Design and Development of ROPS Testing Fixture's for Driver Cabin of Earth Movers

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Abstract:- **The aim is to design and development of ROPS testing fixture's for driver cabin of earth movers by serving a single test fixture instead of three test fixtures in order to overcome the floor space and selection of stabilized structural member in development of test fixture. The test fixture is implemented to validate optimum load impacts sustained by ROPS for safety precautions of driver. So design and development of single fixture to be carried out to test ROPS of different vehicle model for optimum results. The main aim of this project is to carry out static force analysis of portal structure to confirm the following: Least Deflection of Portal structure, Strength of the structure.**

The above analysis is to ensure the 100% force applied with least deflection of portal structure to the test specimen during testing.

Key words: **Fixture, ROPS, Analysis, Sections.**

I. INTRODUCTION

1.1.1 Fixtures in ROPS Test

Fixture is a holding and work piece locating device used with machine tools. It is also used in inspection welding and assembly. Fixture does not guide the cutting tool, but is always fixed to machine or bench. By using fixture, responsibility for accuracy shifts from the operator to the construction of machine tool. [1]

- A ROPS (Roll over Protective Structure) structure is defined as a system that includes a mounting structure or integrated structure, which is mounted to the machine frame via a mounting system to provide crush protection for the operator.[2]
- Roll protective structure, is a frame or a cab like structures surrounding the seat-belated operate with a hard hat, string enough to absorb the impact energy in case of roller over of the vehicle. [3]
- ISO 3471 requires a push test to certify a ROPS system. The requirements are force resistance in the lateral, vertical and longitudinal directions.
- ISO 3471 is the most commonly used standard of most types of earthmoving machinery which specifies the structural performance requirements for a ROPS system.
- Roll over Protection Structure (ROPS) refers to operator compartment structures (usually cabs or frames) intended to protect equipment operators and motorists from injuries caused by vehicle overturns or rollovers.[2]

- The ROPS test to carry out in fixture for the following forces:

1.
2. Lateral force
3. Vertical force
4. Longitudinal force

Lateral load – The Lateral test requires energy absorption and maximum load support as am function of machine mass, without violating the operator space.

Vertical load – The Vertical test requires the cab to support approximately 20 times the machine weight without violating operator space.

Longitudinal load – The Longitudinal test requires the test specimen to absorb energy as a function of machine mass without violation of operator. [2]

1.2 Problem Definition:

- The ROPS test apparatus is the as a matter of first importance imperative and in addition a noteworthy structure in the testing of vehicle lodge and meeting quality approval focuses**.**
- Here the issue lies in different parameters like plan and improvement, cost-viability and gathering, which in along it ought to fulfill the quality and plausibility of test operation.
- In more established model of ROPS test apparatuses, three unique installations were been utilized for testing, at various statures so it brings about enormous cost and floor space.
- The determination of ROPS test apparatus will relies on the vehicle show for its separate installation setup and floor space utilization for three distinctive apparatus setup.

1.3 Objectives:

- Create installation setup model of single structure apparatus for ROPS test.

- Demonstrating the installation utilizing C,&I segment individuals.
- Breaking down the diverse segment of C,& I area for best result.
- Detail plan for the chose area and its examination report with shifting the statures

II. LITERATURE REVIEW

Heavy vehicles used in the rural, mining and construction industries are susceptible to rollovers as they have a high centre of gravity and commonly operate on sloping and uneven terrain. A steel moment resisting frame with either two or four posts is usually attached to these vehicles above the operator's cabin for protection during rollovers. This safety device is called a Rollover Protective Structure (ROPS) and its role is to absorb some of the kinetic energy of the rollover, whilst maintaining a survival zone for the operator. The design and analysis of ROPS is complex and require dual criteria of adequate flexibility to absorb energy and yet, enough stiffness to maintain a survival zone around the operator. [4]

Research carried out on ROPS behavior using analytical and experimental techniques include those of Clark et al. (2006 and 2005), Kim and Reid (2001), Tomas et al. (1997), Swan (1988) and Huckler et al. (1985).A comprehensive research project was carried out at the Queensland University of technology (QUT) with the objective of establishing the feasibility of using analytical methods for (i) design and evaluation of ROPS and (ii) investigating the influence of parameters for enhancing ROPS performance. Limited experimental testing is required, both to capture physical behavior and to use the results to validate the finite elements models, which could then be used in further investigation.[4]

Trappey and Liu (1990) carried out a literature survey of fixture design automation and emphasized computer aided fixture design. In the frictionless case, Lakshminarayana (1978) investigated the minimum requirements for the form closure of a rigid body and proved that at least four and seven contacts are necessary to achieve force closure for 2D and 3D parts respectively. For the same frictionless case, Salisbury and Roth (1982) demonstrated that a necessary and sufficient condition for force closure is that a strictly positive linear combination of the primitive wrenches at contacts is zero and the primitive wrenches span the whole wrench space. Mishra and Silver (1989) later proved that when friction is taken into account, three contacts are sufficient in the planar case while four are adequate in the spatial case.

Deiab and Elbestawi (2005) stated that the tangential friction force plays an important role in fixture configuration design and presented the results of an experimental investigation of the work piece-fixture contact characteristics.

Roy and Liao (2002) reported that stability analysis plays a critical role in determining the applicability of a fixture design and developed a computational methodology for quantitatively analyzing the stability of the work piece in the automated fixture design environment. [5]

2.1 Types of Fixtures

Fig : Testing Fixture For dozer Cabin

Fig: Testing Fixture for Body Frame

Fig : Testing Fixture For Generic Double Cab

The mounting of the ROPS frame to the load bin was done by the client, which conforms to the actual installation method in practice. The position of the DLV was considered in the assessment phase after relevant displacements due to test loads were determined and compared to the volume to be taken up by the DLV.[4]

2.2 Materials Used

- Steel is preferred to be used for ROPS test fixture.
- Carbon steels, alloy steels, stainless steels and tool steels are the available steels. Among these, alloy steels are the most preferable type as it has the better mechanical properties compared to other materials.
- Hardness is the major criteria to select ROPS material as it is a crucial property which enables the material to resist against deflection under different loading conditions.

III. ANALYSIS REPORT

3.1 Project Description

- To plan another item in particular "ROPS test apparatus" and to check the push dispersion in basic part.
- . To streamline the plan by considering the very much fathomed investigation repot of its individual apparatus

3.2 Acceptance Criteria:

The objectives are:

- Displacement
- Maximum stress concentration.

3.3 Model Preparation:

- Readiness of our new model which include diverse area like C,I sections. For this segment we are planning 3Dmodel in solid works 2014.
- Investigation is done in hyper mesh 2014 for various areas at various statures. In this product we check the perspective proportion. The hyper mesh model shown in fig.

3.4 C-Section

3.4.1 C-Section Analysis for 2.5 Meters Height

- *50TON*

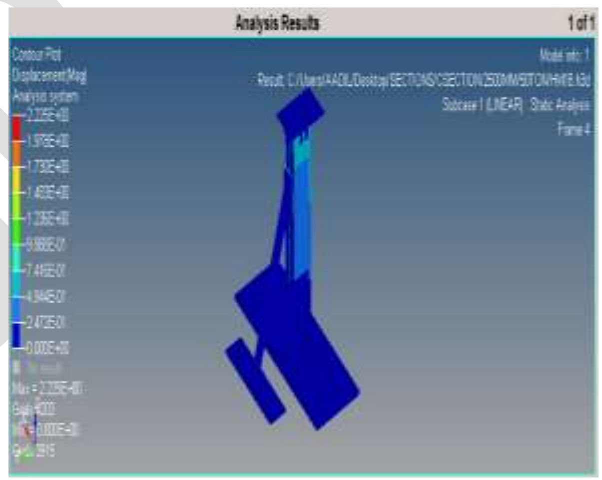


Fig: Displacement for 2.5m at 50ton

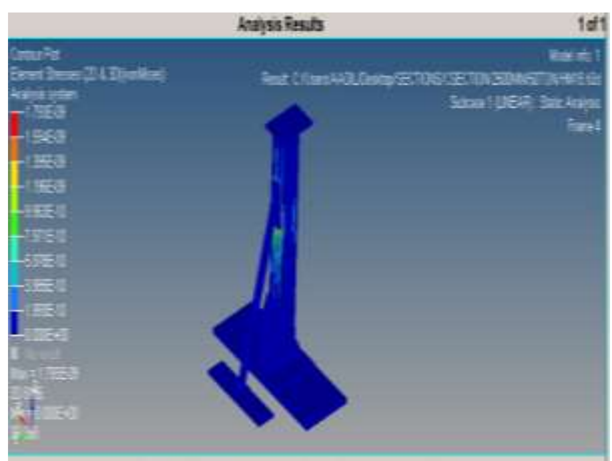


Fig: Stress For 2.5m at 50ton

- *150 TON*

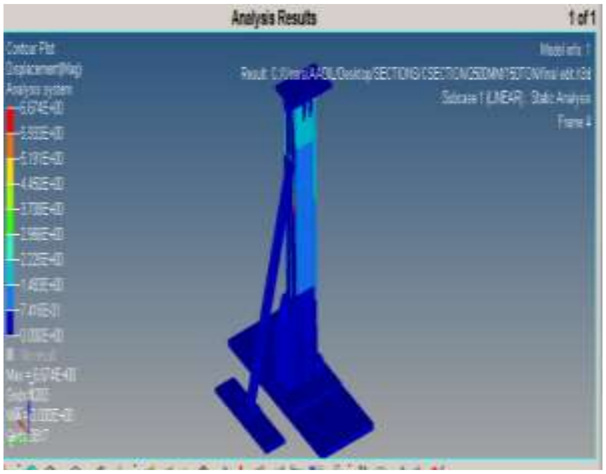


Fig: Displacement For 2.5m at 150ton

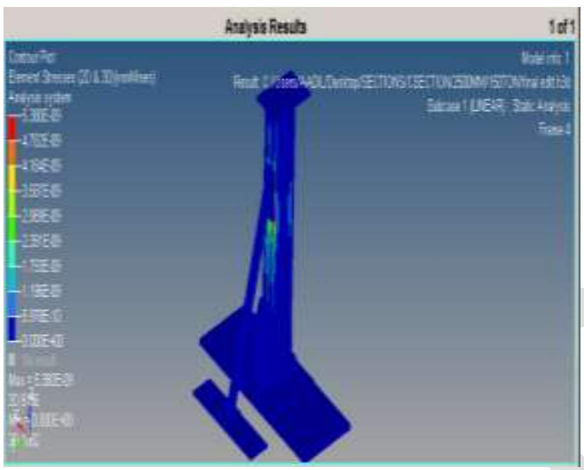


Fig: Stress For 2.5m at 150ton

3.4.2 C-Section Analysis For 3.5 Meters Height

- *50 TON*

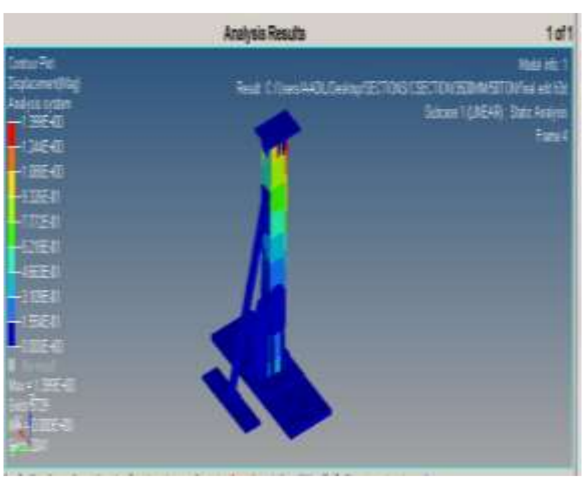


Fig: Displacement For 3.5m at 50ton

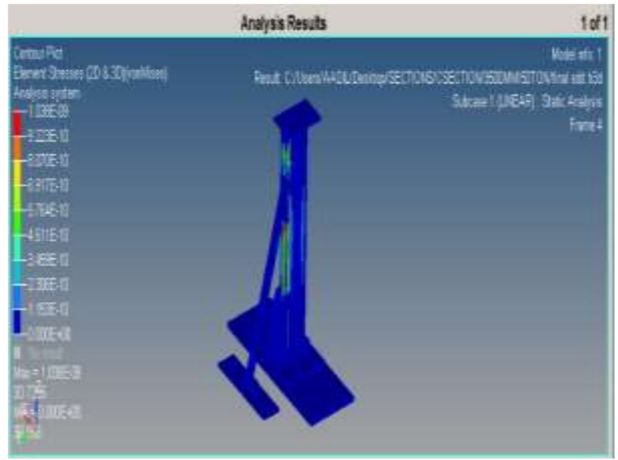


Fig: Stress For 3.5m at 50ton

- 150 TON

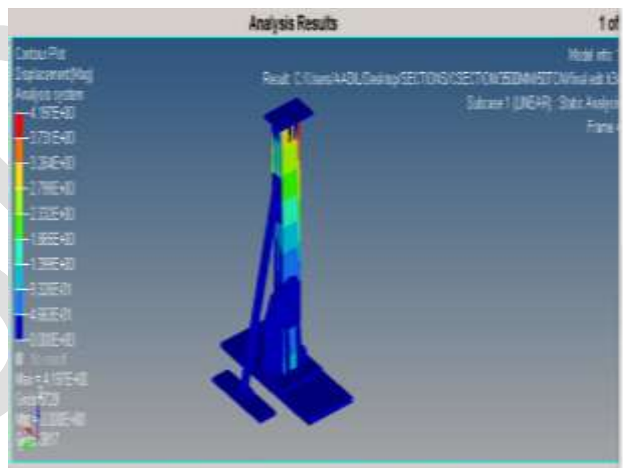


Fig: Displacement For 3.5m at 150ton

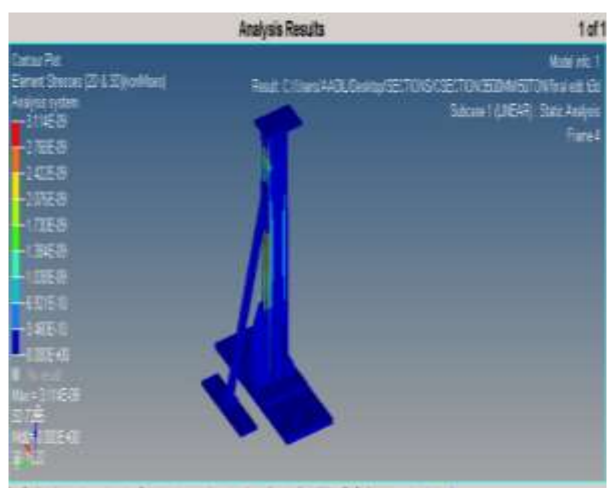
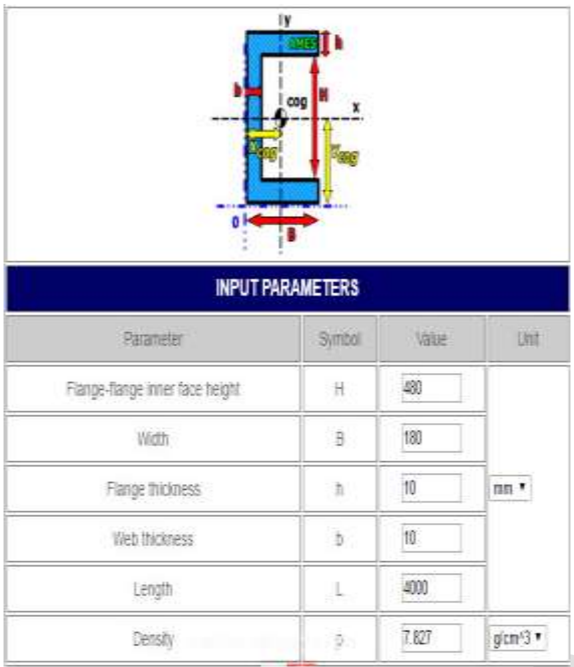


Fig: Stress For 3.5m at 150ton

3.4.4 Calculations

- *C-Section Input Parameters*



- Cross section area:

$A=2Bh+Hb$

$=2(180)(10)+480(10)$

$=8400\ cm^2$

- Mass:
$M = AL\rho$
$=8400*4000*7.827$
$=262987.184\ kg$
- Area moment of inertia:
$I_{xx}=H^3b/12+2[h^3B/12+hB(H+h)^2/4]$
$=480^3(10)/12+2[10^3(180)/12+10(180)(480+10)^2/4]$
$=308280000\ mm^4$

$I_{yy} = b^3H/12 + 2(B^3h/12)$
$=10^3 480/12+2(180^3 10/12)$
$=24622858\ mm^4$
- Radius of gyration:
$r_x= (I_{xx}/A)^{0.5}$
$=(308280000/8400)^{0.5}$
$=1915.72\ mm$
$r_y=(I_{yy}/A)^{0.5}$
$=(24622858/8400)^{0.5}$
$=541.41\ mm$

Material properties considered are

Youngs Modules – 2e5 kg/mm^2

Poissons ratio – 0.3

Material used _ Alloy steel

Results Obtained

HEIGHT IN METERS	LOAD IN TONS	DISPLACEMENT IN mm	STRESS MPA
2.5	50	2.25	1.793e^{-09}
	150	6.674	5.380e^{-09}
3.5	50	1.399	1.038e^{-09}
	150	4.197	3.114e^{-09}

TABLE : C-Section Results

3.5 I -Section

3.5.1 I-Section Analysis For 2.5 Meters Height

- *50 TON*

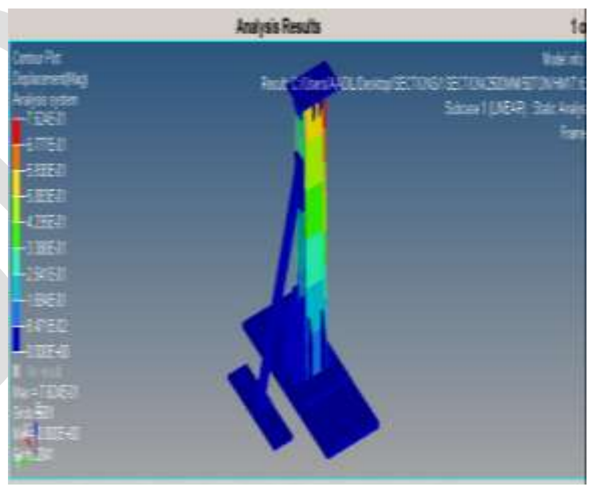


Fig: Displacement For 2.5m at 50ton

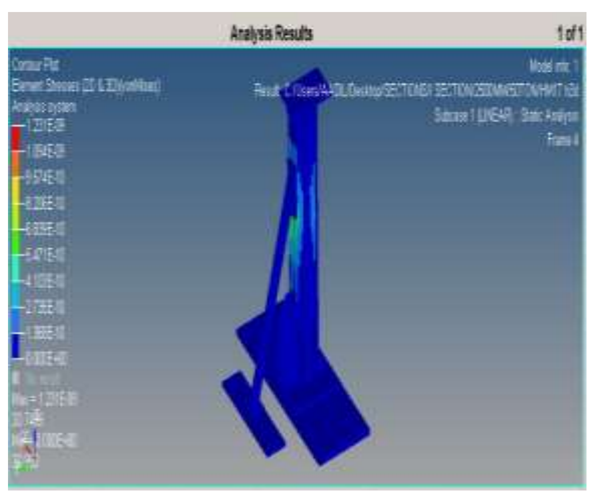


Fig: Stress For 2.5m at 50ton

- *150 TON*

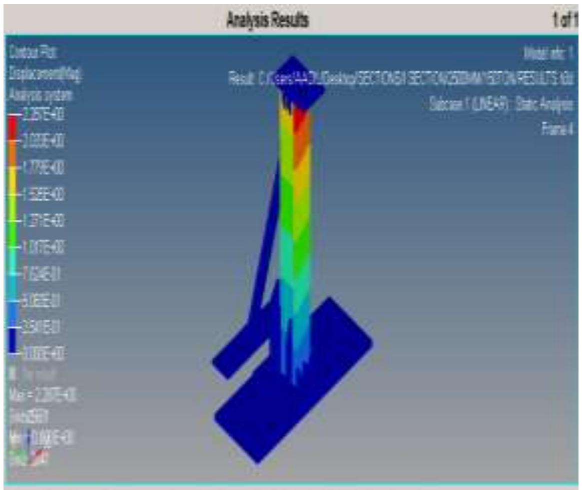


Fig: Displacement For 2.5m at 150ton

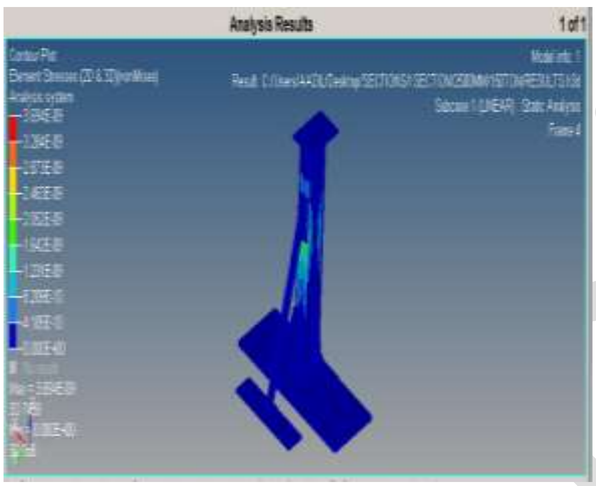


Fig: Stress for 2.5m at 150ton

3.5.2 I-Section Analysis For 3.5 Meters Height

- *50 Ton*

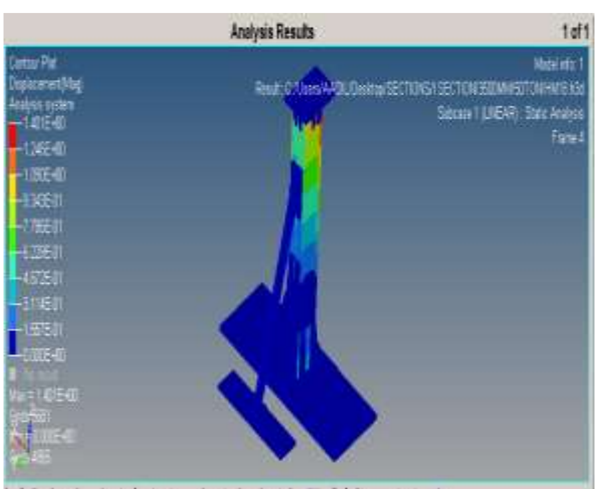


Fig Displacement For 3.5m at 50ton

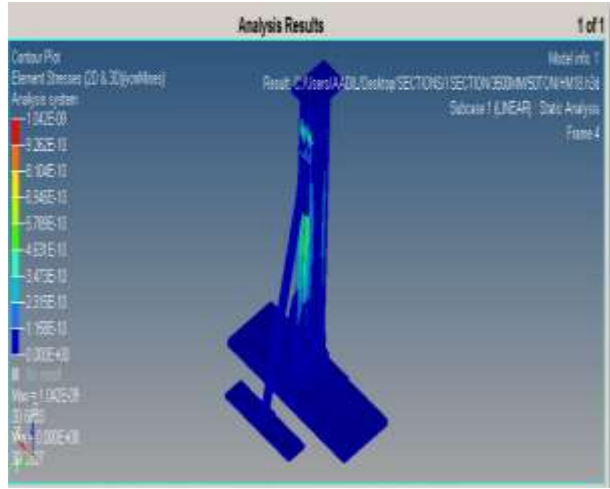


Fig: Stress For 3.5m at 50ton

- *150 TON*

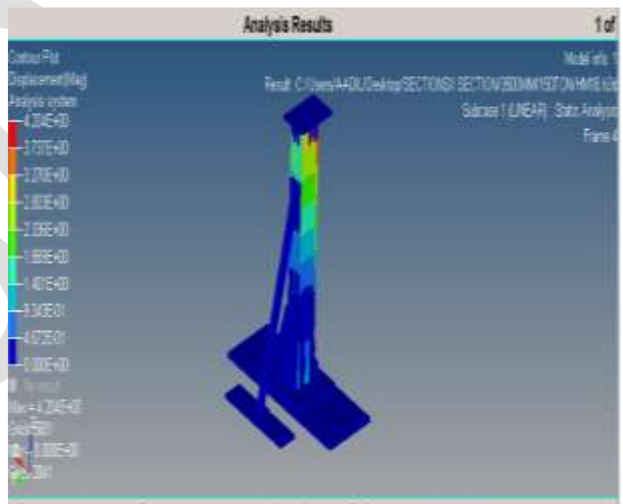


Fig: Displacement For 3.5m at 150ton

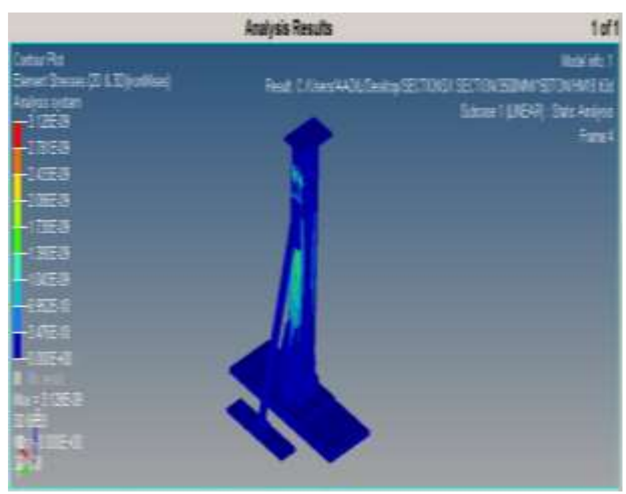
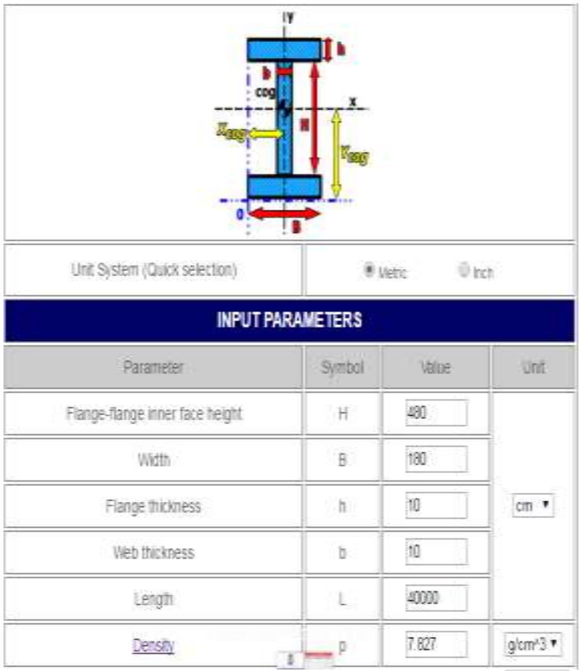


Fig: Stress For 3.5m at 150ton

3.5.4 Calculations

- *I -Section Input Parameters*



- Cross section area:

$A = 2Bh + Hb$

$= 2(180)(10)+490(10)$

$=8400\ cm^2$

- Mass:
$M = AL\rho$
$=8400*4000*7.827$
$=209763.6$ kg

- Area moment of inertia:
$I_{xx} = H^3b/12+2[h^3B/12+hB(H+h)^2/4]$
$=480^3(10)/12+2[10^3(180)/12+10(180)(480+10)^2/4]$
$= 308280007\ mm^4$

$I_{yy} = b^3H/12 + 2(B^3h/12)$

$=10^3 490/12+ 2(180^3 10/12)$

$= 49008332800\ mm^4$

- Radius of gyration
$r_x= (I_{xx}/A)^{0.5}$
$= (308280007/8400)^{0.5}$
$= 1915.724$ mm
$r_{y=} (I_{xx/}A)^{0/5}$
$= (49008332800/8400)^{0.5}$
$= 340.867$ mm

Material properties considered are

Youngs Modules – 2e5 kg/mm^2

Poissons ratio – 0.3

Material used _ Alloy steel

Result Obtained

HEIGHT IN METERS	LOAD IN TONS	DISPLACEMEN IN mm	STRESS MPA
2.5	50	0.7624	1.231e^{-09}
	150	2.287	3.694e^{-09}
3.5	50	1.401	1.042^{e-09}
	150	4.204	3.128e^{-09}

Table: I-Section Result

IV. RESULTS

4.1.1 Comparison Results Of C, I Sections At 50ton

HEIGHT IN METERS	50TON			
	C-section		I-section	
	Displacement	Stress	Displacement	Stress
2.5	2.25	1.793e-09	0.7624	1.231e^{-09}
3.5	1.399	1.038e^{-09}	1.401	1.042e^{-09}

Table: Comparison Results Of C, I Section At 50ton

4.1.2 Comparison Results Of C, T, I Sections At 150ton

HEIGHT IN METERS	150TON			
	C-section		I-section	
	Displacement	Stress	Displacement	Stress
2.5	6.674	5.38 e-^{09}	2.287	2.462 e^{-09}
3.5	4.197	3.114 e^{-09}	4.204	2.084 e^{-09}

Table: Comparison Results Of C, I Section At 150ton

- By comparing the results obtained for C,&I section for analysis with 50ton,150ton at different heights of 2.5m3.5m,it is clear that I-section is preferable/best suited for ROPS fixture.

V. CONCLUSION

- Design of three distinctive apparatus for testing on various vehicle model is presently been executed with single-setup testing installation to test diverse vehicle show by beating the lessening of floor space.
- The general process duration and floor space devoured by three distinct apparatuses is diminished. and supplanting single setup apparatus which helps in simplicity of operation.
- Fixture planned by determination of various basic areas, for example, C,&I whereupon the installation of I-segment is been chosen in light of results acquired amid examination for various differing loads.

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