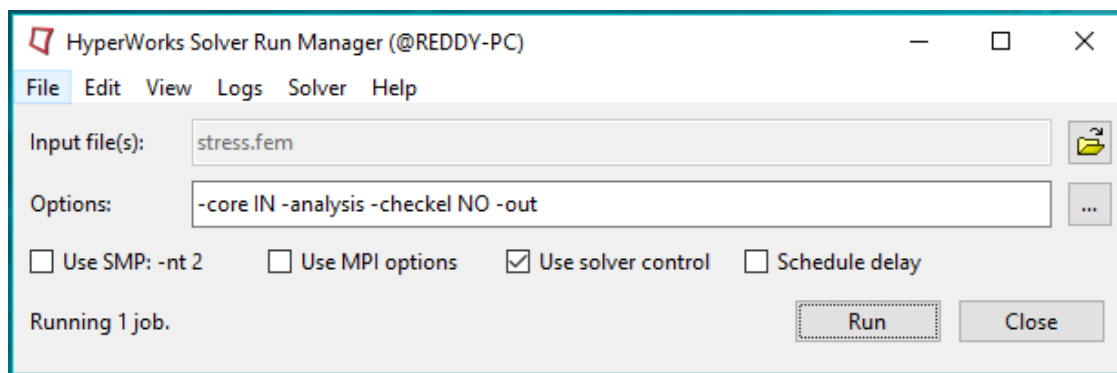


Figure 3.3 hyper works solver- optistruct loading .fem file

Figure shows progress of analysis solution

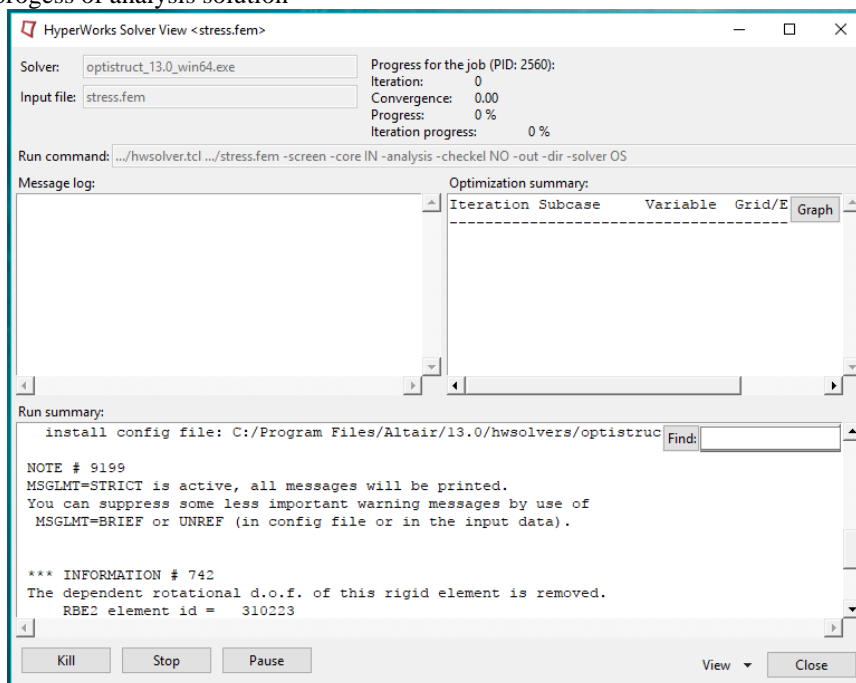


Figure 3.4 progress of analysis solution

Post processing with Hyper View

1. Load the .h3d file into Hyper View using Load model
2. Use the Shaded Elements and Mesh lines button to turn the mesh on
3. Use the Contour button and plot Strain Energy
4. Change the traffic light from transient to linear/modal
5. Animate the first mode by clicking the Play button
6. If the deformation is too large change it to Model percent (10%) using the Deformed options

7. Add more frames and control the speed of the animation using the Animation controls button
8. Step through the modes using load case selector

RESEARCH METHODOLOGY

Following is the research methodology adopted for the problem stated earlier,

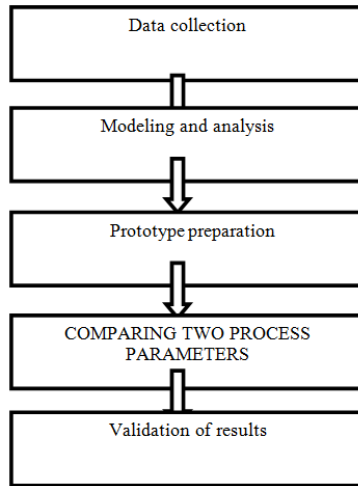


Fig 5.1: Flow chart of Research methodology

3.2 Data collection:

Based on the data collected relevant to the work, totally two components are selected with dimensions Data is taken from Emugenginnering services, suchitracircle, hyderabad

The components selected for study are

1. seat adjustment handle
2. floor support brace

3.3 Modeling of components

The following models with different configuration are modeled using CATIA V5 R20 CAD software.

1. Seat recliner handle
2. floor support brace

Figure shows Isometric view of seat recliner handle

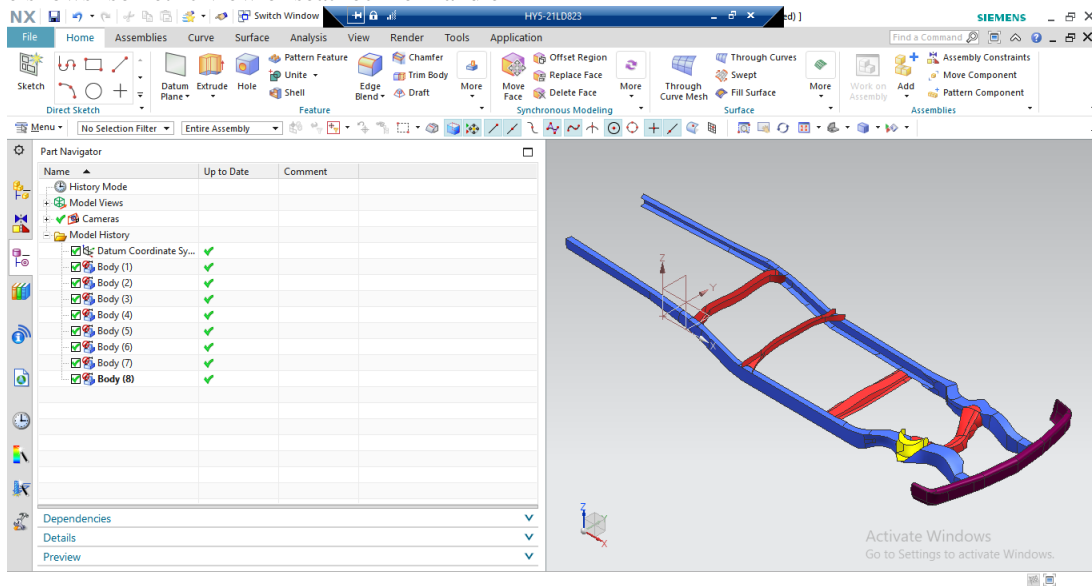


Figure 3.2 Isometric view of seat recliner handle

CURRENT SITUATION IN HEAVY COMMERCIAL VEHICLE

Indian customer expectations are growing day by day as per their requirement & Indian Automotive sector is also growing in line with the same concept. Based on that in earlier days the Truck features are less than the present Truck features normally these Feature are based on Different application on Heavy Trucks like.

- Tractors
- Dumpers or Tippers
- Cargos

3.4. TYPES OF TRUCK CHASSIS FRAME

- Fish belly type chassis Frame
- Straight Chassis Frame

3.4.1. FISH BELLY TYPE CHASSIS FRAME:

Chassis Frame contains Long member & Reinforcement and Cross members. In which long member having different cross section on various locations based on load conditions & requirement. Those Frames are called Fish belly frames.

3.4.1.1. ADVANTAGES:

- ❖ Easy for mass production.
- ❖ Variable section of Long member “C” can be obtained.
- ❖ Weight can be reduced due to variable section on Long member
- ❖ Required section modules can be meet on local area where ever its require.

3.4.1.2. DISADVANTAGES:

- ❖ Making cost is very high.
- ❖ Large space is required for manufacturing.
- ❖ Low load capacity can be occurred.
- ❖ Not suitable for other manufacturing process like rolling forming.
- ❖ High maintains cost.

3.4.1.2. MANUFACTURING PROCESS:

Stamping:

This type of fish belly sections is made under Stamping process. The most common method used to form structural underbody components. The basic stamping operation utilizes a two – piece die set inserted into a mechanical or hydraulic press. Material placed between the two dies is formed into a part by the load imposed by the dies is held along the edges of the part by a binder the binder controls the flow of material into the dies and is critical to the outcome of the finished part.

Most parts require several operations, each one involving a separate operation and die set, to produce a final part.

3.4.2. STRAIGHT TYPE CHASSIS FRAME:

These chassis Frames are contains same component like fish belly frame but the cross section of Long member is straight entire length of Chassis frame. Those are called Straight type chassis frame.

3.4.2.1. ADVANTAGES:

- ❖ High loading capacity.
- ❖ Flat top ensures easy mounting of load body super structure & other aggregate mountings.
- ❖ Frame can be made with roll forming.
- ❖ Low cost required for manufacturing
- ❖ Uniform distribution load can be obtained.
- ❖ Tool can be easily changed for different type of “C” section.
- ❖ Large volumes can be obtained.
- ❖ Reduced labor cost and Time Consumption for material handling.
- ❖ Greater accuracy, uniformity of long member can be achieved with roll forming.
- ❖ Far longer lengths are achievable.

3.4.2.2. DISADVANTAGES:

- ❖ More weight as compare to Fish belly frame.
- ❖ Less fuel efficiency.

3.4.2.3. MANUFACTURING PROCESS:

Roll forming:

Cold roll forming is an ideal, low cost method of producing shapes with a uniform cross-section. A sheet or strip of metal is fed longitudinally through a roll forming mill. The mill consists of a train of pairs of driven roller dies, which progressively form the flat strip until the finished shape is produced.

3.5 Benchmarking Study

1. Model: Bharat Benz 25 Tonner Tipper with Fish belly Chassis frame.

Long member section Details :

Height : 290mm

Flange width : 72mm

Thickness : 9mm

Material : BSK 46

Section Modulus : 280585 mm³



Fig -1

2. Model: TATA 2523.K with Fish belly Chassis frame.

Long member section Details

Height : 285mm

Flange width : 65mm

Thickness : 7mm

Material : E34

Section Modulus: 204882 mm³



Fig - 2

IV. DESIGN CALCULATION

4.1 LOAD CALCULATION

4.1.1. Load Points on Beam:

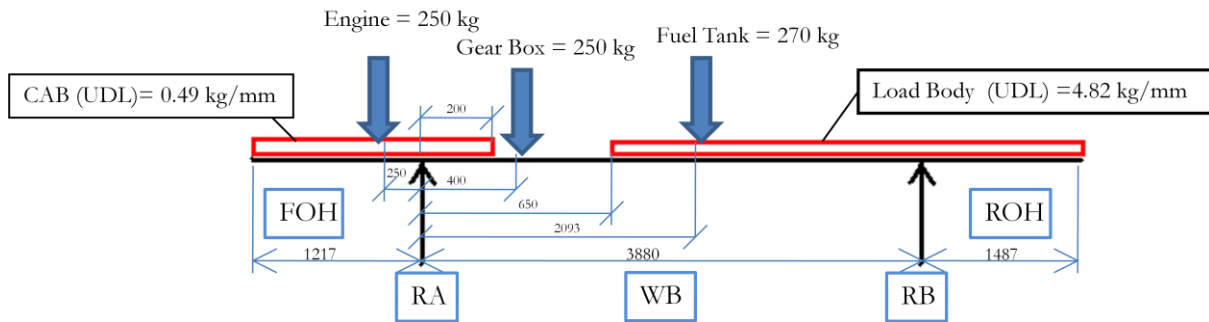


Fig -3

INPUT DATA :

RA = Reaction at the Front Axle.

RB = Reaction at the Rear Axle.

ROH = 1487mm

FOH = 1217mm

WB = 3880mm

Weight :

1. CAB = 700kg
UDL = $700/1417 = 049 \text{ kg/mm}$.
2. Load Body
 - a. Pay load = 17740 kg
 - b. Load Body = 5000 kg
 - Total = 22740
 - UDL = $22740/4717 = 4.82 \text{ kg/mm}$.
3. Fuel Tank = 270kg
4. Gear Box = 250kg
5. Engine = 437 kg

Location :

- Fuel Tank : 2093mm
- Gear Box : 400 mm
- Engine : -250mm

4.1.2. PAY LOAD CALCULATION:

- GVW = 25000kg
- Laden FAW : 6000 kg
- Laden RAW : 19000 kg
- Un laden FAW : 3130 kg
- Un laden RAW : 4130 kg

Pay Load = GVW – Un laden FAW – Un laden RAW
 = 25000 – 3130 – 4130 = **17740 kg**

4.1.3. Bending Moment Calculation:

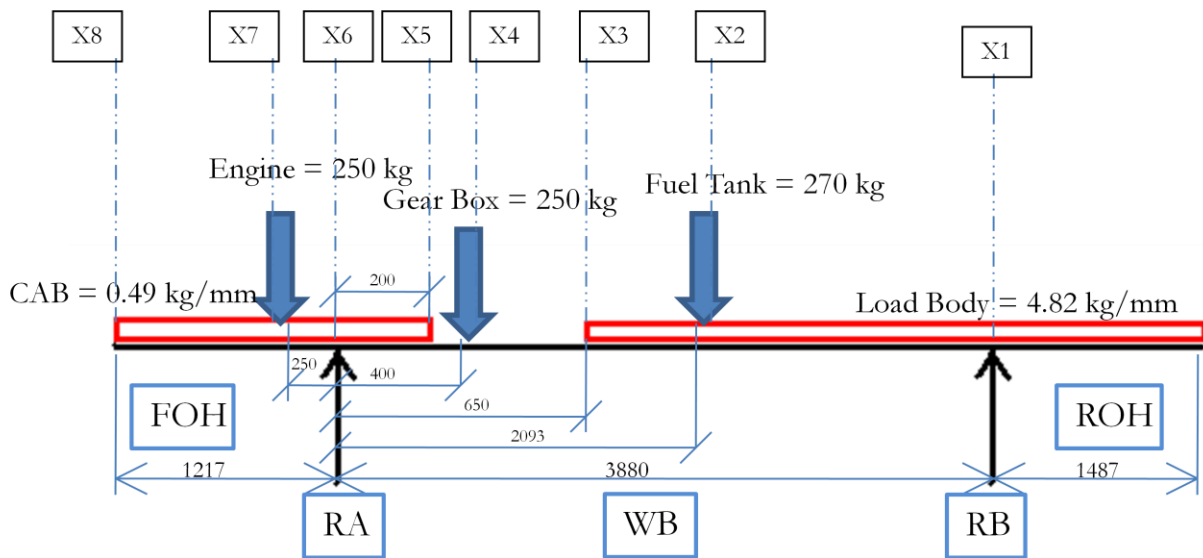


Fig-4

Bending Moment Calculation :

Reaction at front & Rear axle :

$$RB = 4.82 \times 4717 \times 3008.5 + 270 \times 2093 + 250 \times 400 - 437 \times 250 + 0.49 \times 1417 \times (-508.5)$$

$$RB = 17681 \text{ kg}$$

$$RA = 4.82 \times 4717 \times 871.5 + 270 \times 1787 + 250 \times 3480 + 437 \times 4130 + 0.49 \times 1417 \times 708.5 + 3680$$

$$RA = 6048.27 \text{ kg}$$

$$\mathbf{X1} \text{ B.M} = -4.82x^2 / 2$$

$$\text{B.M}_{x=0} = 0$$

$$\text{B.M}_{x=500} = -602500 \text{ kg-mm}$$

$$\text{B.M}_{x=1487} = -5328917.29 \text{ kg-mm}$$

$$\mathbf{X2} \text{ B.M} = -4.82(1487 + x)^2 / 2 + RB \times x$$

$$\text{B.M}_{x=500} = -674587.29 \text{ kg-mm}$$

$$\text{B.M}_{x=1787} = +5762973.84 \text{ kg-mm}$$

**Max.
Bending Moment**

$$\mathbf{X3} \text{ B.M} = -4.82(1487 + (3880-2093) + x)^2 / 2 - 270 \times x + RB (3880-2093+x)$$

$$\text{B.M}_{x=1443} = +3097305.51 \text{ kg-mm}$$

$$\mathbf{X4} \text{ B.M} = -4.82 \times 4717 (2358.5 + x) - 270 (1443 + x) + RB (3230 + x)$$

$$\text{B.M}_{x=250} = +1766070.51 \text{ kg-mm}$$

$$\mathbf{X5} \text{ B.M} = -4.82 \times 4717 (2358.5 + 250 + x) - 270 (1443 + 250 + x) - 250 \times x + RB (3480 + x)$$

$$\text{B.M}_{x=200} = +644261.728 \text{ kg-mm}$$

$$\mathbf{X6} \text{ B.M} = -4.82 \times 4717 (2358.5 + 250 + 200 + x) - 270 (1443 + 250 + 200 + x) - 250 (200 + x) - 0.49x^2 / 2 + RB (3480 + x)$$

$$\text{B.M}_{x=200} = +473705.49 \text{ kg-mm}$$

$$\mathbf{X7} \text{ B.M} = -4.82 \times 4717 (2358.5 + 250 + 200 + 200 + x) - 270 (1443 + 250 + 200 + 200 + x) - 250 (200 + 200 + x) - 0.49(200 + x)^2 / 2 + RB (3880 + x) + RA \times x$$

$$\text{B.M}_{x=250} = +870034.51 \text{ kg-mm}$$

$$\mathbf{X8} \text{ B.M} = -4.82 \times 4717 (2358.5 + 250 + 200 + 200 + 250 + x) - 270 (2343 + x) - 250 (650 + x) - 0.49(450 + x)^2 / 2 + RB (3880 + 250 + x) + RA (250 + x) - 437 (x)$$

$$\text{B.M}_{x=967} = +802374.68 \text{ kg-mm}$$

4.1.4. Bending Moment Diagram:

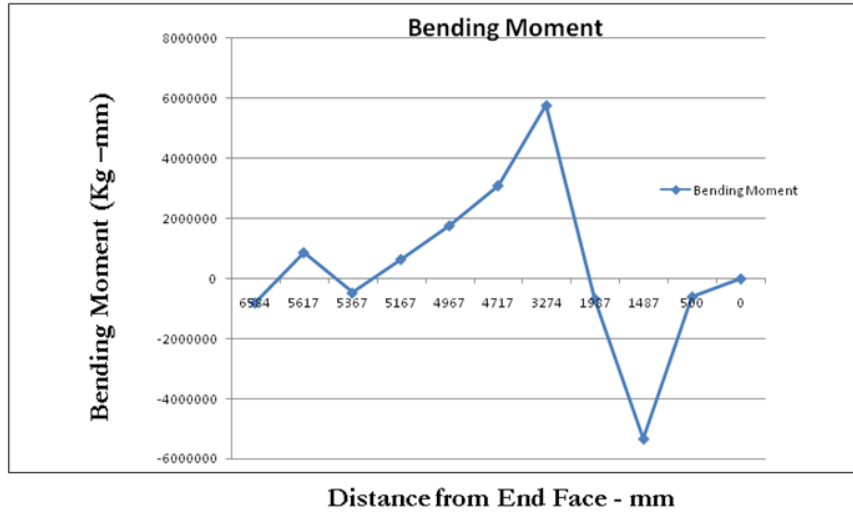


Fig-5

4.2. Fish Belly “C” section construction:

4.2.1. Different Section Location on Beam :

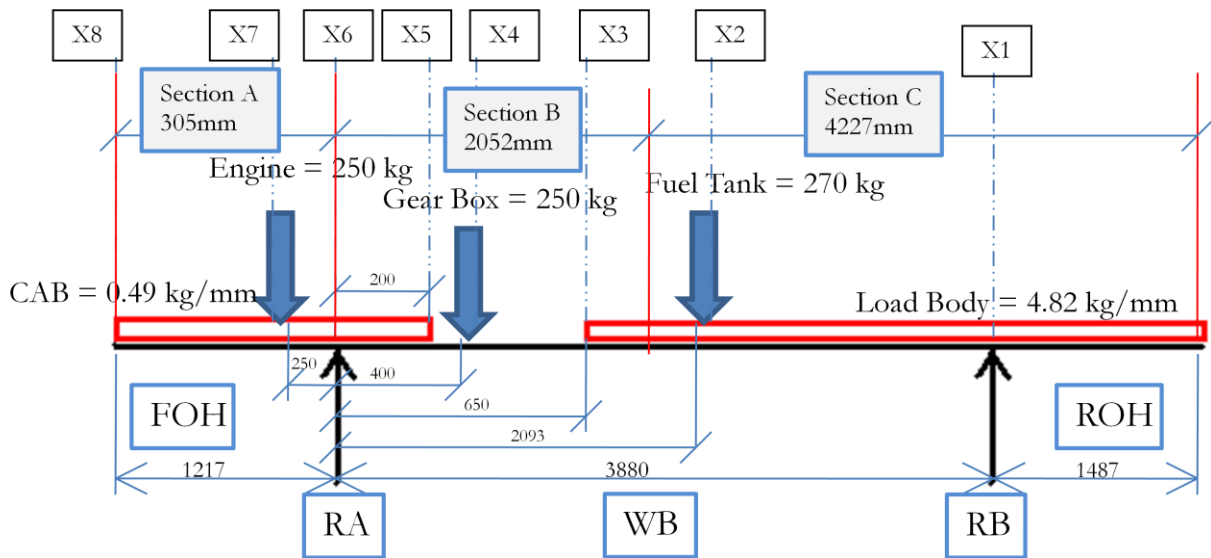


Fig-6

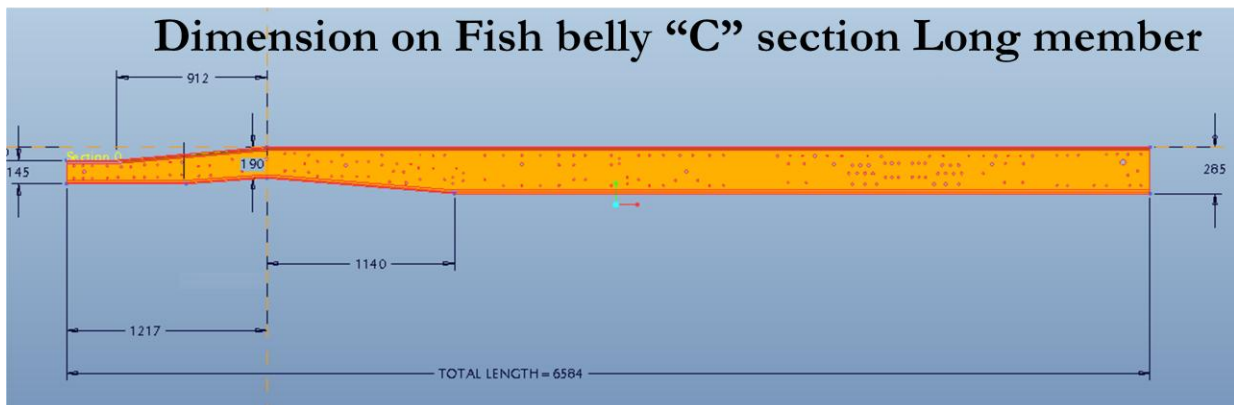


Fig-7

Different Section Dimension on Long member:

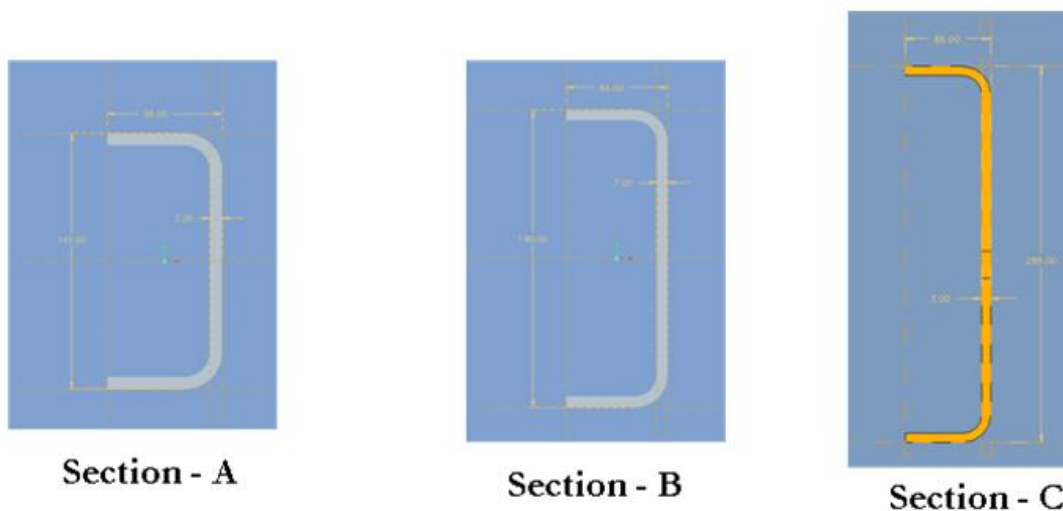


Fig-8

4.3. Straight “C” section construction:

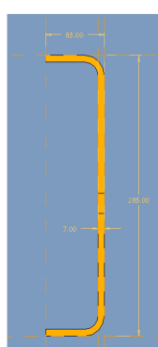
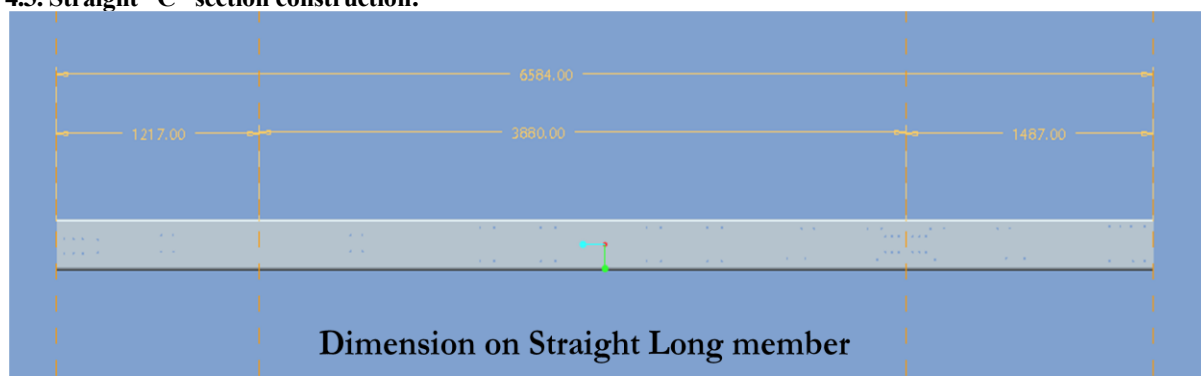


Fig -9

4.4. Material Selection :

LOW CARBON OR MILD STEEL IS USED

Advantages of Mild steel:

- It is cheap and malleable.
- Its surface hardness can be increased by the method of carburizing.
- It is not brittle and hence can bear heavy loads without failure.
- Good wear resistance.
- It can be easily machined.
- It is easily available and its composition can be varied to get desired properties.

4.4.1. Material Composition of Mild Steel :

	Property	Mild Steel
Chemical Composition (%) :-	C	0.12 max
	Si	0.40 max
	Mn	1.00 max
	P	0.025 max
	S	0.025 max
	Al	0.02 min
	Nb	0.06 max
	V	0.095 max
	Ti	0.45 max
Mechanical Properties	Min Tensile strength (Kg/mm2)	50
	Min Yield strength (Kg/mm2)	46
	Young's Modulus(E) (Kg/mm2)	20680
	Poisson's Ratio	0.29
	Density(ρ) (Kg/mm3)	7.85 E-06
	Modulus of Rigidity(G)	8.6531437907564e-9
	Min Elongation(%)	21
	Bend	0.5 t

4.5. Stress calculation:

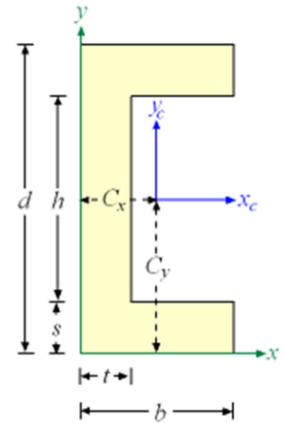
Section Modulus Calculation :

d : Web depth in mm
 b : Flange in mm
 t : Thickness in mm

Formula for Moment of Inertia (I) mm⁴ :
$$\frac{bd^3 - h^3(b-t)}{12}$$

Cy (y) : d/2

Formula for Section modulus (Z) mm³ : Moment of Inertia / Cy (I/y)



Bending Stress Calculation :

Formula for Stress : Bending Moment / Section modulus (BM/Z)

Resistance Bending Moment (RBM) Calculation :

Formula for RBM : Yield strength x Section modulus (σy x Z)

4.6. Comparison of Section :

4.6.1. Section Comparison on fish belly frame :

Yield strength of material = 46 kg/mm²

Long member	Section -A	Section -B	Section -C
Web (mm)	145	190	285
Flange (mm)	65	65	65
Thickness (mm)	7	7	7
Section Modulus (mm ³)	77898	113712	204882
Limiting Stress (kg/mm ²)	15.636	15.636	15.636
Resisting Bending Moment (kg-m)	3583.308	5230.752	9424.572
Weight (kg/m)	14.3	16.8	22
Length (m)	0.305	2.052	4.227
Weight (kg)	4.3615	34.4736	92.994
Total Weight of one side of Long member (kg)	131.8291		

4.6.2. Section Comparison on Straight “C” frame:

Long member	Section
Web (mm)	285
Flange (mm)	65
Thickness (mm)	7
Section Modulus (mm ³)	204882
Limiting Stress (kg/mm ²)	15.636
Resisting Bending Moment (kg-m)	9424.572

Weight (kg/m)	22
Length (m)	6.584
Total Weight of one side of Long member (kg)	144.848

❖ 26 kg increased on Straight “C” frame over fish belly frame.

4.6.3. Bending stress comparison on Both Frames :

S.no	Section Modulus for Fish belly "C" Section (mm ³)	Section Modulus for Straight "C" section (mm ³)	Distance from End of the Long member (mm)	Bending moment (kg-mm)	Bending Stress For Fish belly Long member (kg/mm ²)	Bending Stress For Straight Long member (kg/mm ²)
1	204881.57	204881.57	0	0	0	Same as fish belly
2			500	-602500	-1.470361634	Same as fish belly
3			1487	-5328917.3	-13.00487225	Same as fish belly
4			1987	-674587.29	-1.646285925	Same as fish belly
5			3274	5762973.84	14.06415872	Same as fish belly
6	113712.27		4717	3097305.51	13.61904705	7.55877044
7			4967	1766070.51	7.765523061	4.309978955
8			5167	644261.728	2.832859321	1.572278385
9			5367	-473705.49	-2.08291282	-1.156047101
10	77898.1		5617	870034.51	5.584439864	2.123262014
11			6584	-802374.68	-5.150155652	-1.958142648

Formula for Allowable Bending Stress (or) Limiting Stress: Material Yield strength / Factor of safety.

Material Yield strength of Mild steel: 460 N/mm²

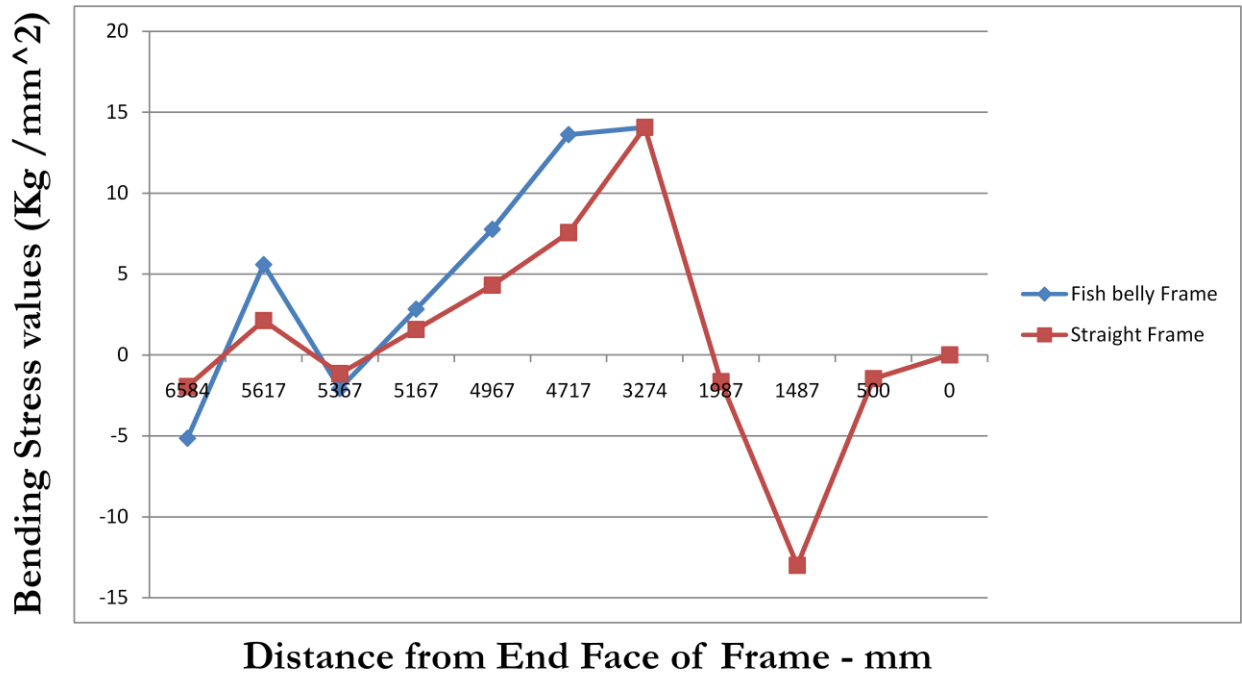
Factor of safety : considering 3 for Heavy Vehicles.

$$\begin{aligned} \text{Allowable Bending Stress} &= 460 / 3 = 153.333 \text{ N/mm}^2 \\ &= 153.333 / 9.806 \text{ N} = \mathbf{15.6 \text{ kg/mm}^2} \end{aligned}$$

Max. Bending Moment achieved on Beam: **5762973.84** kg-mm

Max. Bending Stress achieved on each Long member: **14.06415872** kg-mm²

4.6.4. Bending stress Comparison chart:



V. Meshing and Boundary Conditions

5.1 CAD MODELS

5.1.1 FISH BELLY FRAME:

5.1.1.1 CAD MODEL OF FISH BELLY ASSEMBLY FRAME:

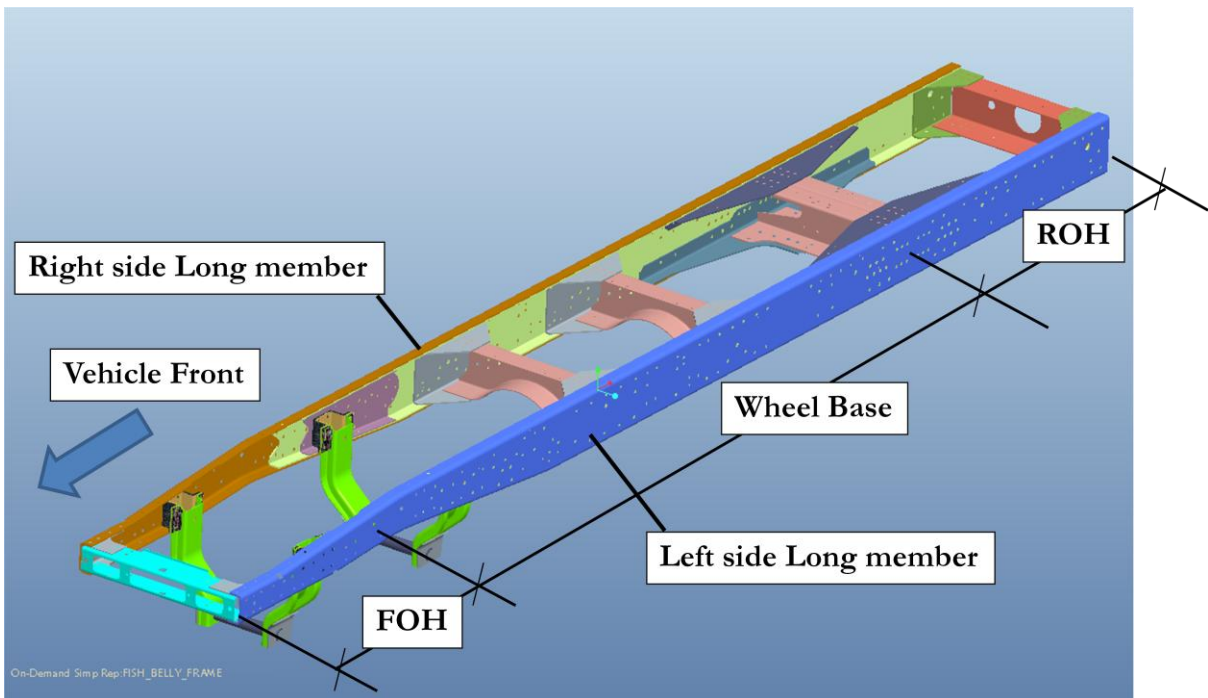
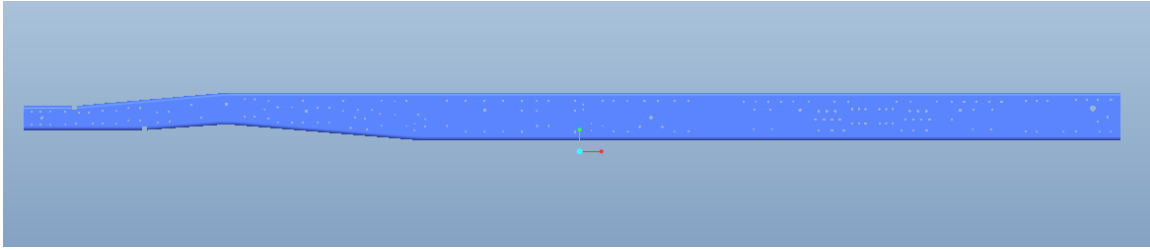
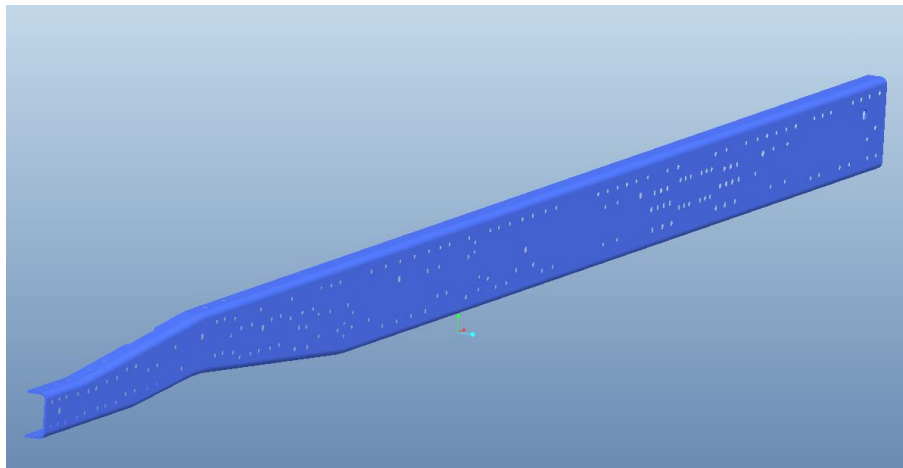


Fig – 5.1.1

5.1.1.2. CAD MODEL OF FISH BELLY LONG MEMBER:



Side View Fig – 5.1.2



Isometric View Fig – 5.1.3

5.1.2. STRAIGHT FRAME:

5.1.2.1. CAD MODEL OF STRAIHT ASSEMBLY FRAME:

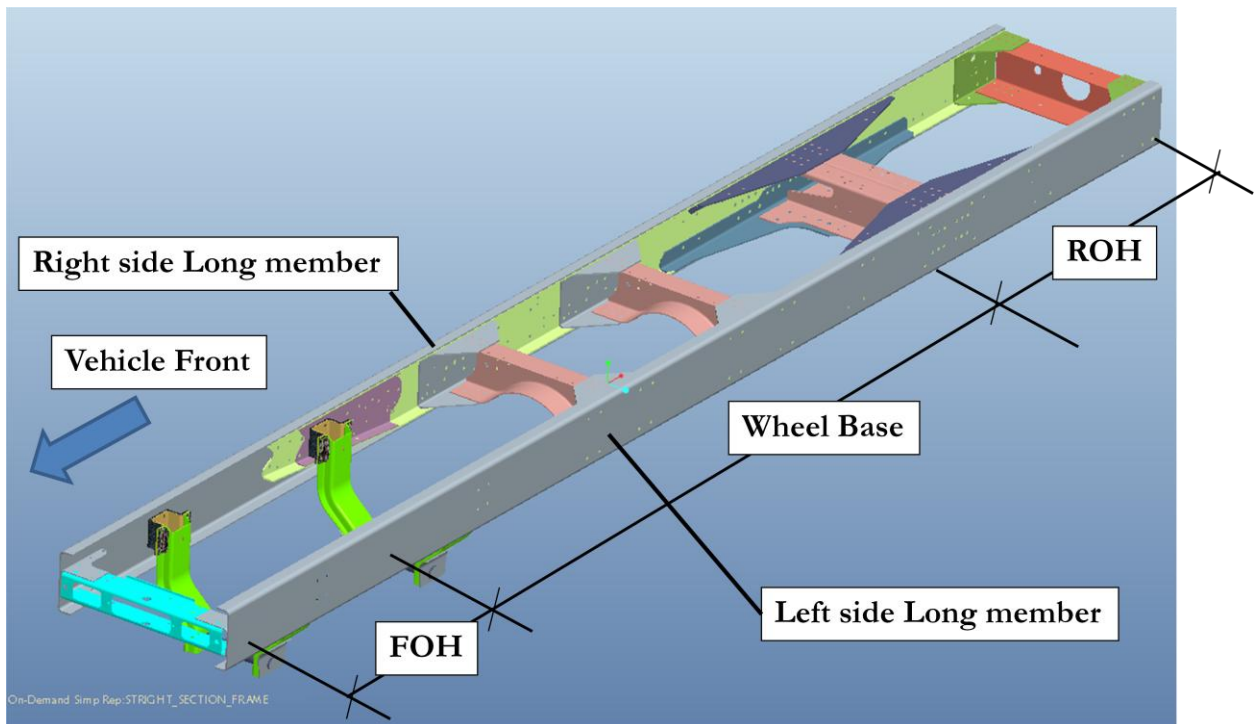
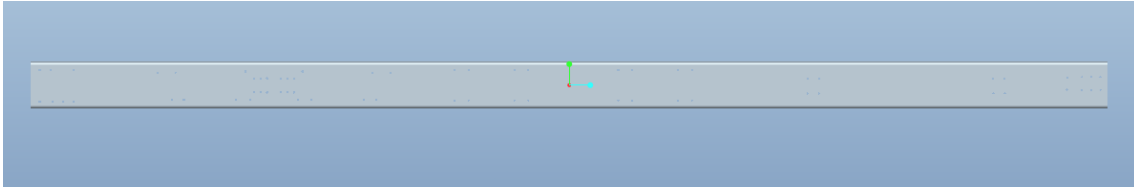
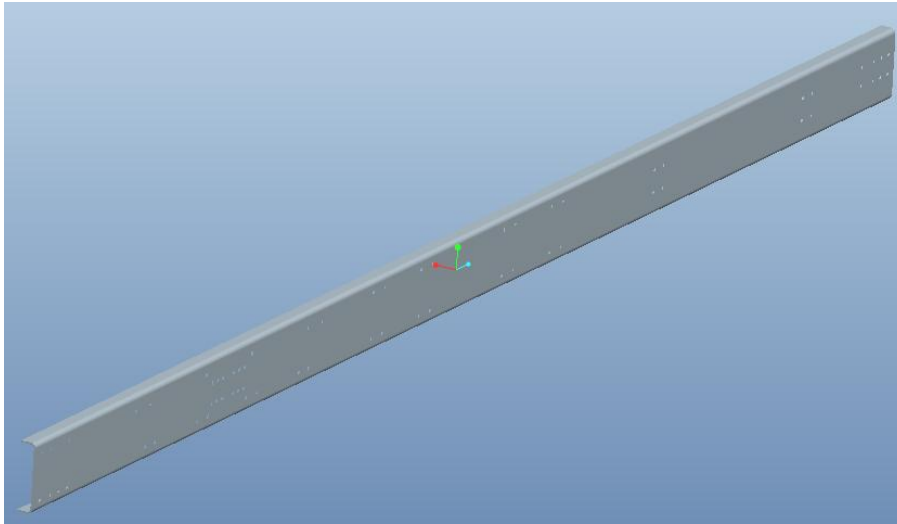


Fig – 5.2

5.1.2.2. CAD MODEL OF STRAIGHT LONG MEMBER:



Side View Fig – 5.2.1



Isometric View Fig – 5.2.2

1.3. Model Comparison:

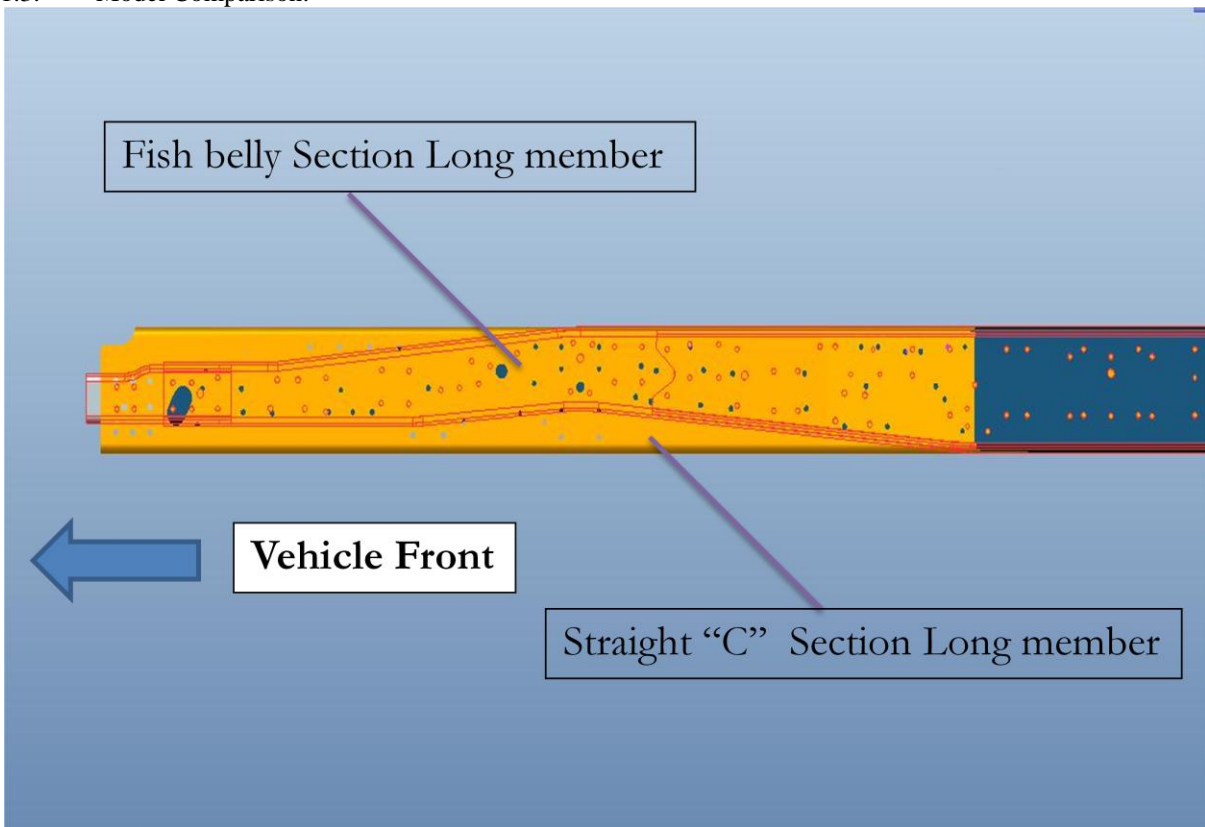


Fig – 5.3

5.2 Analysis Comparison

The truck chassis model is loaded by static forces, the maximum loaded weight of truck plus body is 10,000 kg. The load is assumed as a uniform distributed obtained from the maximum loaded weight divided by the total length of chassis frame. The finite element model of the chassis, applied with boundary conditions is shown in Fig

5.2.1. Fish belly “C” Section Frame:

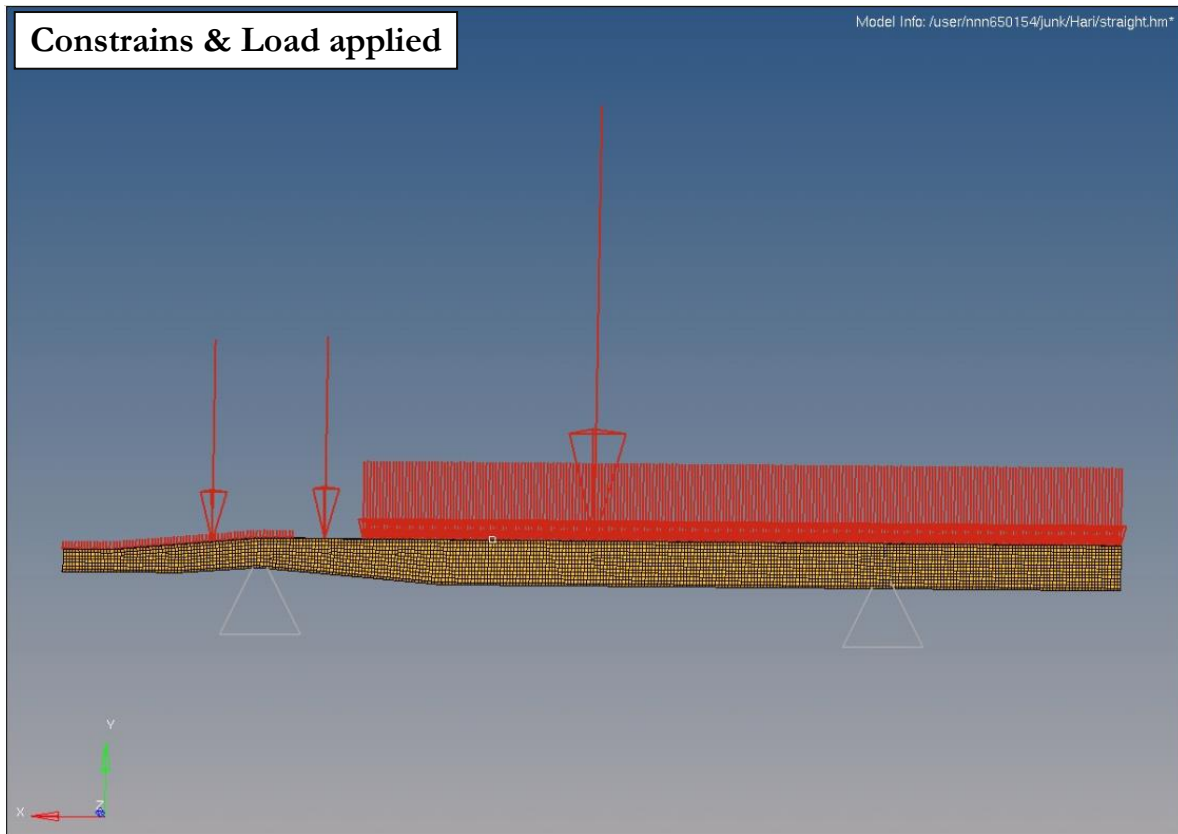


Fig – 5.2.1

5.2.2. Analysis Report:
Structural Analysis of FISHBELLY Chassis

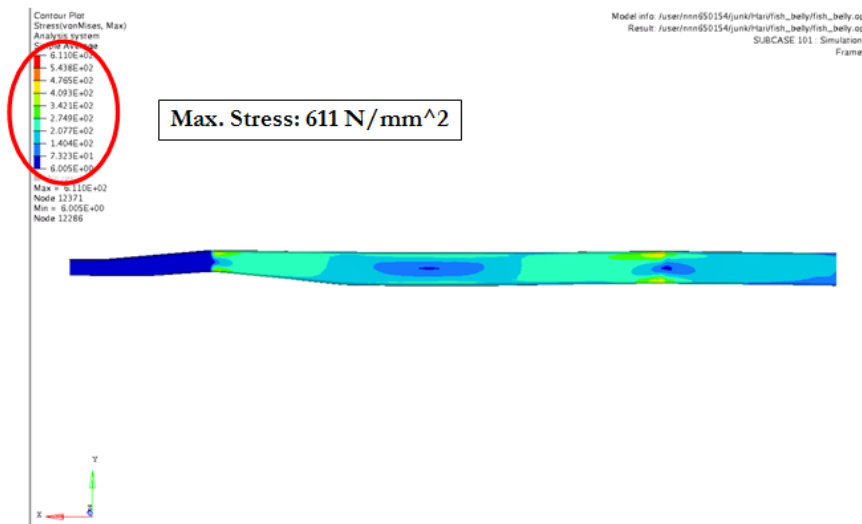


Fig – 5.2.2

5.2.3. Straight “C” Section Frame:

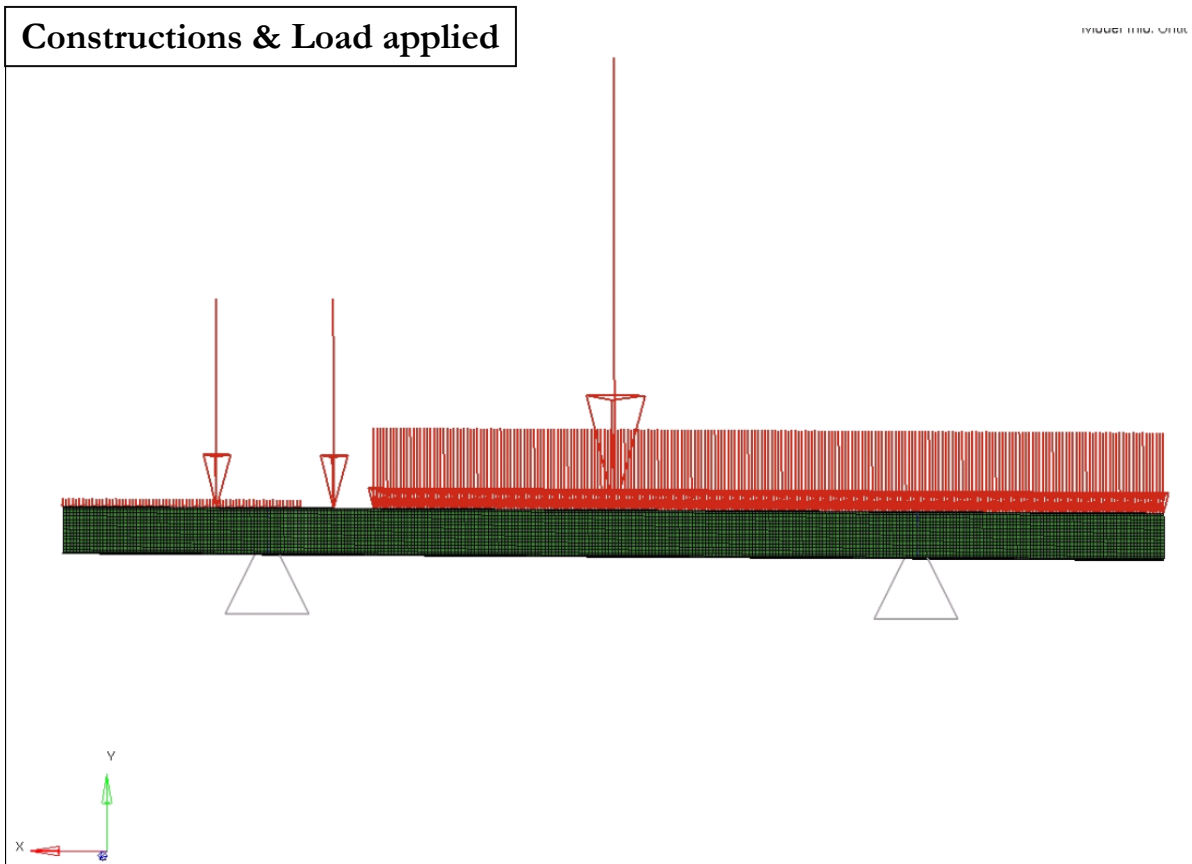


Fig – 19

5.2.4. Analysis Report:

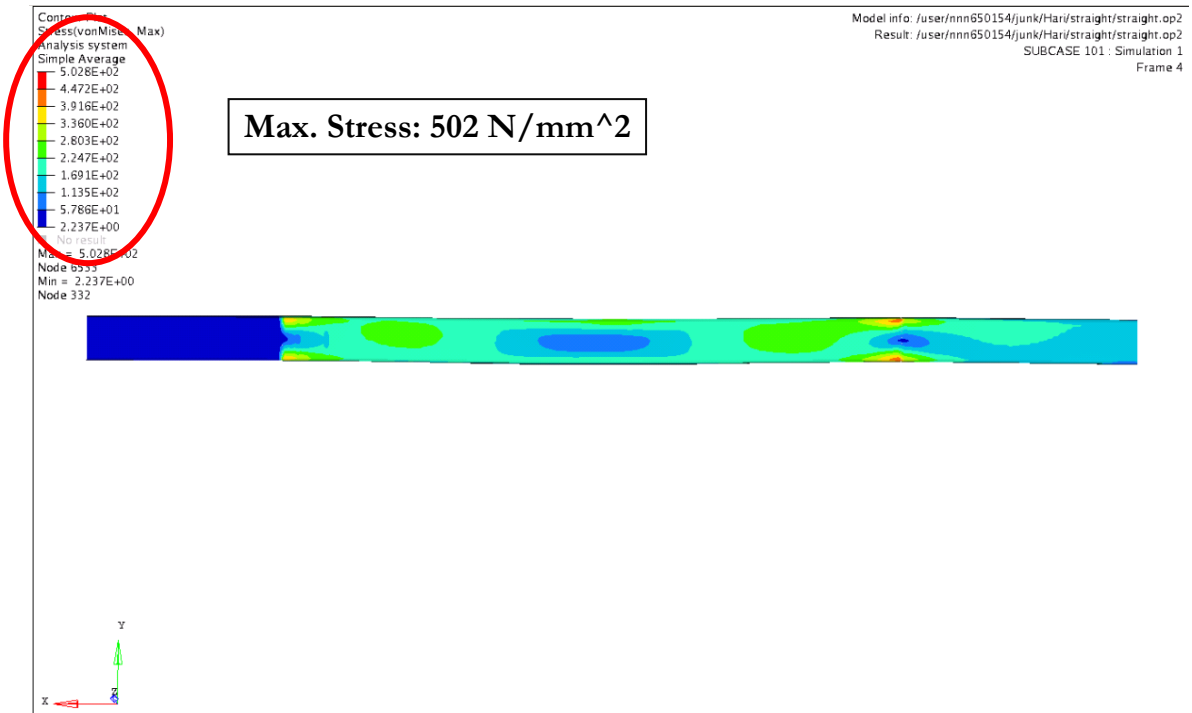
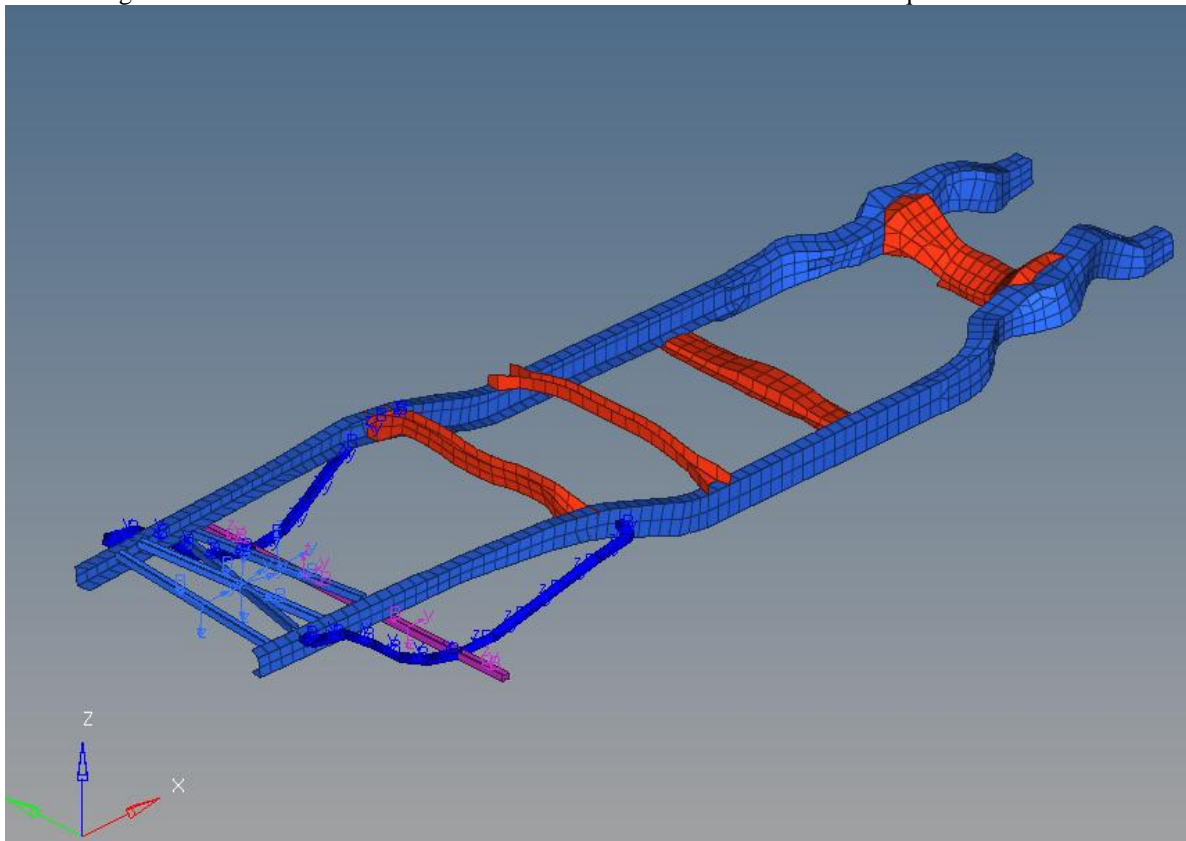


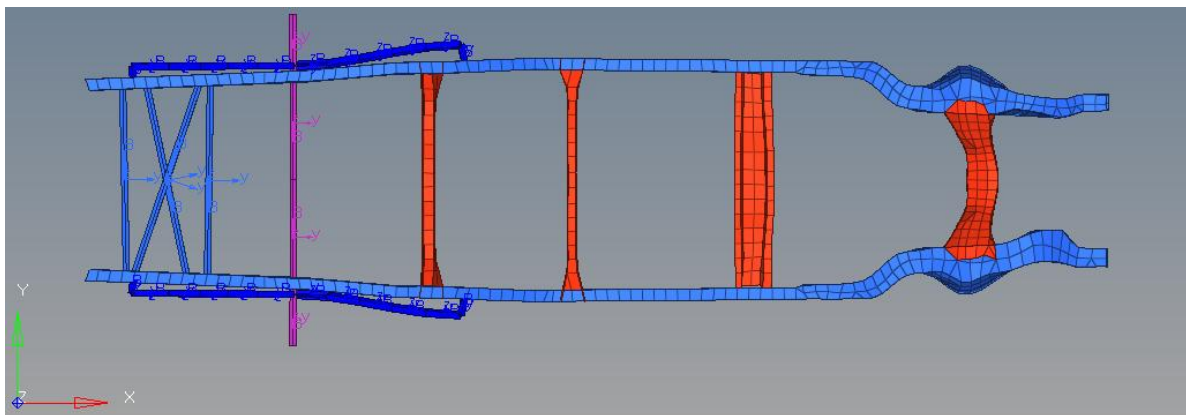
Fig - 20

5.3. FE MESH FILE:-

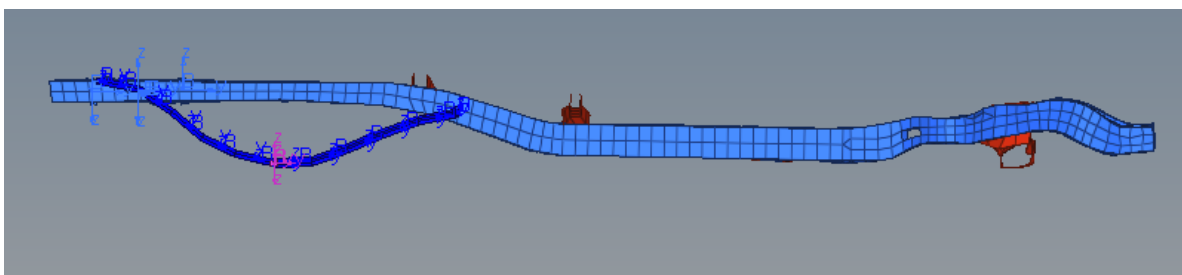
The meshing is done on the model with 1669 number of nodes and 1359 numbers of quad and tria elements



Isometric view



Top view

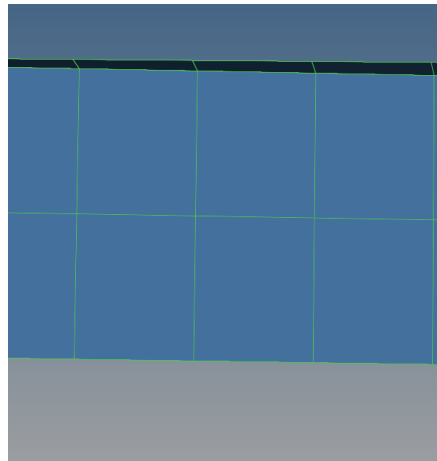


Side View

ELEMENT INFORMATION:-

Element Type Used :-

Here the element types are used for the flow considerations due and also the type of analysis considered.



Quad elements

QUALITY :-

Quality checks :

Element criteria:-

Global element size – 50mm

Minimum element size – 30mm

Maximum element size – 65mm

Warpage – 15 deg

Skew – 45 deg

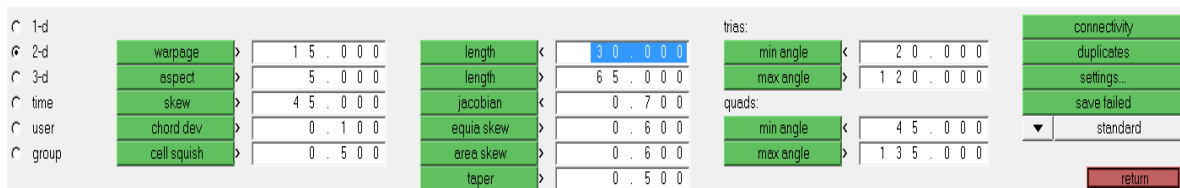
Aspect ratio – 45

Minimum Quad angle – 35

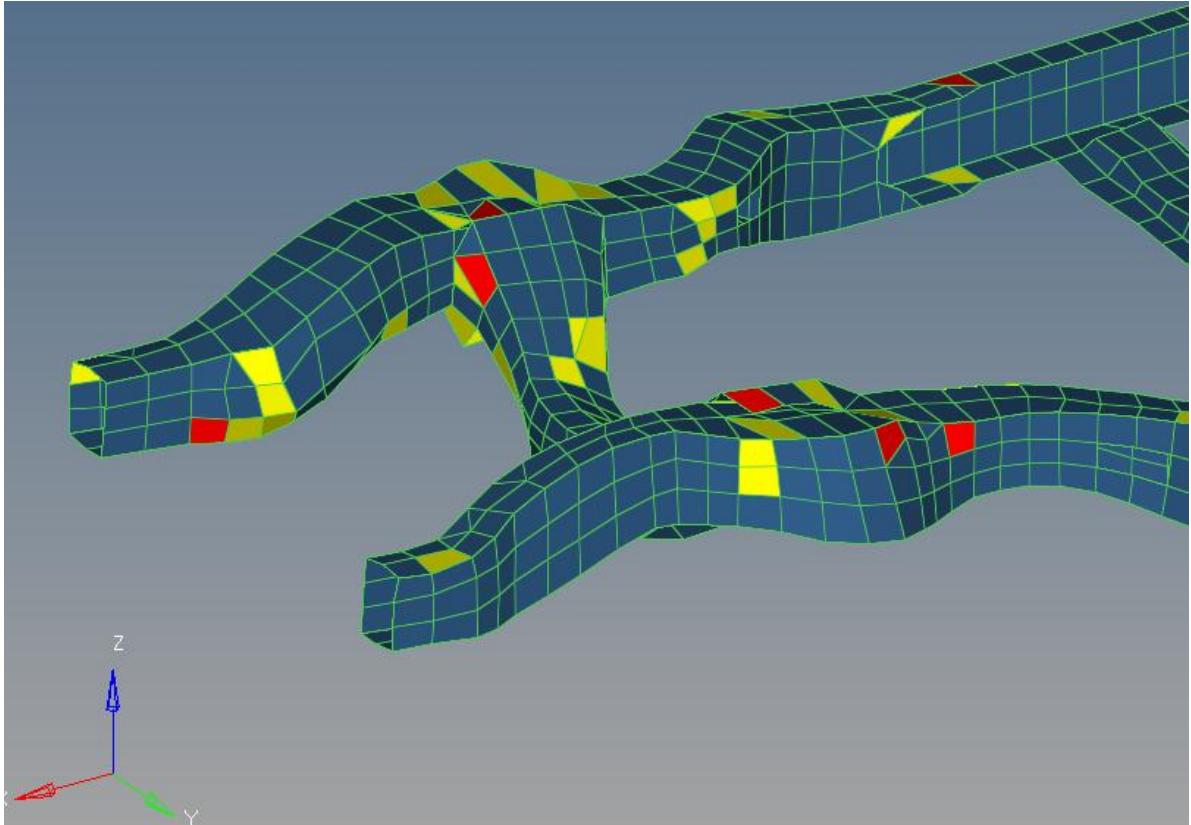
Maximum quad angle – 135

Jacobian - .7

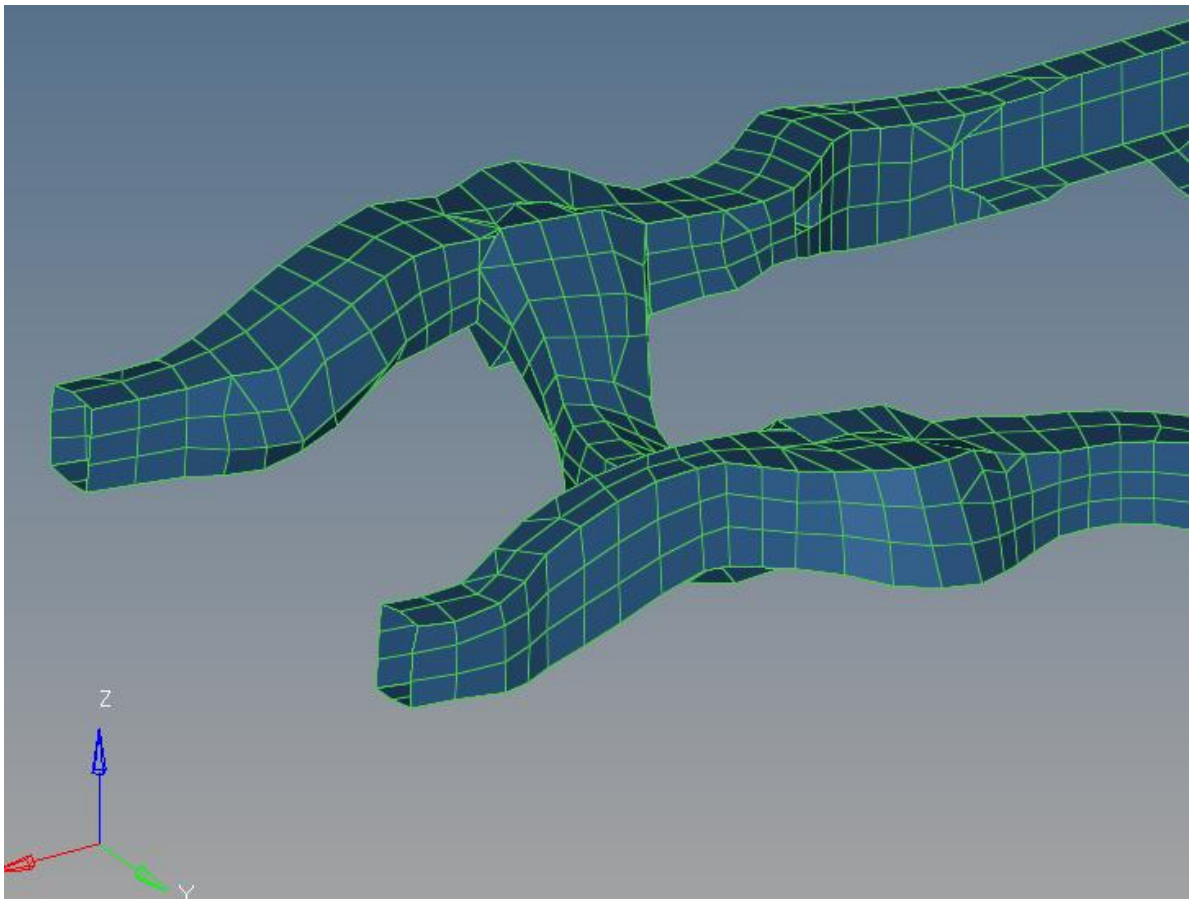
Thickness and property information will be provided in the next chapter.



Quality table in hypermesh data base



Before quality removing the quality



After removing the bad quality

Here the above both images are explained about the quality operation in progress
The 1st one showing the while working and the other one is for after removing the quality

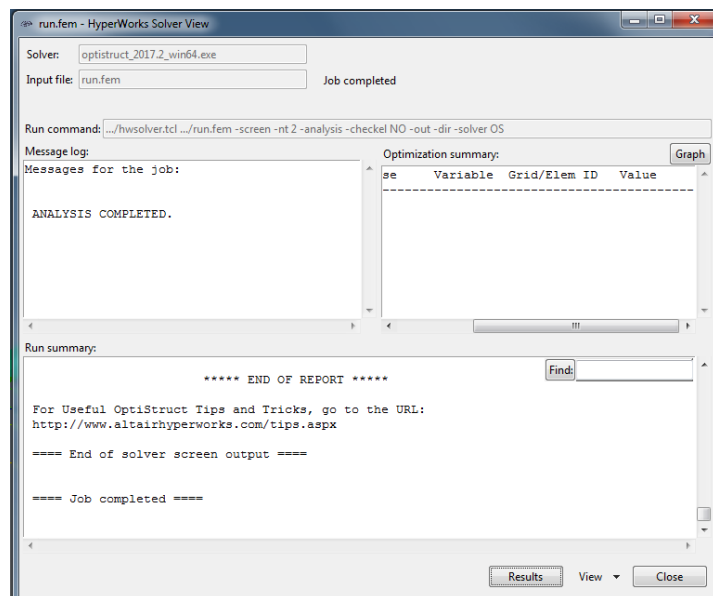
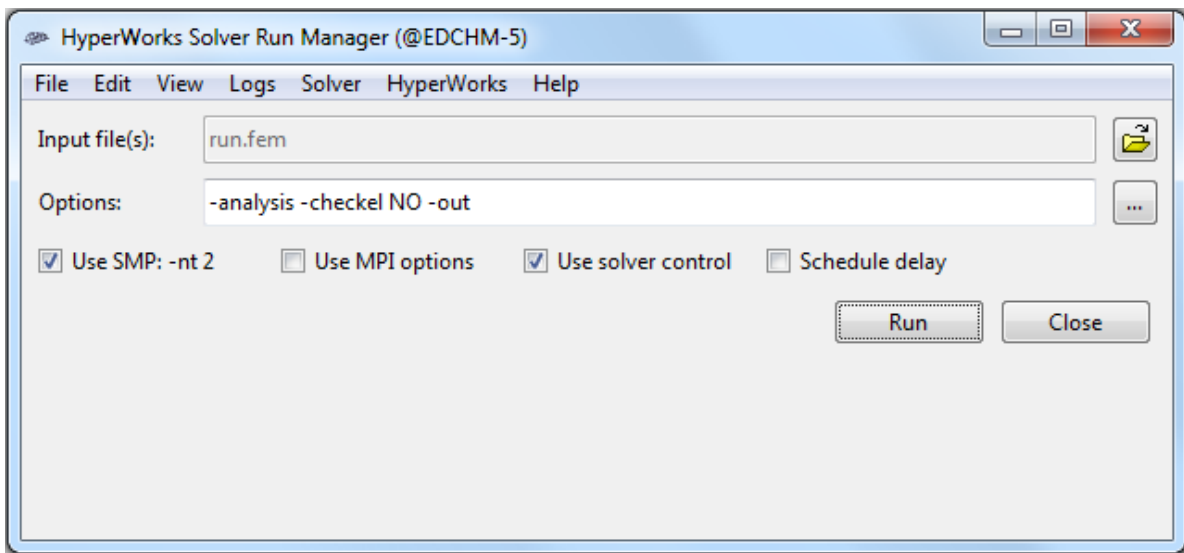
5.4. BOUNDARY CONDITIONS:-

The modal analysis is carried out in free free condition so we have not constrained the chassis only we have applied the load the card image and the load collector based on our area of interest we have chosen the modal frequency analysis.

MODAL ANALYSIS: `

Modal analysis has been performed after creating the chassis finite element model and meshing in free-free state and with no constraints. The results have been calculated for the first 14 frequency modes and show that road simulations are the most important problematic for car chassis. In this analysis we have made use of subspace method in opti struct.

Since chassis has no constraints, the first 6 frequency modes are vanished. 3 modes are related to the chassis displacement in x, y and z directions.
and 3 modes are related to chassis rotation about x, y and z axes.



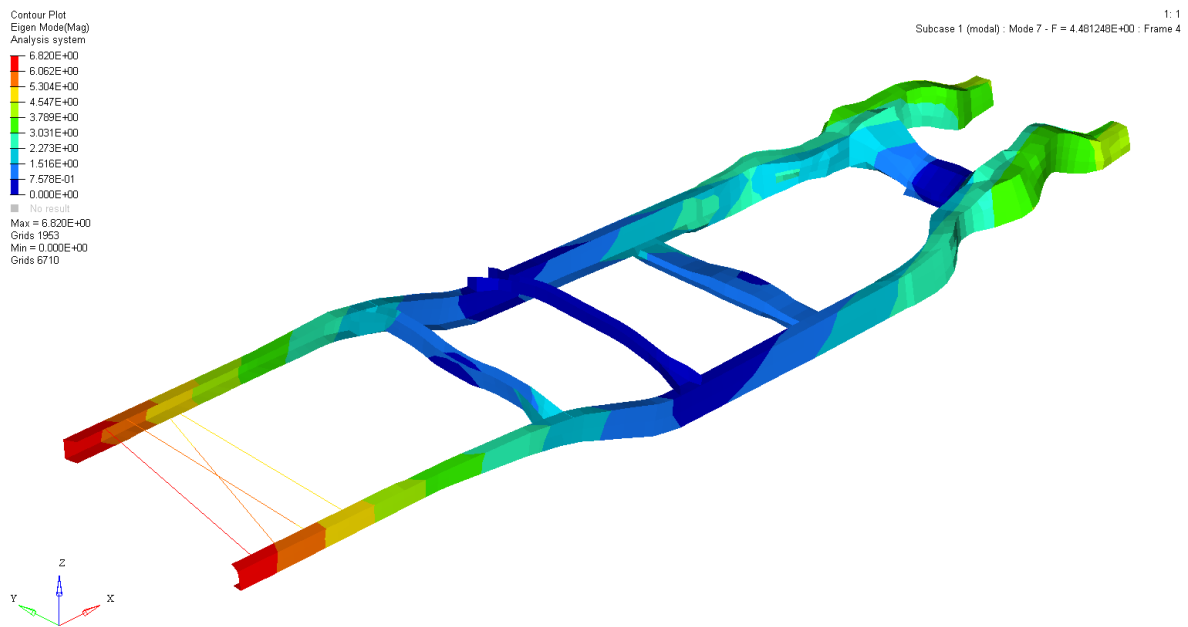
Subcase	Mode	Frequency	Eigenvalue	Stiffness	Mass
1	1	1.921653E-04	1.457840E-06	1.457840E-06	1.000000E+00
1	2	2.048765E-04	1.657081E-06	1.657081E-06	1.000000E+00
1	3	2.277690E-04	2.048090E-06	2.048090E-06	1.000000E+00
1	4	2.494071E-04	2.455712E-06	2.455712E-06	1.000000E+00
1	5	2.577897E-04	2.623558E-06	2.623558E-06	1.000000E+00
1	6	2.797716E-04	3.090060E-06	3.090060E-06	1.000000E+00
1	7	4.481248E+00	7.927893E+02	7.927893E+02	1.000000E+00
1	8	8.975816E+00	3.180590E+03	3.180590E+03	1.000000E+00
1	9	1.225136E+01	5.925547E+03	5.925547E+03	1.000000E+00
1	10	1.394420E+01	7.676209E+03	7.676209E+03	1.000000E+00
1	11	1.528445E+01	9.222733E+03	9.222733E+03	1.000000E+00
1	12	2.375300E+01	2.227393E+04	2.227393E+04	1.000000E+00
1	13	2.704002E+01	2.886514E+04	2.886514E+04	1.000000E+00
1	14	3.110097E+01	3.818630E+04	3.818630E+04	1.000000E+00

Frequency with in the structuere

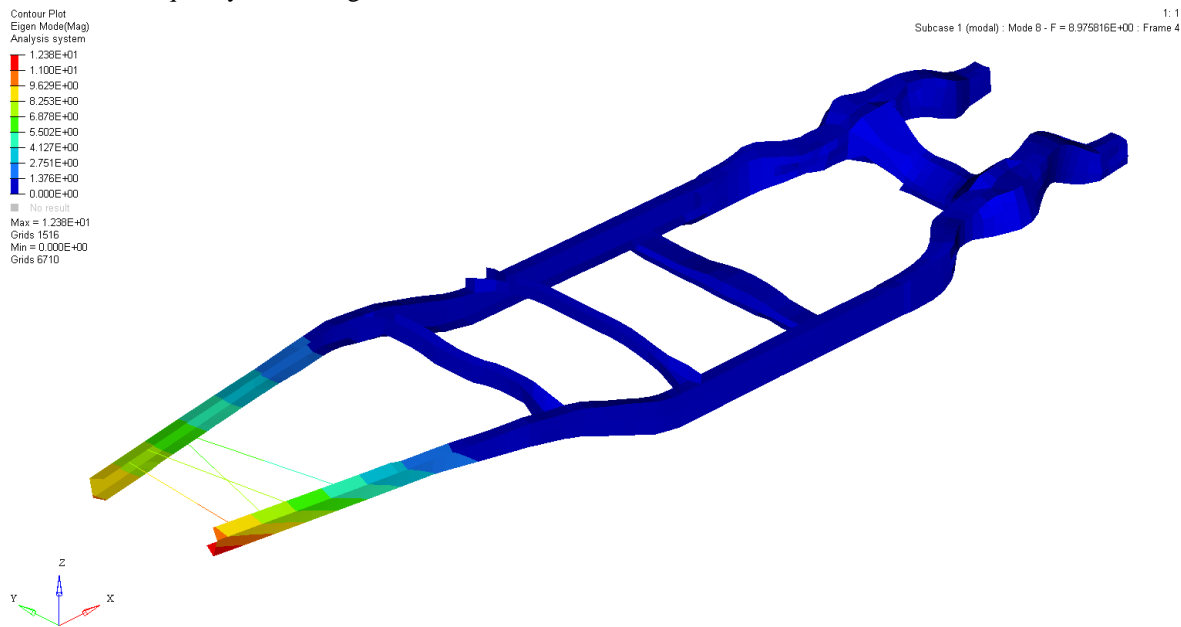
Mode shapes:-

7th mode of frequency:-

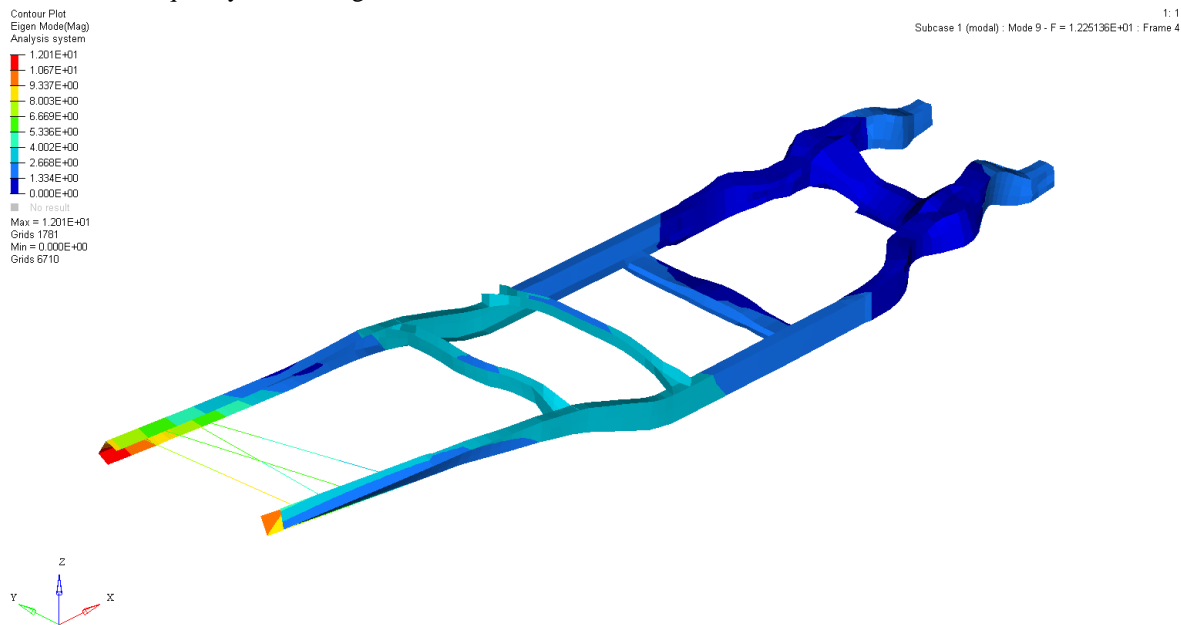
Hare the mode shape is bending



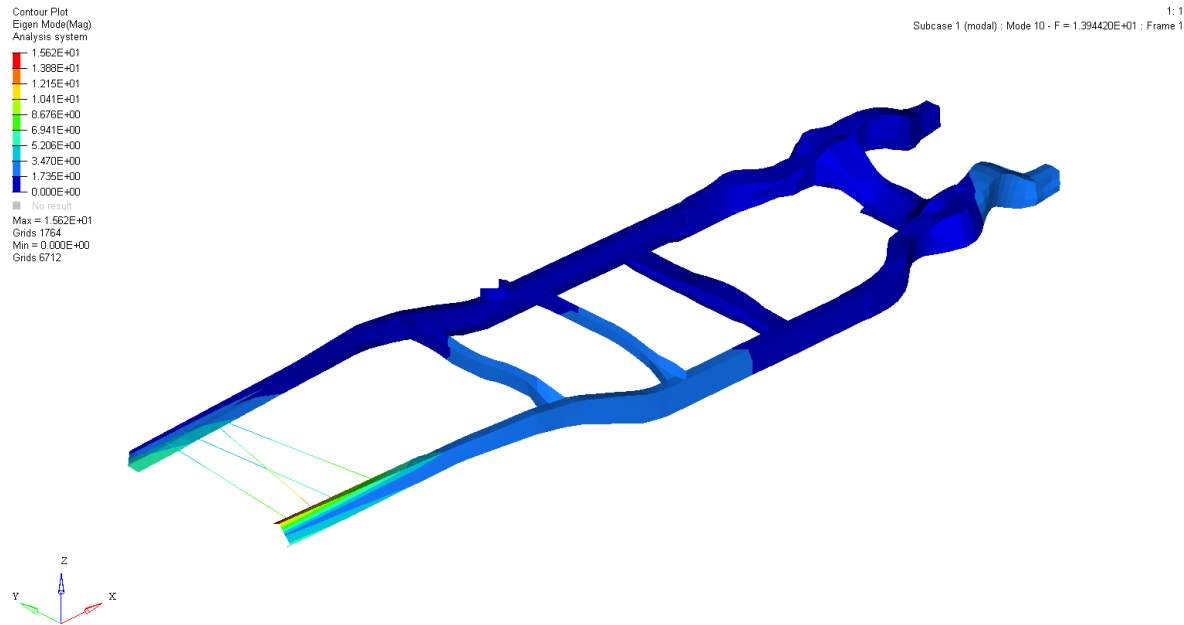
8th mode of frequency:- Bending mode



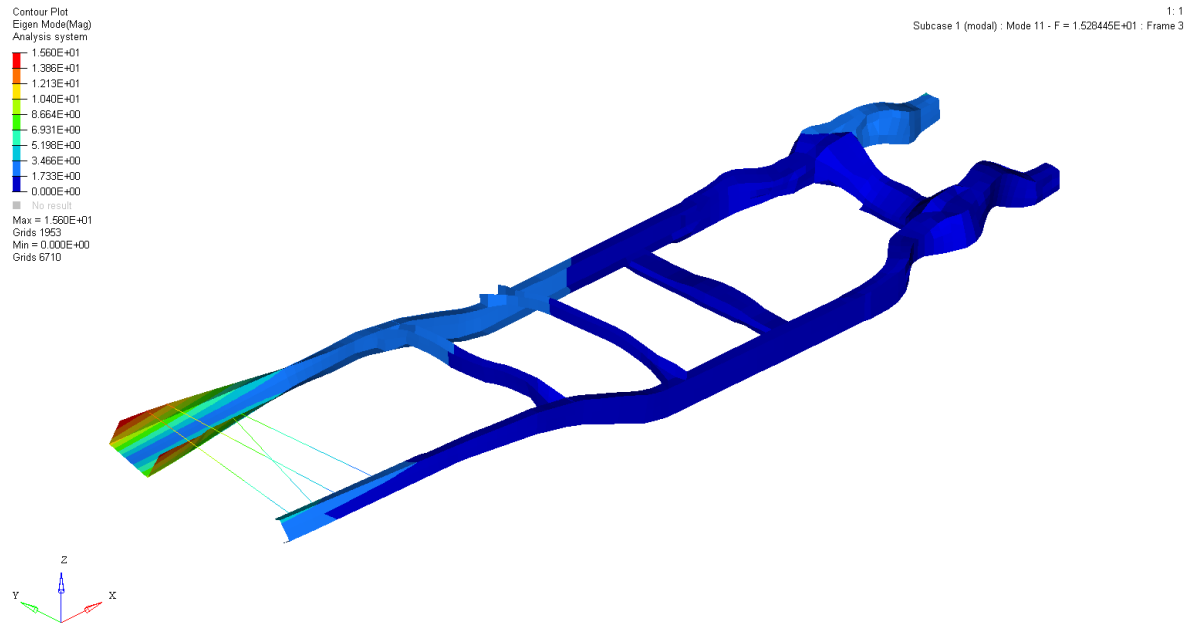
9th mode of frequency:- Twisting mode



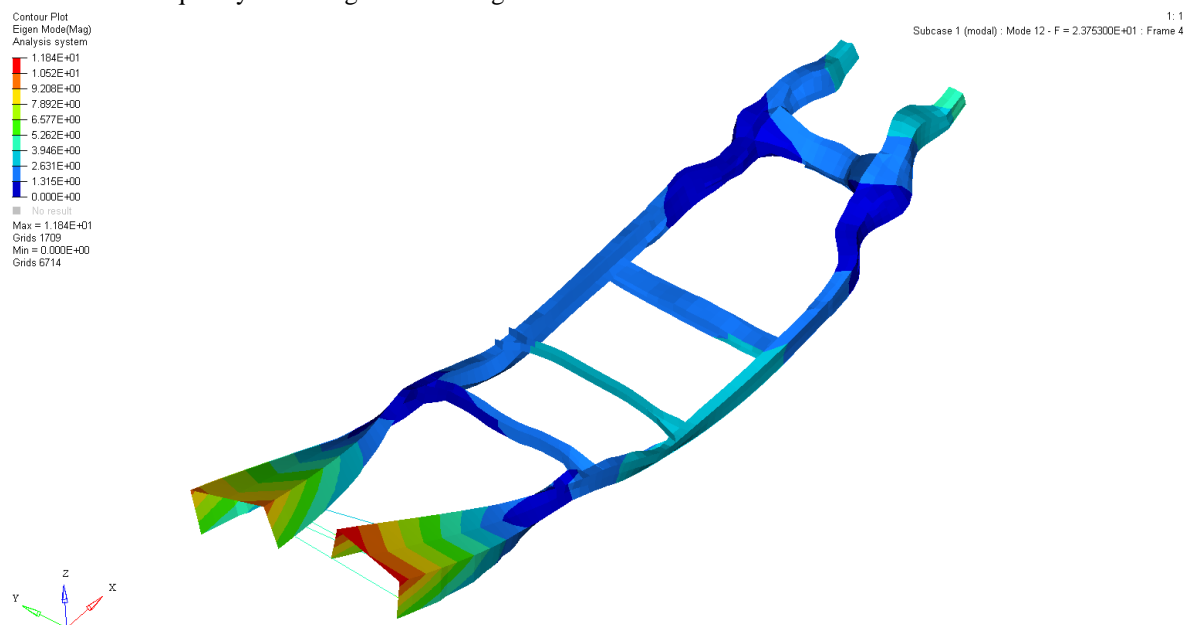
10th mode of frequency:- Twisting about x direction



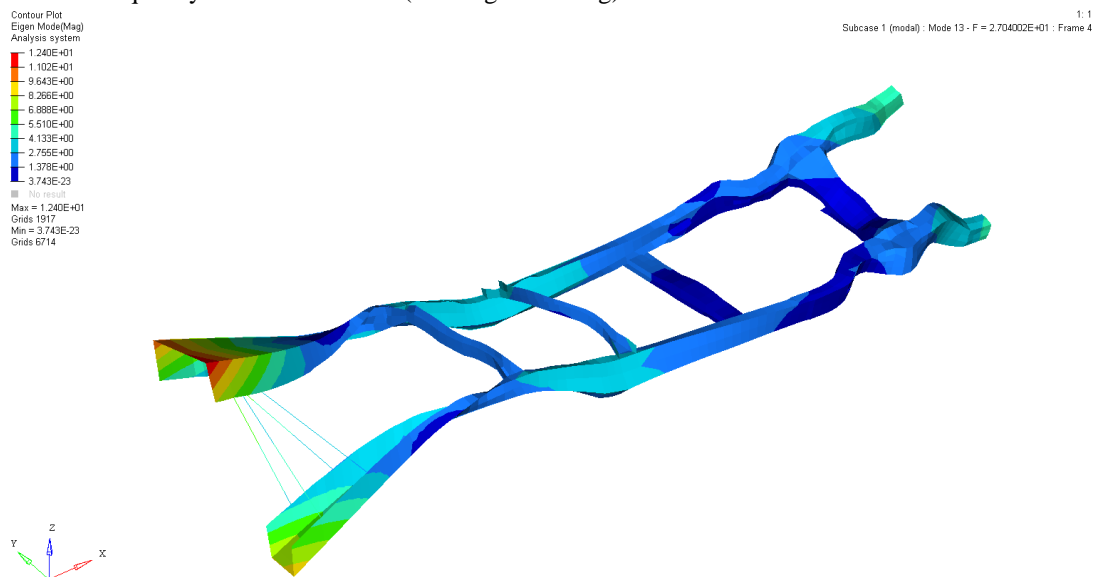
11th mode of frequency:-



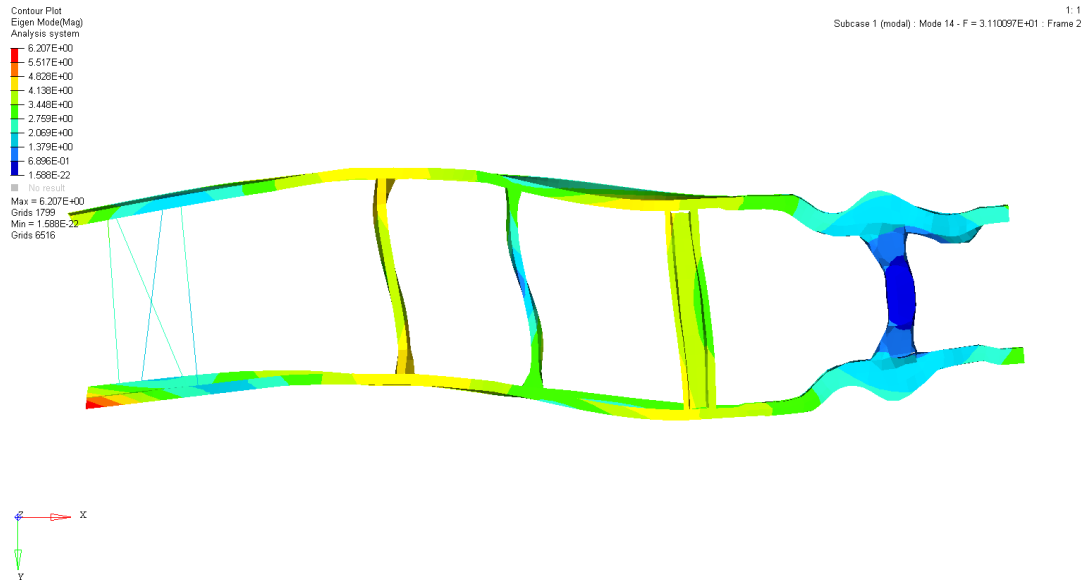
12th mode of frequency:- bending with twisting



13th mode of frequency:- combined mode (bending + twisting)



14th mode of frequency:- Twisting mode shape



Mode Number	Natural Frequency
1	0
2	0
3	0
4	0
5	0
6	0
7	4.4
8	8.9
9	12
10	14
11	15
12	23
13	27
14	31

VI. CONCLUSION

- ✚ Design is safe on Both Fish belly “C” section & Straight “C” section Frames on given Load conditions.
- ✚ Low Bending Stress achieved on straight on “C” section Frame over Fish belly “C” section Frame.
- ✚ High Resistance Bending moment achieved entire Long member on Straight “C” Frame.
- ✚ Weight of Long member is increased on straight “C” section frame over fish belly “C” section frame.
- ✚ Max. Bending moment values are same on Both Frames.
- ✚ Stress levels are high on fish belly “C” section frame over Straight “C” Frame on Analysis Report.

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I would also like to thank all the supporting staff of the Department of Mechanical Engineering and all other departments who have been helpful directly or indirectly in making the project a success.

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- [1]. Abhishek Singh, et al, "Structural Analysis of Ladder Chassis for Higher Strength", International Journal of Emerging Technology and Advanced Engineering, ISSN: 2250-2459, Volume 4, Issue 2, February 2014.
- [2]. Patel Vijaykumar, et al, "Structural Analysis of Automotive Chassis Frame and Design Modification for Weight Reduction", International Journal of Engineering Research & Technology, ISSN: 2278-0181, Volume 1, Issue 3, May 2012.
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- [4]. Monika S. Agarwal, et al, "Finite Element Analysis of Truck Chassis", International Journal of Engineering Sciences & Research, ISSN: 2277-9655, December 2013.