Modeling And Finite Element Analysis of full trailer chassis frame for Using Defence Application

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ABSTRACT

This paper represents the study of the static structural analysis of the trailer chassis at different load condition and the responses of the trailer chassis which include the stress distribution and displacement under various loading conditions. An extra-long automotive carrier vehicle mainly consists of a prime mover in the form of tractor and a multi axle long trailer. This paper is centered on an ongoing design of trailer at the VRDE (DRDO) Ahmednagar. In this research the problem was to work out structural design & Analysis of full-trailer for transportation & handling pay load of 70 tons.

Chassis is one of the important part that used in automobile industry. it is a rigid structure that forms a skeleton to hold all the major parts together. Chassis frames are made of "steel section" so that they are strong enough to withstand the load and shock. Chassis must be light in weight to reduce dead weight on the vehicles. Major challenge in today's automobile vehicle industry is to overcome the increasing demands for higher performance, lower weight in order to satisfy fuel economy requirements, and longer life of components, all this at a reasonable cost and in a short period of time. The study is to produce results to rectify problems associated with structures of a commercial vehicle such as strength, stiffness and fatigue properties along with stress, bending moments. This can be achieved by static analysis; Design of a Chassis is carried by using solid works .And finite element analysis will be carried out by using ANSYS.

Keywords: Stress Analysis; Finite Element Method; full trailer chassis.

I. INTRODUCTION

Mobility of a Tracked Vehicle is one of the important parameter in the design of any Armored Fighting Vehicle. The components of the mobility strategic, tactical and battlefield mobility are, to be taken into considerations. The battlefield mobility dictates the design parameters like capacity of power pack and power to weight ratio, where as the main parameter for the strategic and tactical mobility is the weight of the vehicle. For the strategic and tactical mobility, the requirements of additional vehicles for the transportation need to be catered for this case was presented to Hon. Defense Minister during his review of the Land Systems. Hon. Defense Minister directed that the task of the development of the transporter should be taken up by DRDO. During the review of the Automatic Commercial Environment (ACE) cluster by DG (ACE), it was decided that the said developmental task will be taken up by VRDE, Ahmednagar. The decision was based on the experience and expertise available with VRDE for the transportation of heavy load in the pay load of 150 t for the Strategic Programs. [1].

II.TYPE OF TRANSPORTER

As a strategic step in the battlefield, tanks need to be transported up to the theater of operation. There are two main types of the tank transporter viz. Full Tractor and Trailer combination and Semi-Trailer and Tractor combination.

A. Full Trailer and Tractor:

In this transporter, there is a tractor which pulls a trailer with the payload. The trailer is having axles in the front as well as in the rear and the load is distributed between all the axles.

Fig.1 Full-trailer [2]

B. Semi-Trailer and Tractor:

In this transporter, the tractor is attached to the trailer via a fifth wheel coupling. The trailer has a goose neck which is connected to the fifth wheel coupler.

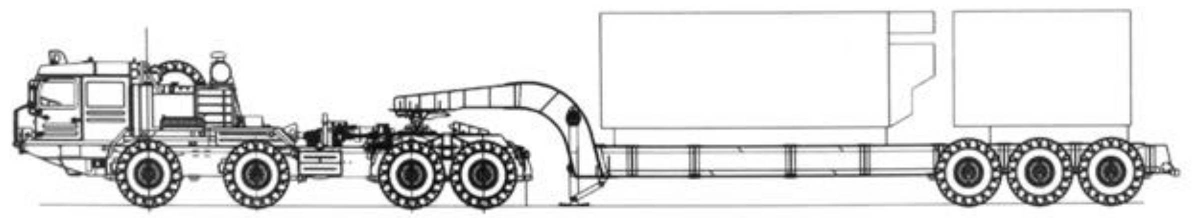

Fig.2 Semi-trailer

III. DESIGN OF RAMP AND PLATFORM:

A. Platform

This section is presents Designation of various sections and areas:

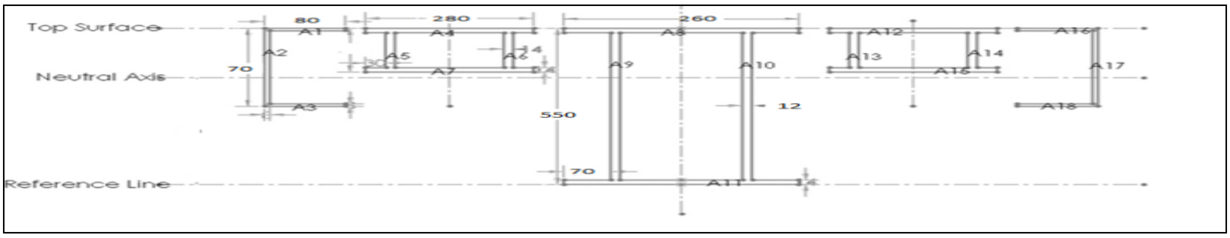

Fig.3: Designation of various sections and areas

Sum of Area= 50872 mm^2

Sum of Area x Y= 17314960 mm^3

$$\text{Neutral axis from reference line (Y)} = \frac{17314960}{50872}$$

Neutral axis from reference line (Y) = 34(mm

$$\text{Section Modulus (Z)} = \frac{I}{Y}$$

$$\text{Section Modulus (Z)} = \frac{1319792988}{340.363}$$

Section Modulus (Z) = 387 mm^3

So above calculated section modulus (mm^3 is more than the required section modulus for both the cases hence the above selected sections are safe for design of chassis.

- **Bending moment equation is**

$$M = \sigma \ x \ Z$$

$$Z = \frac{M}{\sigma}$$

From above bending moment diagram (BMD)

Maximum bending moment (M_{max}) = 529510000 N-mm

Case 1

Considering factor of safety 2 with allowable normal stress 166.667 MPa

$$Z = \frac{M}{\sigma}$$

$$Z = \frac{529510000}{166.66}$$

Z= 3,177,054.315 mm^3

The minimum required section modulus necessary to keep the normal stresses below the 166.667 MPa allowable stress limit is 3,177,054.315 mm^3.

Case 2

Considering factor of safety 2.5 with allowable normal stress 140 MPa

$$Z = \frac{M}{\sigma}$$

$$Z = \frac{529510000}{140}$$

Z= 3,782,215.082 mm^3

B. Ramp:

The input for the design of ramp is:

Height from ground – 1162 mm

i. Entry angle – 17°
ii. Width – 800 mm (Considering the Track width of the Tank)

With the constraints the finalsied dimensions of the ramp are as follows:

Total Length - 3862 mm

Total Width – 800 mm

The actuation of the ramp will be carried out by using hydraulic cylinder. Proper mounting of the cylinder has been provided. The details of the selected cylinder are as follows:

IV. FEM MODELING RAMP AND PLATFORM:

A.Platform: The final selected sections with dimensions are as follows:

C Section:

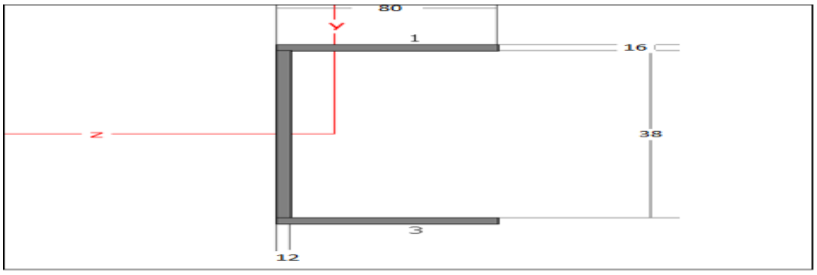

Fig.4 Double II Section between C and Central Section:

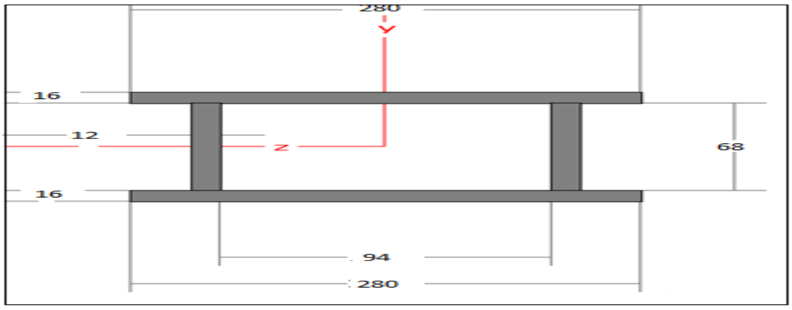

Fig.5 Double II Section between C and Central Section

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- **Central Double II Section:**

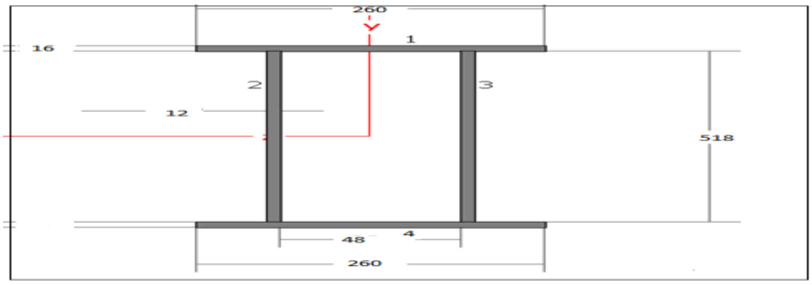

Fig.6 Central Double II Section

- **Trailer chassis with selected sections:**

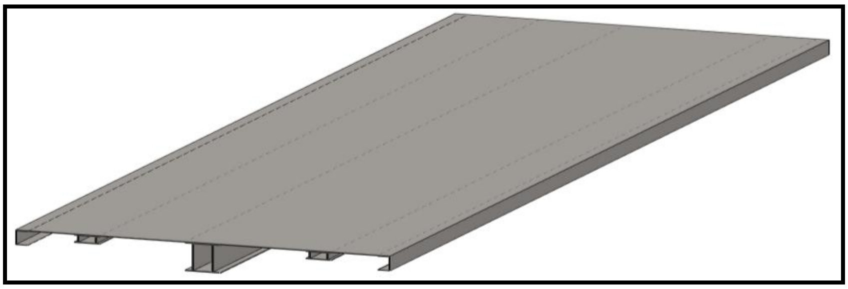

Fig.7 Trailer chassis with selected sections

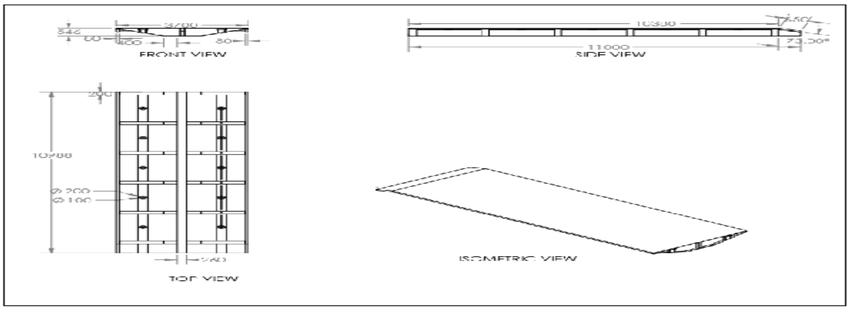

Fig.8 Drawing of platform chassis

B.Ramp:

Ramp has been provided at the rear of the trailer for loading and unloa21ding of tank. Considering the transportation mode of the trailer, a bi-fold ramp has been designed. To reduce the fatigue to the operator, the ramp operation will be carried out using hydraulic power with manual override. The ramp would be foldable in length and provided a gradual slope. A linkage mechanism coupled with pulley and chain will be incorporated for bi-folding of lower ramp.

- Ramp of full trailer various sections and areas:

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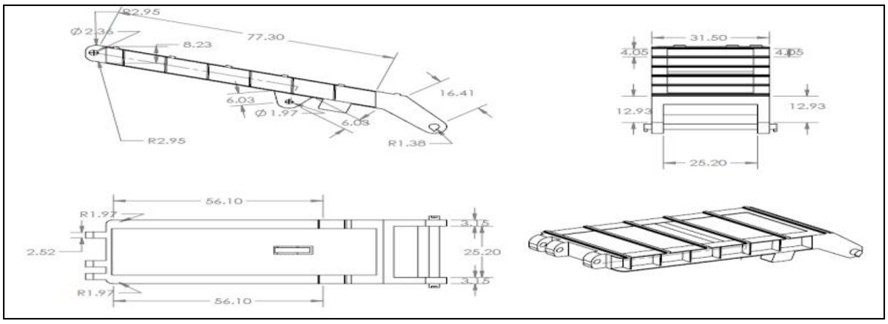

Fig.9 drawing of upper ramp

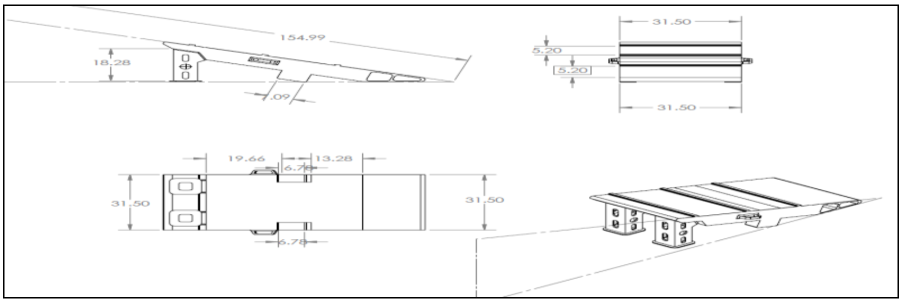

Fig.10 Drawing of lower ramp

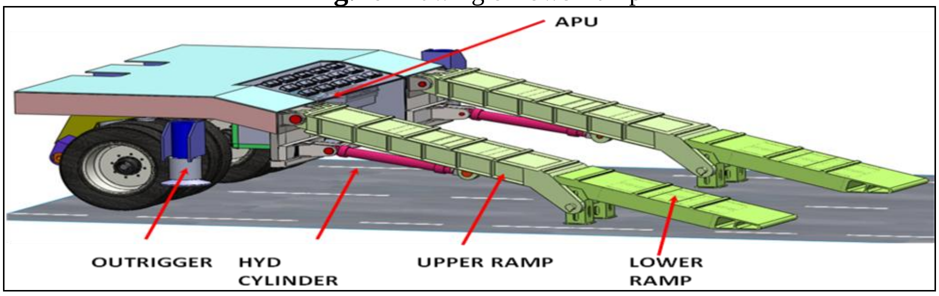

Fig.11 Ramp

V.MESHING

A.Chassis of full trailer:

Tetrahedral elements are used. In order to get a better result, locally finer meshing applied in the region which is suspected to have the highest stress. The time of completed in mesh is 2.25 minute, the meshing used computer name is tvd-05.

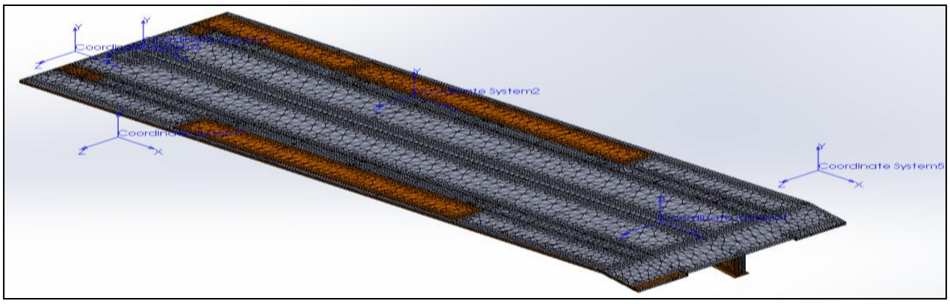

Fig.12 Meshing

Table no.1 Meshing details

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Physics reference	:	Mechanical
Relevance centre	:	Fine
Element size	:	20
Method	:	Tetrahedral
Algorithm	:	Patch confirming method
Element quality	:	High
Behavior	:	Soft
Nodes	:	79898
Elements	:	37024
Mesh time	:	2:25

B.Ramp:

Tetrahedral elements are used. In order to get a better result, locally finer meshing applied in the region which is suspected to have the highest stress. The time of completed in mesh is 2.59 minute, the meshing used computer name is tvd-05.

1) Upper ramp

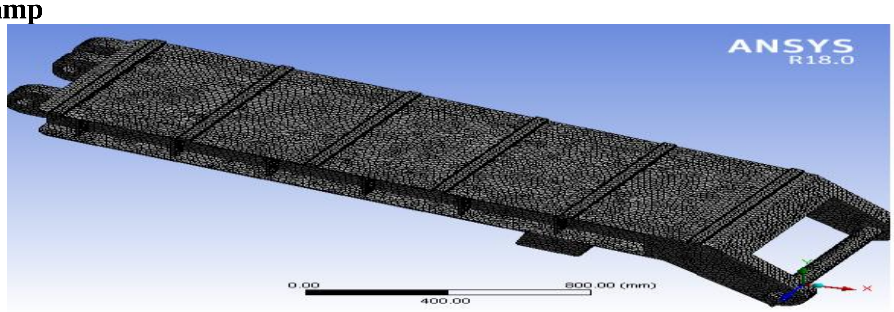

Fig.13 Meshing

Table no 2: Meshing details

Physics reference	:	Mechanical
Relevance centre	:	Fine
Element size	:	20
Method	:	Tetrahedral
Algorithm	:	Patch confirming method
Element quality	:	High
Behavior	:	Soft
Nodes	:	101231
Elements	:	52251
Mesh time	:	2:59

2) Lower Ramp:

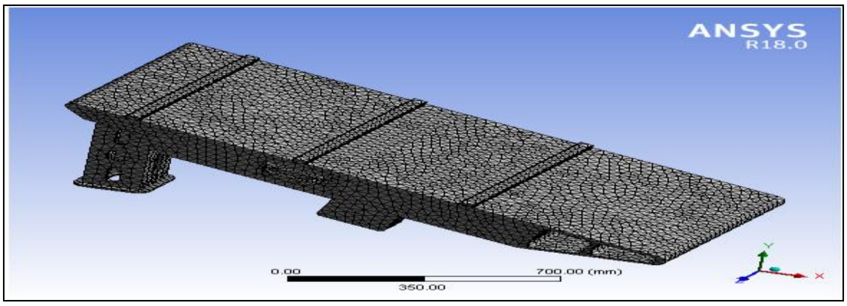

Fig.14 Meshing

Table no 3: Meshing Details

Physics reference	:	Mechanical
Relevance centre	:	Fine
Element size	:	20
Method	:	Tetrahedral
Algorithm	:	Patch confirming method
Element quality	:	High
Behavior	:	Soft
Nodes	:	262062
Elements	:	136246
Mesh time	:	2:30

VI. FINITE ELEMENT ANALYSIS OF CHASSIS FRAME:

A. Different Load Cases considered for analysis:

1) Static analysis

2) Braking Analysis

3) Gradient 14°

4) Pulling 23 t at 14°

B. Materials for the structure:

Table no 4: Material Specification

Material	:	SAILMA 410
Yield Stress	:	410 MPa
UTS	:	540 – 660 MPa
%age Elongation	:	19

It is high tensile structural steel plate. It is high strength structure steel. The material provides excellent welding and bending properties. Analysis has been carried out considering 410 Mpa yield stress.

1] Static Analysis

Table no.5: Static Loads

P1	Spare wheel load	5886 n
P2	Ramp load	16677 n
P3	APU load	3924n
W1	Tank load	686700 n
W2	Steering load	19620 n
W3	Platform weight	147150 n

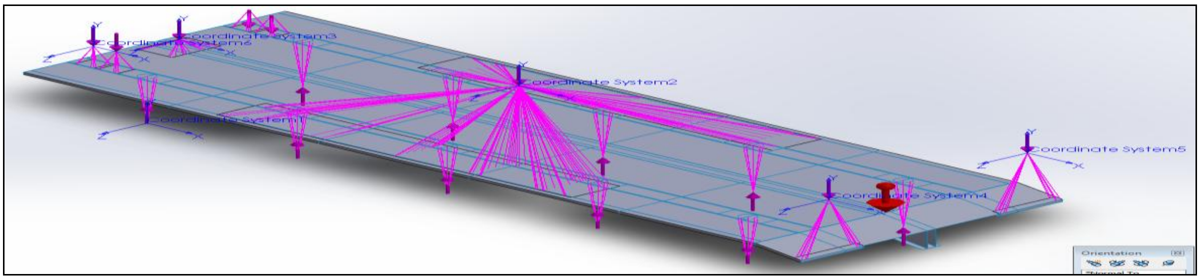

Fig.15 Static Loads

- **Von Mises Stress distribution**

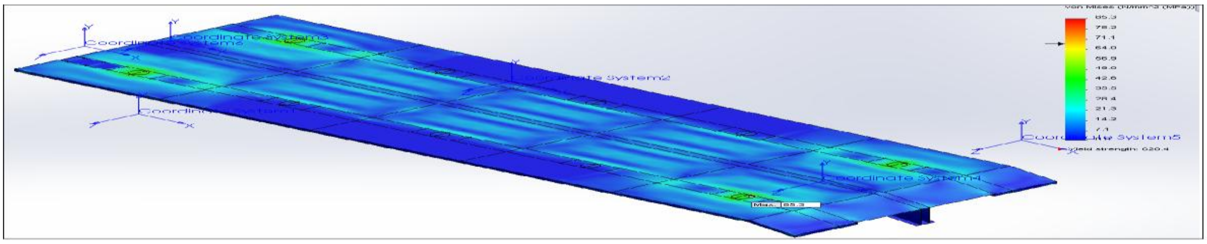

Fig.16 Stress Distribution

In the static analysis, maximum equivalent stress is done.
Fig.16 Shows maximum stress is 85.3 Mpa and minimum
Stress is 7.1. Yield strength is 620.4

- **Displacement of chassis frame:**

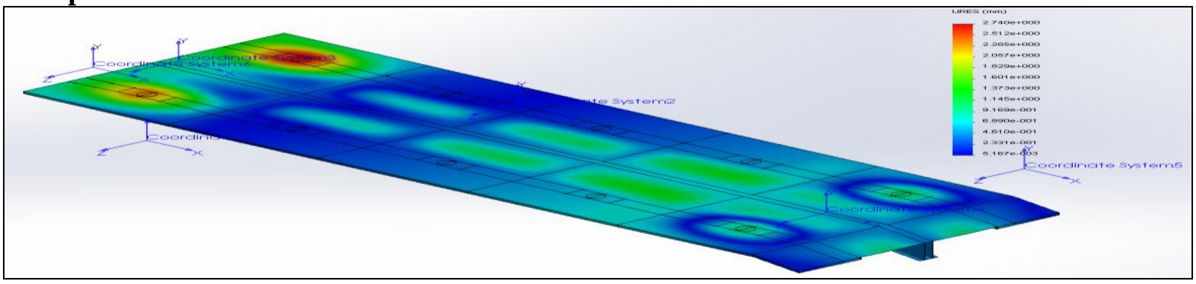

Fig.17 Displacement of chassis frame

The displacement of chassis and location of maximum displacement is shown in Figure 17. The magnitude of maximum displacement is 5.1 mm and minimum deformation is 2.7 mm.

2) Braking Analysis:

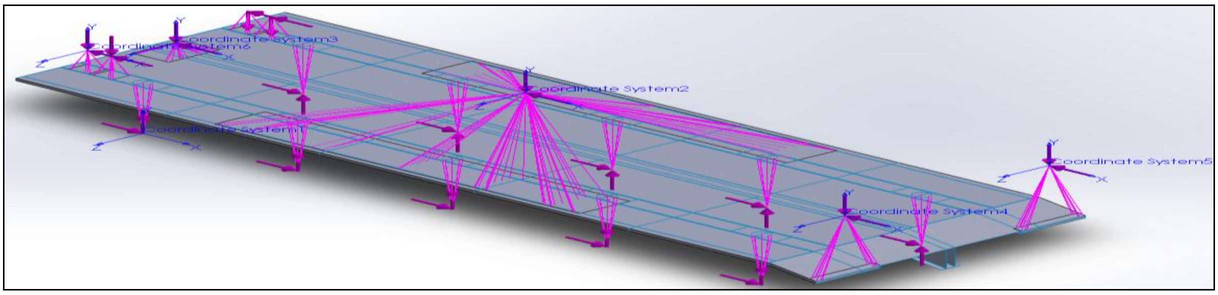

Fig.18 Braking Loads

- **Von Mises Stress distribution**:

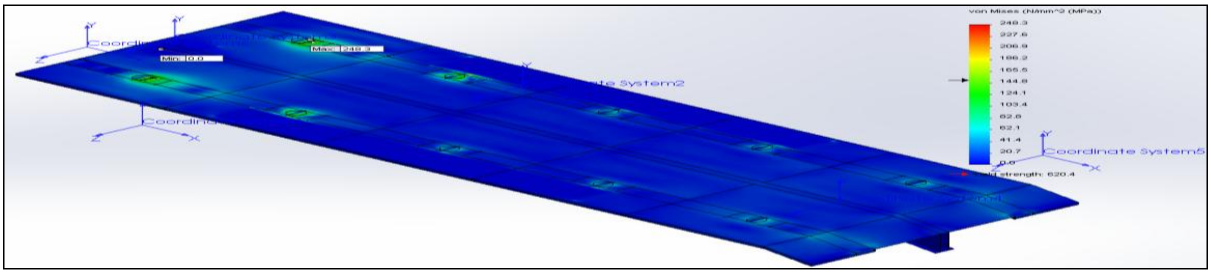

Fig.19 Stress Distribution

In the braking analysis load case, maximum equivalent stress is done. Fig.19 Shows maximum stress is 248.3 Mpa and minimum stress is 20.7 Mpa Yield strength is 620.4.

- **Displacement of chassis frame:**

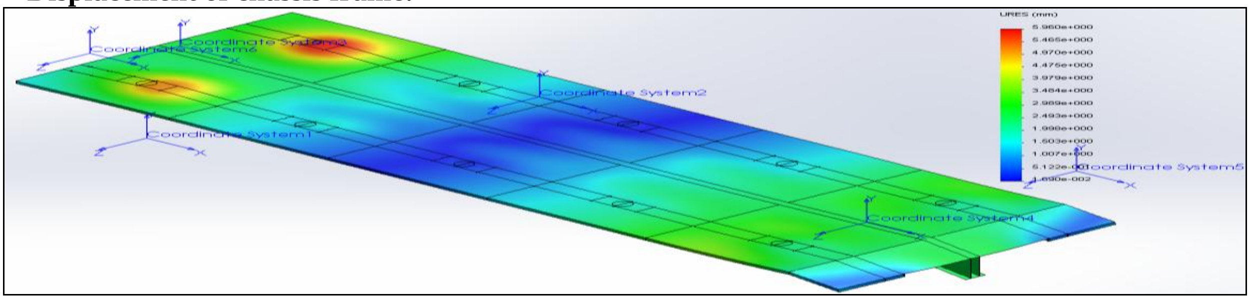

Fig.20 Displacement of chassis frame

In the braking analysis load case, the displacement of chassis and location of maximum displacement is shown in Figure 20. The magnitude of maximum displacement is 5.9 mm and minimum deformation is 5.1 mm.

3] Gradient 14°

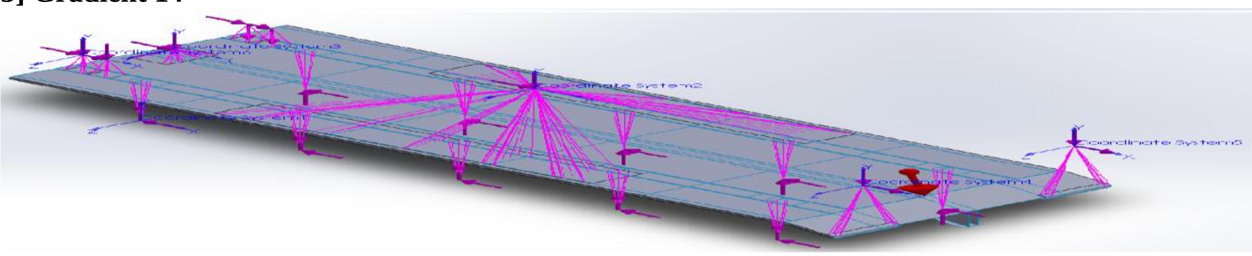

Fig.21 Load for gradient 14°

- **Von Mises Stress distribution:**

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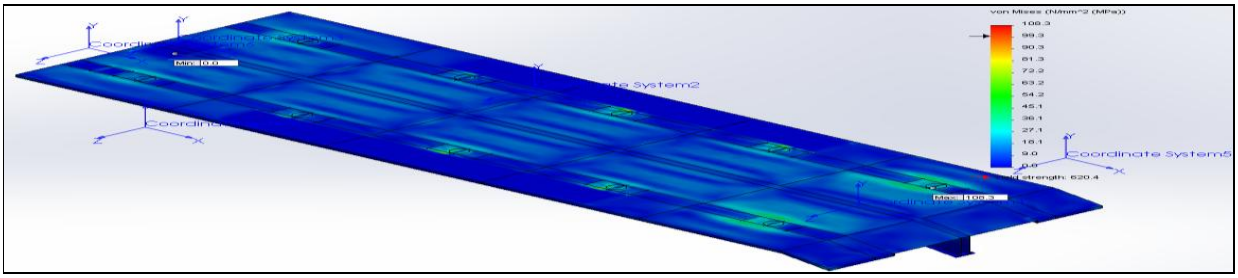

Fig.22 Stress Distribution

In the Gradient 14°, maximum equivalent stress is done.Fig.22Shows maximum stress is 108.3 Mpa and minimum Stress is 9.0 Yield strength is 620.4.

- **Displacement of chassis frame:**

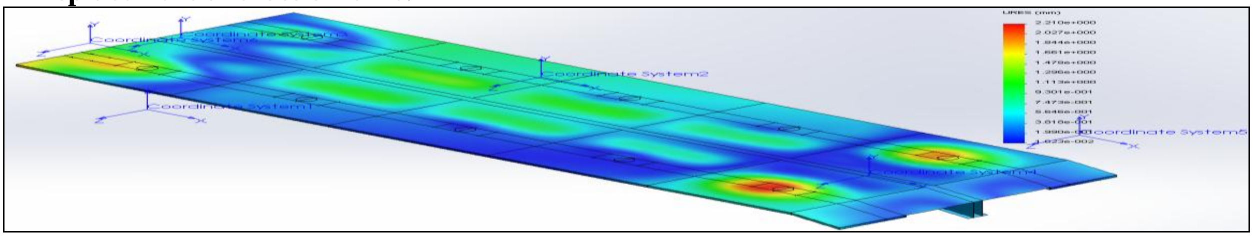

Fig.23 Displacement of chassis frame

In the Gradient 14°, the displacement of chassis and location of maximum displacement is shown in Figure 23.

The magnitude of maximum displacement is 2.2 mm and minimum deformation is 1.6 mm.

4] Pulling 23 t with Gradient 14°

All the vertical forces and reactions of 14 ^{0} gradient case are considered.

Weight of the system including tank wt = 95 t

Max pull required at 14 ^{0} gradient = 95 sin14^{0} = 23t

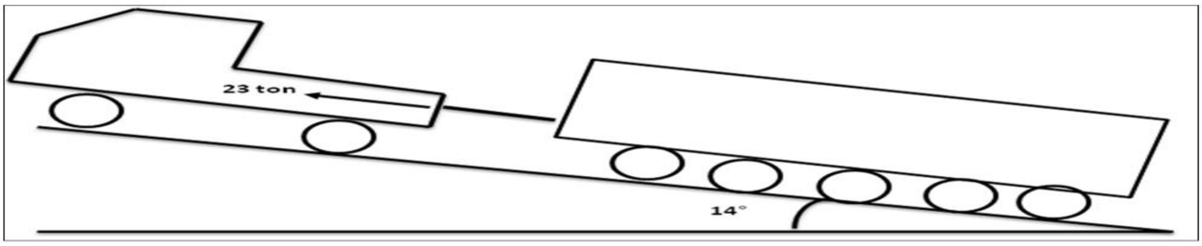

Fig.24 Pulling 23 t Trailer

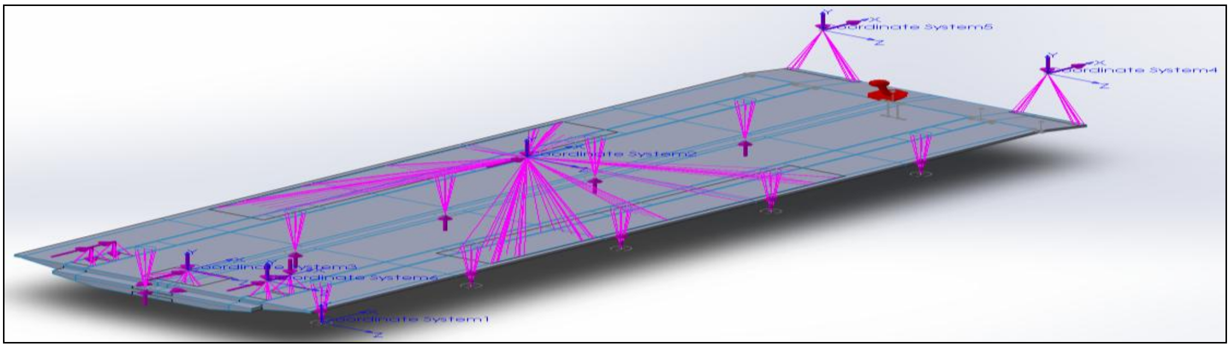

Fig.25 load for Pulling 23 t Trailer

- **Von Mises Stress distribution**:

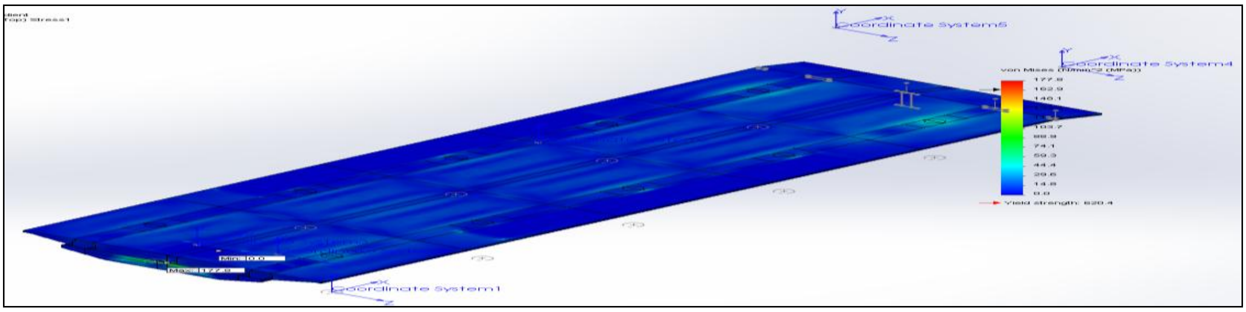

Fig.29 Stress Distribution

In the Pulling 23 t with Gradient 14° load case, maximum equivalent stress is done.Fig.25 Shows maximum stress is 177.9 Mpa and minimum stress is 14.8 Mpa Yield strength is 620.4.

- **Displacement of chassis frame:**

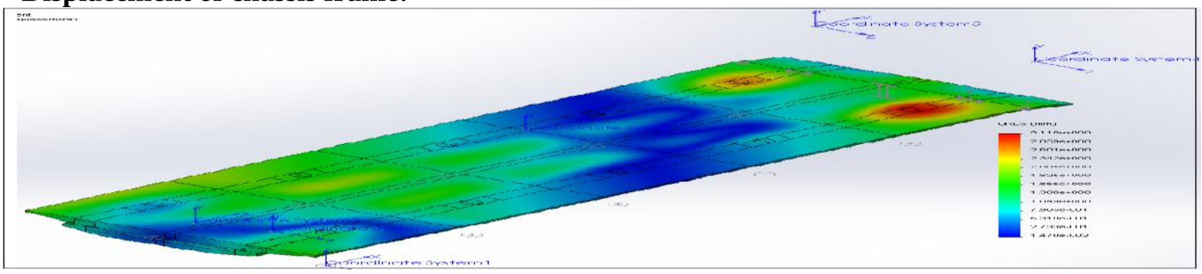

Fig.26 Displacement of chassis frame

In the Pulling 23 t with Gradient 14° load case, the displacement of chassis and location of maximum displacement is shown in Figure 26. The magnitude of maximum displacement is 3.1 mm and minimum deformation is 1.4 mm.

C. Finite element analysis of ramp:

1) Upper ramp

- **Von Mises Stress Distribution:**

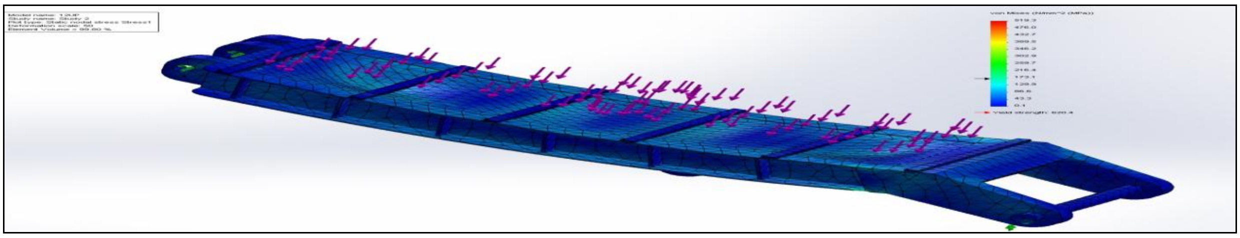

Fig.27 FEA results of Upper Ramp

Upper ramp Maximum equivalent stress is done.Fig.27 Shows maximum stress is 519.2Mpa and minimum stress is 43.3 Mpa Yield strength is 620.4.

- **Displacement of upper ramp:**

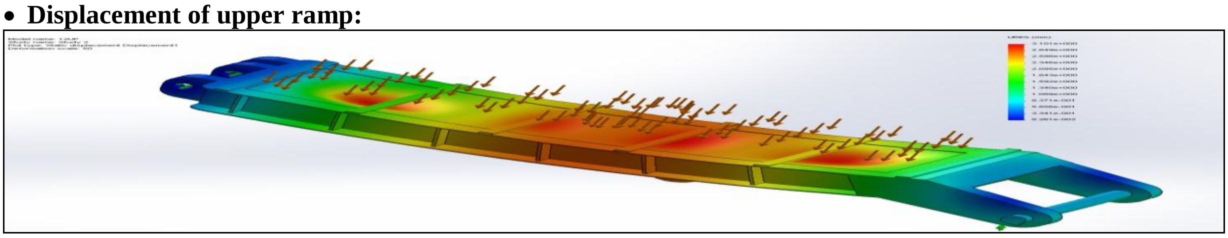

Fig.28 Deflection of Upper Ramp

The upper ramp, displacement analysis is done. Fig.28 shows that maximum deformation 8.2 mm and minimum deformation is 3.1mm.

2) Lower ramp:

- **Von Mises Stress distribution:**

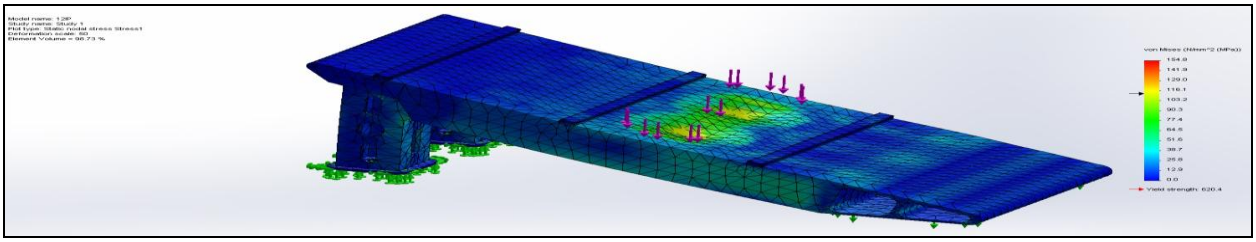

Fig.29 FEA Results of Lower Ramp

Lower ramp Maximum equivalent stress is done.Fig.29 Shows maximum stress is 154.8 Mpa and minimum stress is 12.9 Mpa Yield strength is 620.4.

- **Displacement of lower ramp:**

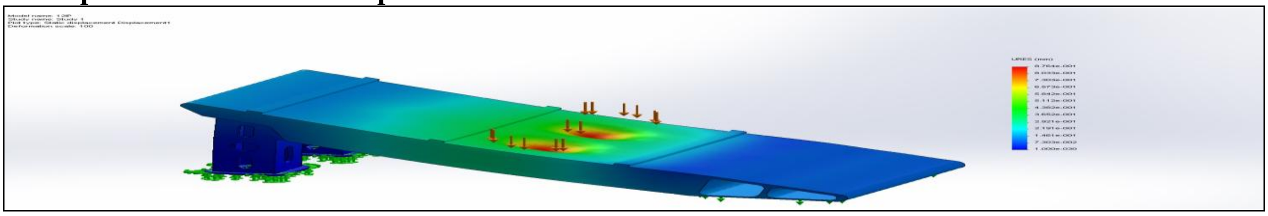

Fig.30 Deflection of Lower Ramp

The Lower ramp, displacement analysis is done. Fig.34 shows that maximum deformation 8.7 mm and minimum deformation is 1.0 mm. The allowable stress values for the selected material considering a Factor of Safety of 2.5 is 140 MPa and the maximum deflection is 8.7 mm. The obtained results from the FEA are well within the allowable stress value.

VII. CONCLUSIONS

1. In this phase Static structural analysis has been carried out at four different conditions.
2. At each condition as per the loads force are applied and the proper mesh type has been selected.
3. The results are checked for displacements and the stresses developed on the component for each load case
4. THE static analysis for platform maximum equivalent stress is done. The maximum stress is 85.3 Mpa and minimum Stress is 7.1. Yield strength is 620.4.
5. In the static analysis for platform displacement analysis is done. The maximum deformation 2.7 mm and minimum deformation is 5.1 mm.
6. The ramp Maximum equivalent stress is done.The maximum stress is 519.2Mpa and minimum stress is 43.3 Mpa Yield strength is 620.4.
7. The ramp displacement analysis is done.The maximum deformation 8.2 mm and minimum deformation is 3.1 mm.

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