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Study & FEA Analysis of Transportation Skid

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***Abstract*—Transportation skid plays very important role in various industries. Offshore skids play a vital role in transportation of heavy pumps, engines and blender units used during manufacturing treatments at the well site. For universal acceptance and usage of these skids worldwide, the offshore design should meet various applicable codes and regulations, such as Bureau Veritas, Lloyds, ABS, or Det Norske Veritas (DNV) design standards. The designing of skid plays important role to ensure its use for offshore work. The stress analysis of skid is one of the key factor which gives ides about its sustainability to the desired load.**

***Index Terms*—Introduction, Theoretical calculation, conclusion , future scope, references..**

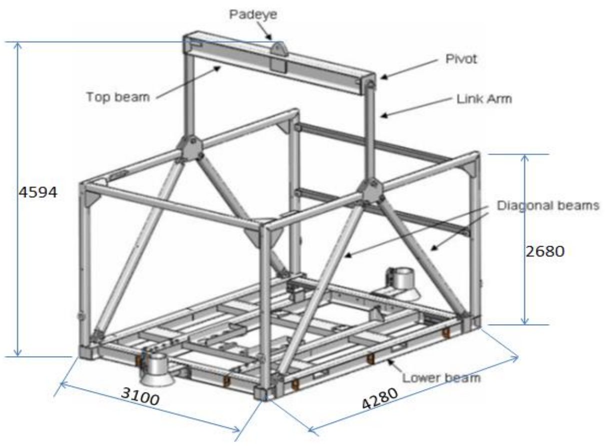
I. INTRODUCTION

Transportation skid plays very important role in various industries. Offshore skids play a vital role in transportation of heavy pumps, engines and blender units used during manufacturing treatments at the well site. For universal acceptance and usage of these skids worldwide, the offshore design should meet various applicable codes and regulations, such as Bureau Veritas, Lloyds, ABS, or Det Norske Veritas (DNV) design standards. The designing of skid plays important role to ensure its use for offshore work. The stress analysis of skid is one of the key factor which gives ides about its sustainability to the desired load.

DNV is an autonomous and independent foundation created in 1864 in Norway. Its main objective is to safeguard life, property, and the environment both on and offshore. This involves the establishment of rules and guidelines regarding classification, quality assurance, and certification of sea-going vessels, structures, and other installations. Like other standards, DNV certification implies that a structure or an item of equipment has been reviewed against a certain set of requirements and furthermore that a document has been issued stating that the item is in compliance with the requirement. DNV certified skids are designed as structural frames that provide good continuity under different loading and lifting conditions. All primary structural members of a skid should qualify the criteria of allowable stresses and member deflection as per DNV design guidelines.

The challenges are geometry of skid assembly is complex, the location of CG is not symmetric.. The skid designed to sustained load of 12 tonnes & the acceptance criteria for the design is as per the international standard DNV 2.7-3.

RTS SKID III



2. ALLOWABLE STRESS AND DESIGN LOAD CALCULATION

DESIGN LOAD CALCULATION ACCORDING TO DNV 2.7-3

RTS-III skid classified as:
PO Unit type: Class A
Risk level: High
Operational class: R45

ACCORDING TO DNV 2-7-3, SEC. 3.5 DESIGN LOADS- LIFTING

Design Factor (DF) calculation		
Operational Class	MGW< 50 tonnes	MGW ≥ 50 tonnes
R60	$1.4 + 0.8 \times \sqrt{50}/\mathrm{MGW}$	2.2
R45	$1.4 + 0.6 \times \sqrt{50}/\mathrm{MGW}$	2.0
R30	$1.4 + 0.4 \times \sqrt{50}/\mathrm{MGW}$	1.8

According to DNV 2.7-3 clause number 3.2.1 only the primary structure shall be included in the design calculations. Strength of frame members may be calculated using manual calculation &finite element Analysis.
Design criteria: Stress In the members shall not exceed than that "σ"
Allowable stress (σ e) = 0.85 x σ y

Whereas,
σ y = Yield strength of material
MGW = Maximum gross weight of RTS-III i.e. 12 tonne.

MATERIAL USED FOR PRIMARY STRUCTURAL ELEMENTS:

Material	**Yield Strength in Mpa (σ y)**	**Material assigned to part**
Norsok M120, Y05	355	Pivot, Link arm, Diagonal beam, Lower beam , Top beam
S165 M	620	Bolts
Norsok M120, Y30	420	Padeye, Hinge

ALLOWABLE LOAD (σ E) CALCULATION TABLE:

Material assigned to part	Yield strength (σ y)	Allowable strength (σ)
Pivot, Link arm, Diagonal beam, Lower beam , Top beam	355	301.75
Bolts	620	527
Padeye, Hinge	420	357

AS PER DNV 2.7-3 CLAUSE 3.5 THE DESIGN LOAD (F) ON THE PRIMARY STRUCTURE SHALL BE TAKEN AS:

F= DF x MGW x g

Where DF = $1.4 + 0.6\mathrm{X}\sqrt{50}/\,\mathrm{MGW}$

= 2.6247

So, F = 2.6247 x 12000 x 9.81= 308979.68 N

3. FEA OF THE PRIMARY STRUCTURAL ELEMENT

A. TOP PADEYE

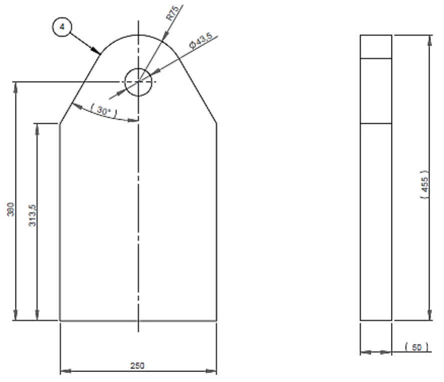


Figure 1 TOP PADEYE

For pad-eyes, as per DNV 2.7-3 “Appendix A” Padeye Calculations

Where, σe Allowable stress of padeye material in MPa, = 357 MPa

E : Elastic modulus = 210 000 MPa

Dh :Diameter of pinhole (mm) = 43.5 mm

t :Total thickness of padeye at hole including cheek plates (mm) = 50 mm

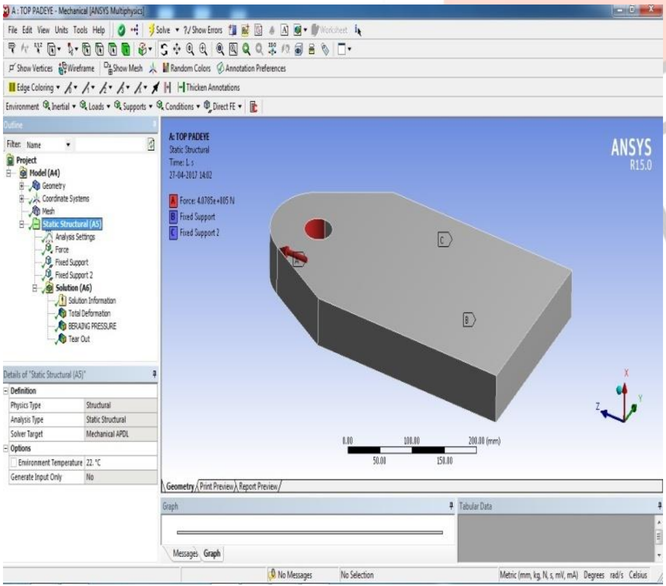
RSF calculation

It is explained in DNV clause 3.5.4. The in plane design load for a lifting point is equal to the resultant sling force (RSF) on the padeye. In our case single lifting point is used.

So,

RSF = 1.4 x F -------------------- (F= Design load)

RSF Padeye in line design load. = 407853.18 N



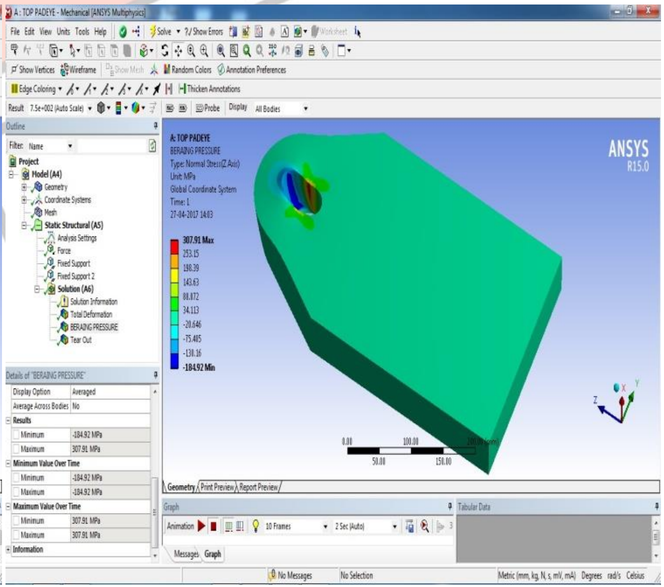


Figure 2 Modelling of Padeye

Figure 3 Bearing pressure Padeye

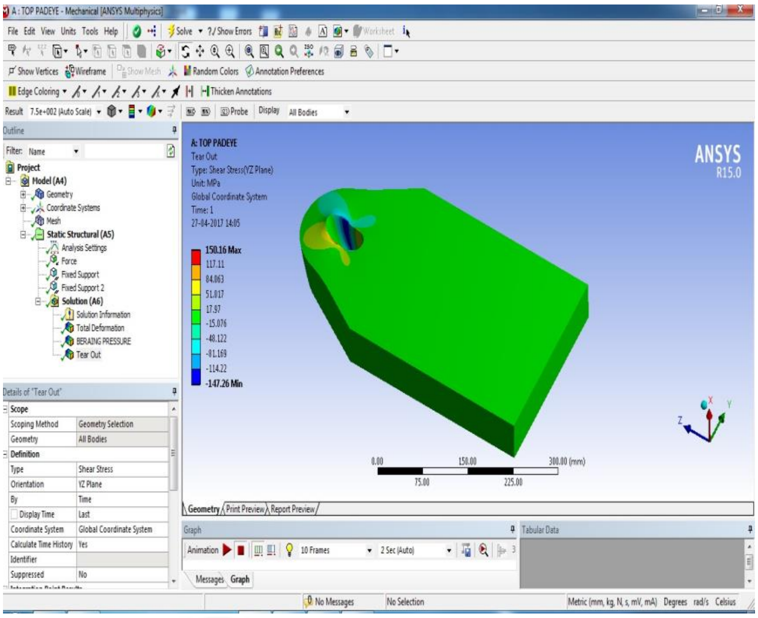


Figure 4 Shear stress of Padeye

The Bearing pressure of Top Padeye observed is 307.91 Mpa maximum and Maximum stress observed at Padeye is 150.16 Mpa

σa>> σb(Bearing Pressure)--------------Design is safe

σa >>σt (tear out)--------------Design is safe

B. <u>HINGE –TOP HOLE</u>

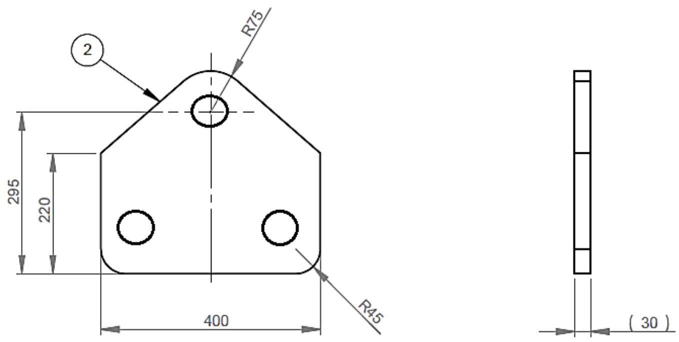


Figure 4 Hinge

<u>RSF calculation</u>

It is explained in DNV clause 3.5.4. The in plane design load for a lifting point is equal to the resultant sling force (RSF) on the padeye. In our case single lifting point is used.
So,
RSF = 1.4 x F/2 -------------------- (F= Design load)

RSF Padeye in line design load. = **203926.59 N**

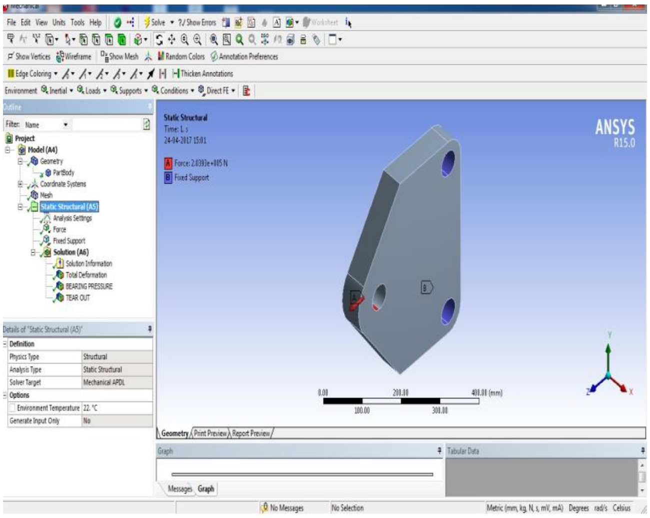


Figure 5 modeling of Hinge

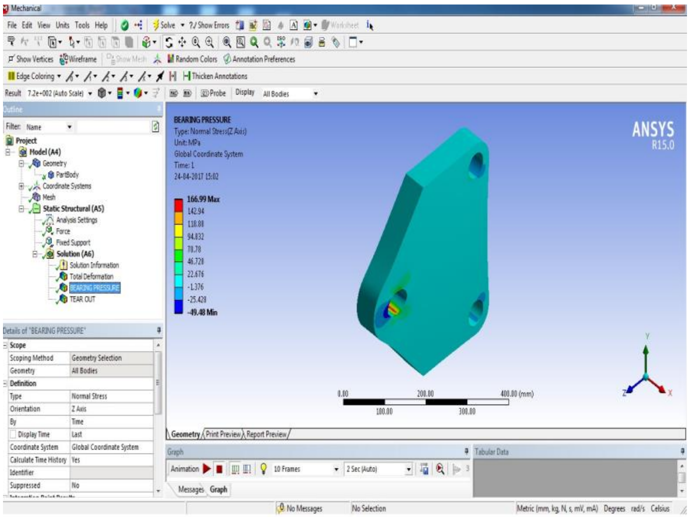


Figure 6 Bearing pressure on Hinge

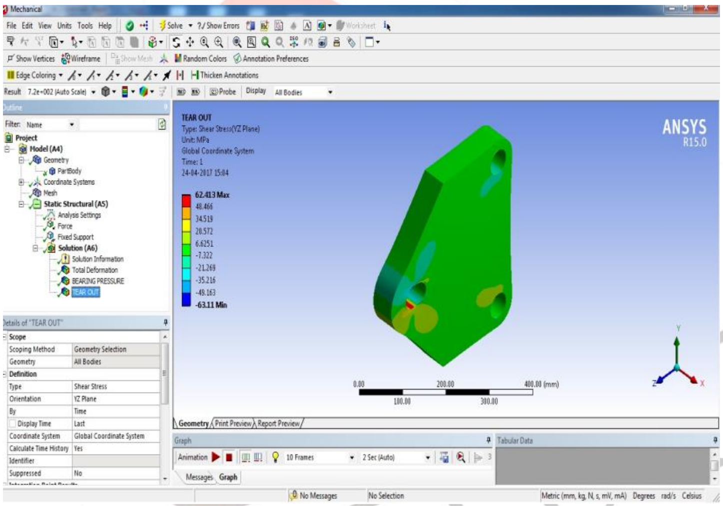


Figure 6 Shear Stress on Hinge

Maximum Bearing pressure of hinge at top hole is observed as **166.99 Mpa** and Maximum shear stress the hinge top hole observed as **62.413 Mpa**.

σa>> σb(Bearing Pressure)--------------Design is safe

σa >>σt (tear out)--------------Design is safe

C. LINK ARM

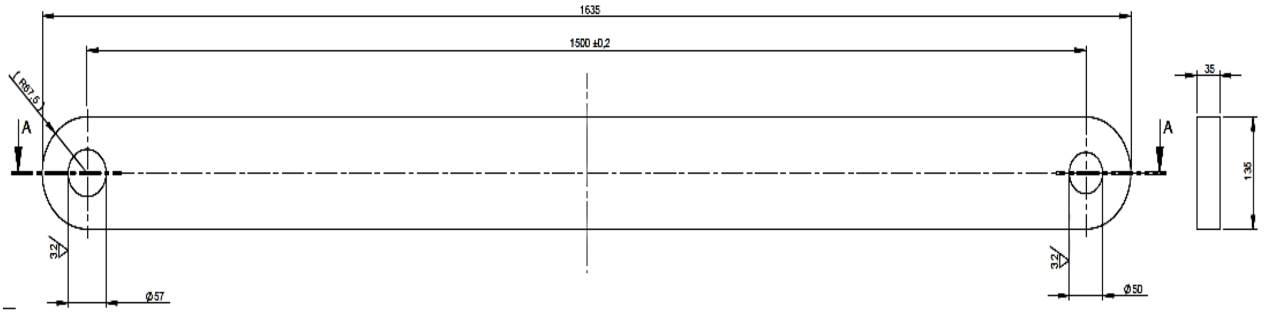


Figure 7 Link Arm

RSF calculation

It is explained in DNV clause 3.5.4. The in plane design load for a lifting point is equal to the resultant sling force (RSF) on the padeye. In our case single lifting point is used**.**

So,

RSF = 1.4 x F/2 -------------------- (F= Design load)

RSF Padeye in line design load. = **203926.59 N**

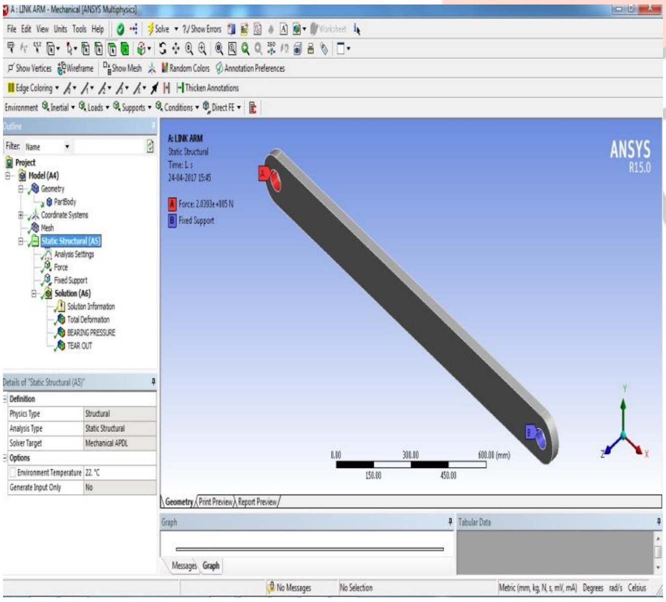


Figure 8 Modeling of Link Arm

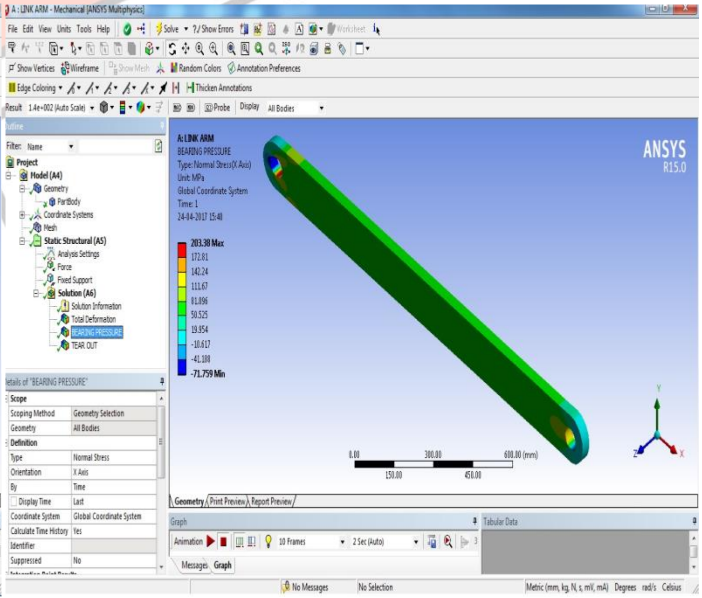


Figure 9 Bearing pressure of link Arm

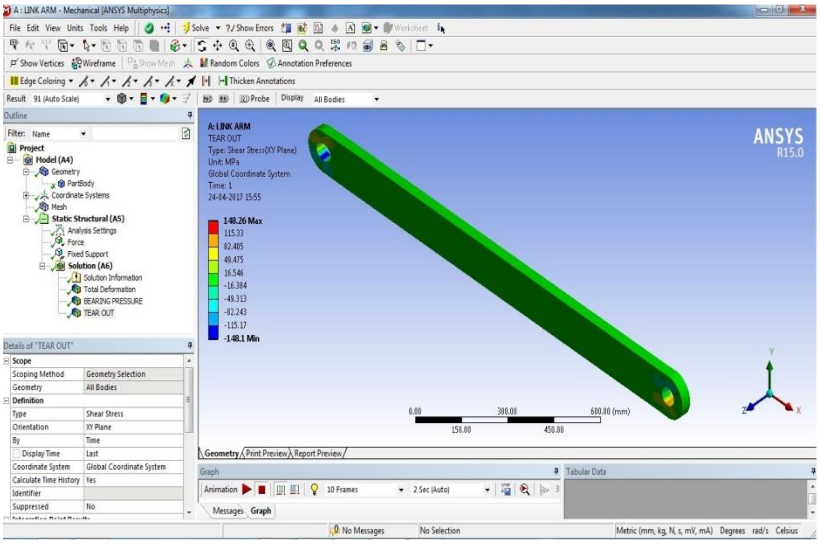


Figure 8 Shear stress on Link Arm

Maximum Bearing pressure on link arm hole is observed as **203.38 Mpa and** Maximum Shear Stress observed in link arm is **148.26 Mpa**.

σa>> σb(Bearing Pressure)--------------Design is safe

σa >>σt (tear out)--------------Design is safe

D. Top Beam

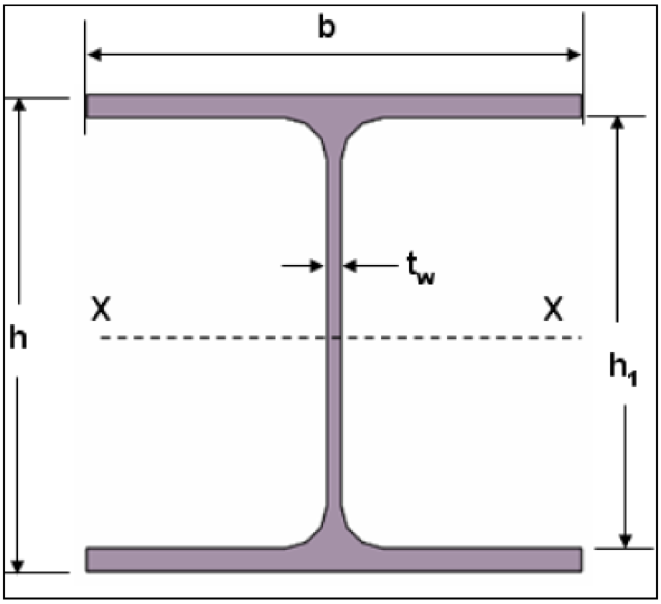


Figure 9 Top Beam

MGW= 12000 Kg , σy = 355 Mpa, b = 280, h = 270, h_1 = 244 mm, t_w = 13 mm, g = 9.81 m/s^2

Design force (F) = 2.5 MGW x g = **294.300 KN**

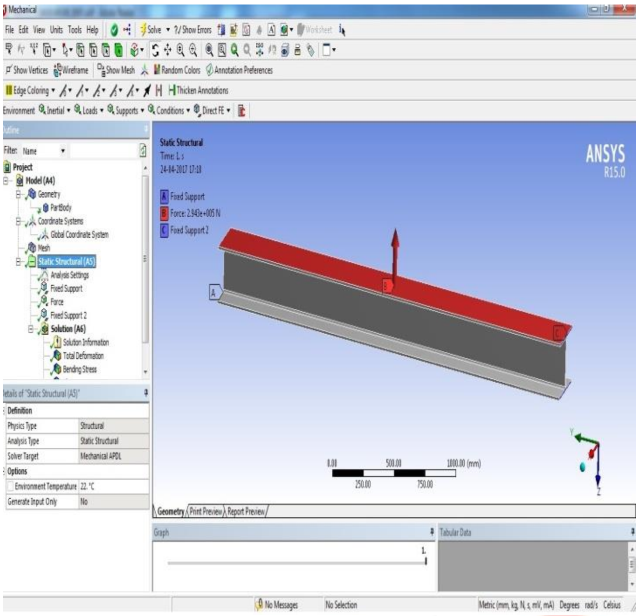


Figure 10 Modeling of Top Beam

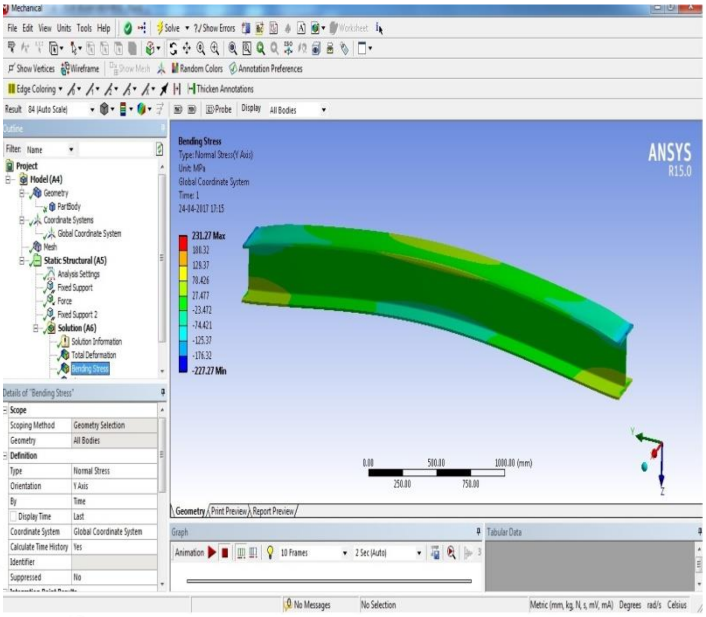


Figure 11 Bending stress on Top Beam

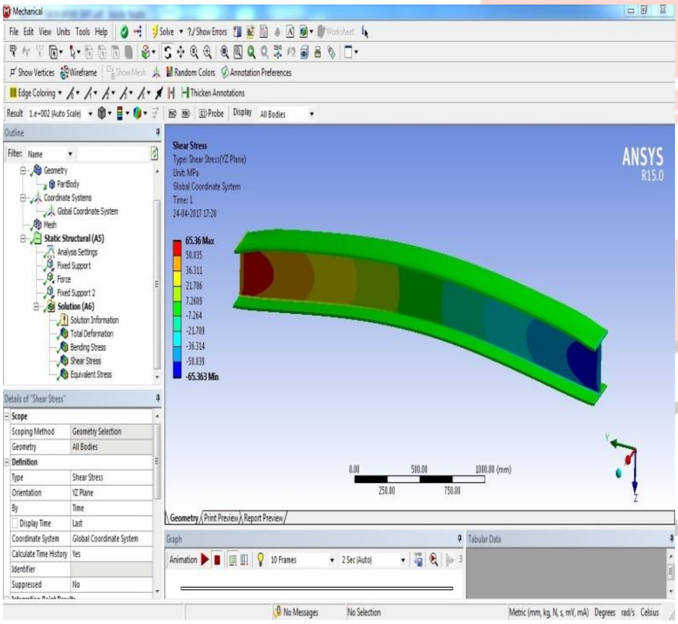


Figure 10 Modeling of Top Beam

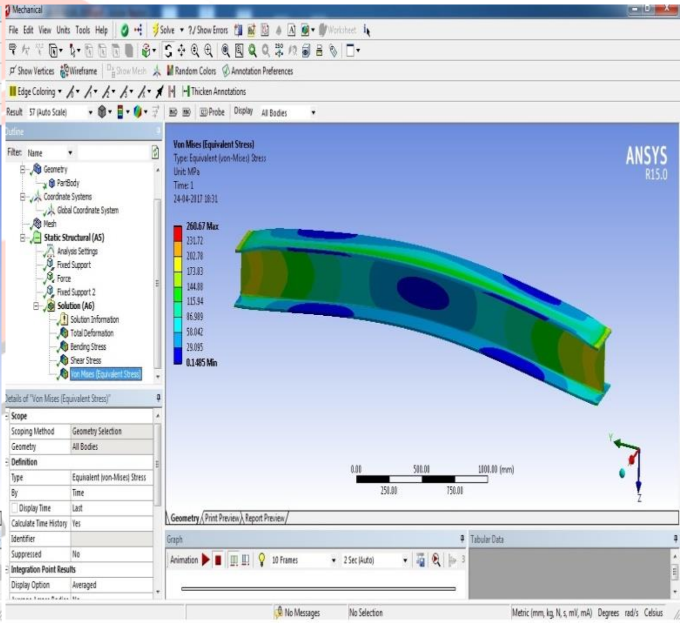


Figure 11 Bending stress on Top Beam

Maximum Bending stress on top beam is **232.77 Mpa**, Maximum Shearing stress in Top Beam is observed is **65.36 Mpa.** And Maximum Von Misses stress observed in the Top Beam is **260.67 Mpa**.

Maximum bending stress, shear stress and von Misses stress in top beam is lesser than that of allowable stress limit.

E. Pivot Bolts

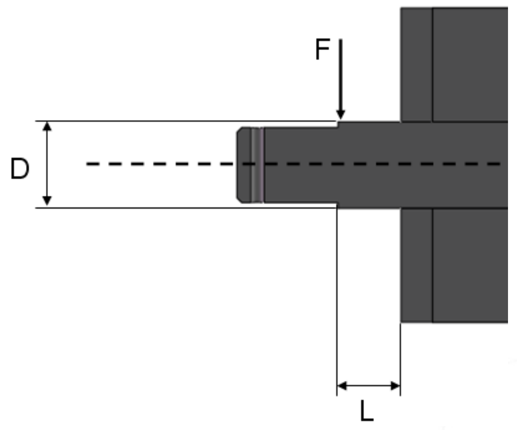
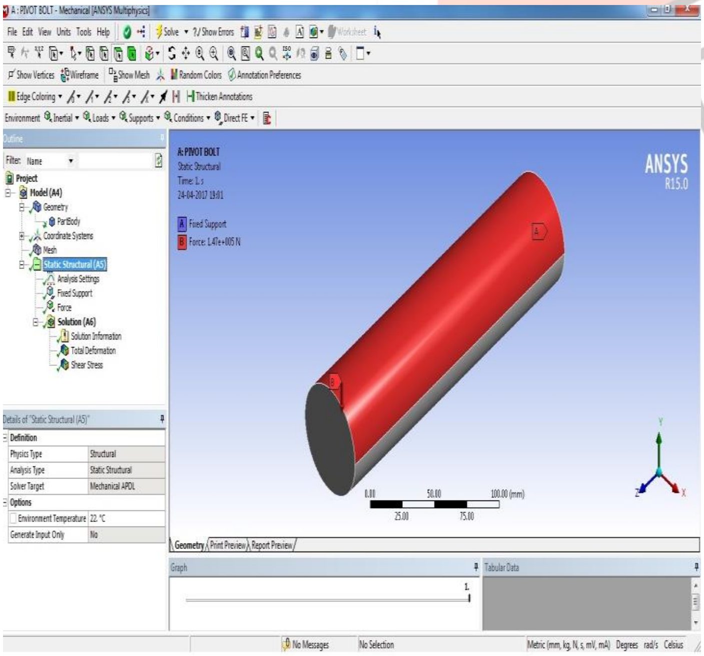


Figure 12 Top Beam

MGW = 12000Kg, σy = 355Mpa, Number of bolts (N_b) = 2 and Diameter D = 55 mm.

$$\text{Design Force} = \frac{2.5 \times MGW \times g}{N_b}$$

$$= \mathbf{0.147\ MN}$$



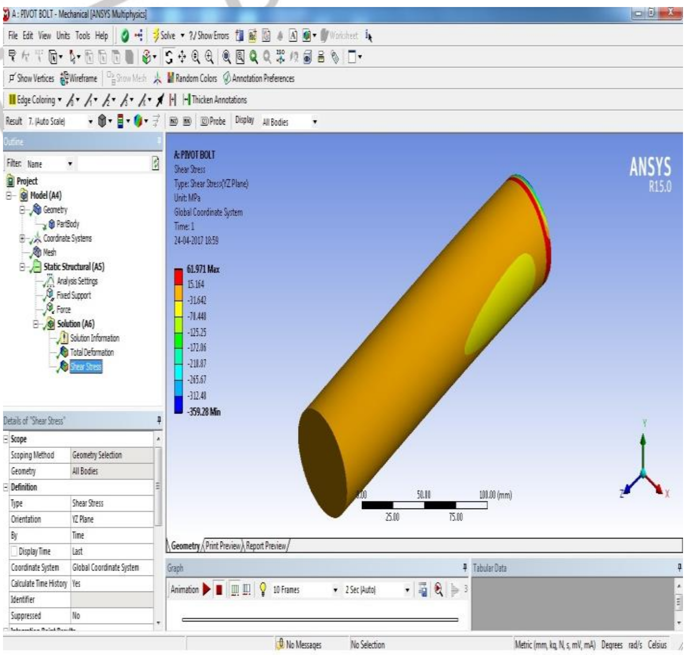


Figure 12 Modeling of pivot

Figure 13 Shear stress on Pivot

Maximum Shear stress observed in Pivot is **61.971 Mpa. Consolidate**

4. CONSOLIDATED FEA RESULTS

Sr. No.	Name of primary structural element	FEA Results
1	Top Padeye	σ_b = 307.91 Mpa σ_t = 150.16 Mpa
2	Hinge	σ_b = 166.99 MPa σ_t = 62.41 Mpa
3	Link Arm	σ_b = 199.19 Mpa σ_t = 141.69 Mpa
4	Top Beam	σ_b = 231.27 Mpa $F\tau$ = 66.231Mpa σ_{vm} = 260.67 Mpa
5	Pivot Bolt	τ = 61.971 Mpa

5. RESULTS AND CONCLUSION

As per the FEA report RTS –III skid is meeting all design requirements. All primary structural elements are well within the allowable stress limit..

6. FUTURE SCOPE

As all primary structural elements are well within allowable stress limit there is possibility of change in material to lower grade for secondary structural elements.

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