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OPTIMIZATION IN CHASSIS OF SOIL COMPACTOR

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ABSTRACT

Chassis forms the structural Backbone of Heavy Off road vehicle Soil Compactor. The main function of the chassis is to support the components and payload placed upon it. Chassis should be rigid enough to withstand the shock, twist, vibration and other stresses & its principle function is to carry the maximum load for all designed operating condition safely. An important consideration in chassis design is to have adequate bending stiffness along with strength for better handling characteristics. In order to optimize the total weight and hence the thickness of different members One should do detail Static & Dynamic analysis with all possible practical operating conditions. This paper presents the detail work of Static Analysis of chassis of Soil Compactor. All the stress calculations made are on the basis of engineering design, it can be considered as application of engineering design.

KEYWORDS: *Functions of Chassis, Static loading conditions, Reaction Calculations, SFD and BMD, Maximum Bending stress.*

I. INTRODUCTION

In today's scenario of developing India machines with optimum design characteristics which are capable of working in our conditions is the need. In ABC Company it was found that soil compactors with different capacity in "Tone" have same chassis. This Soil Compactor is designed for long working hours at tough applications. They are utilized for compaction of most types of soil, typical applications are road building, airfields, harbors and industrial sites. Optimization work is started with static analysis. Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by steady loads that do not induce significant inertia and damping effects. Soil compactor is consist of four main parts chassis, Drum-frame, Drum and Hitch which is connects chassis and Drum frame. Except drum assembly all other parts are assembled on chassis. A mechanical arrangement is provided within drum for vibration generation with help of shaft and eccentric mass system.

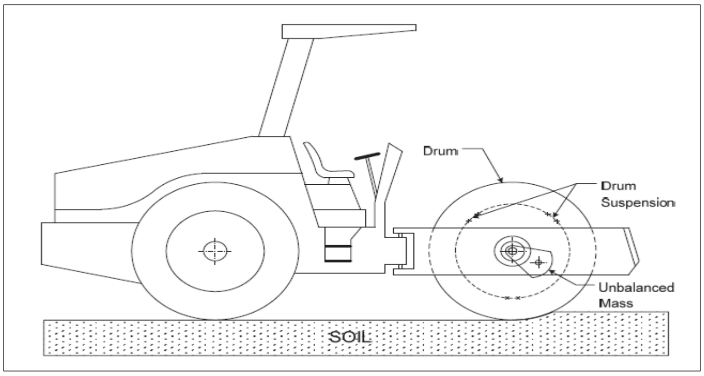
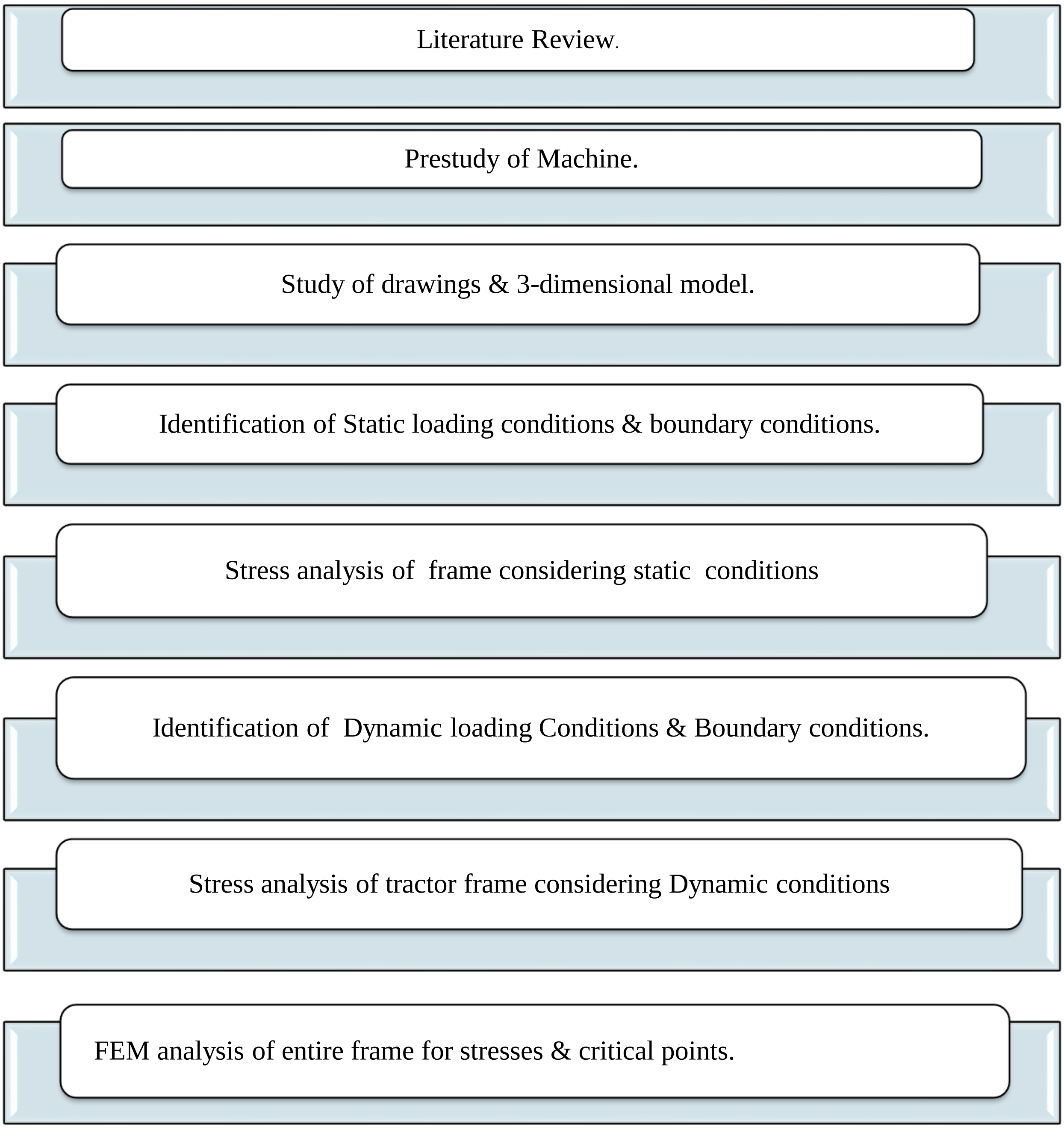


Fig 1. Soil compactor

II. ORGANIZATION



III. FUNCTIONS OF CHASSIS

Main function of chassis is to provide way to assemble functional requirement components.

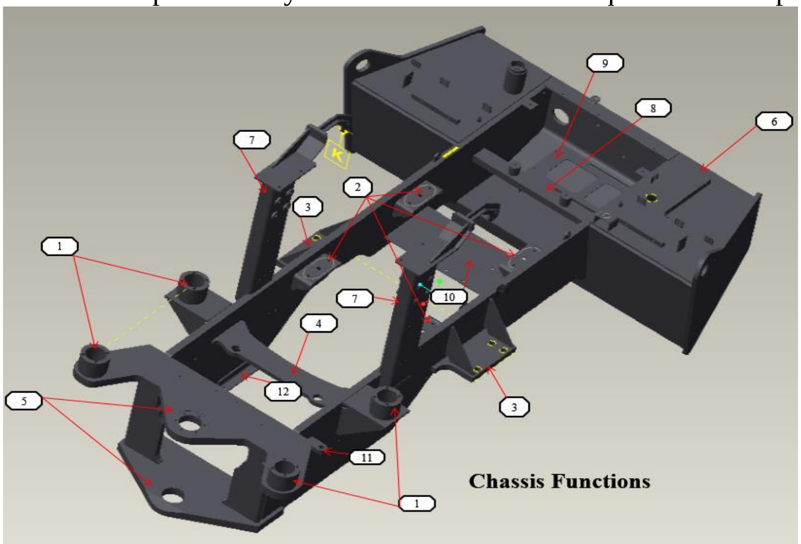


Fig 2. Chassis

1:-Platform Mounting.
2:-Engine Mounting.
3:-Axel Mounting.
4:-Steering Cylinder Mounting.
5:-Hitch Mounting Plates.
6:-Fuel tank.
7:-Bracket For Mounting Oil-tank & Engine hood and Canopy
8:-Radiator Assembly Mounting.
9:-Battery Mounting.
10:-Muffler Mounting.
11:-Hitch safety Lock Mounting.
12:-Bottom Safety base Cover plate.

IV. STATIC LOADING CONDITIONS

Soil compactor is consider in stationary conditions and the all loads acting on the different loading points on chassis are considered. As in static analysis only chassis is considered an assumption is made that at location of hitch hinge support is present. Also fuel tank is considered as the separate part because of it is created by attaching different plates to main chassis and its effect on chassis is calculated in the next portion of paper. Following table provides important loading points and their respective location.

Table 1 – Loading and Boundary Condition

No	Components	Weight (kg)	Reaction (KN),UDL, And Moments	Position From Origin (mm)
1	Fuel tank	508	3.73 (N.mm) (on each side plate)	0-666.57
2	Radiator Assembly	110	1.46 (N.mm) (Between Side plates)	479.65-548.49
3	Engine	650	1.595 (on each Mount)	994-1691
4	Axel	516	18.56 (on each Mounting plate)	1470
5	Hydraulic oil Tank at Side Bar of chassis	124	0.608 (on each side bar)	2015
6	Canopy	112	0.549 and (164.89 KN.mm) (on each side bar)	2015
7	Steering Cylinder	33	0.323 (Between Side plates)	2253-2368
8	Platform	414	1.0514 (on each Mount)	2277-2969
9	Hitch	976.33	9.57	2946

V. Reaction Calculations

Base on loading conditions reactions at each point on chassis is calculated as follows

1. Reaction on Frame Due to wheel Module.
2. Reaction on Frame Due to Drivers Cabin Mounting.
3. Reaction on Frame Due to Engine Mounting.
4. Reaction on Frame Due to Fuel Tank & Fuel.
5. Reaction on Frame Due to Radiator Assembly.
6. Reaction on Frame Due to Hydraulic Oil Tank, Canopy, Engine Hood.
7. Reaction on Frame Due to Steering Action.

5.1 Reaction on Frame Due to Wheel Module

Total Weight on Wheel Module = 4250 Kg
Weight of One Tire = 208 Kg
Weight of Axel = 516 Kg
Reaction at Tire's (Wheel Module Weight – Tire Weight–0.5*Axel Weight)
= (4250-208-0.5*516)
= 3784
Reaction at each Tire = (3784*9.81) / 2 = 18.560 KN

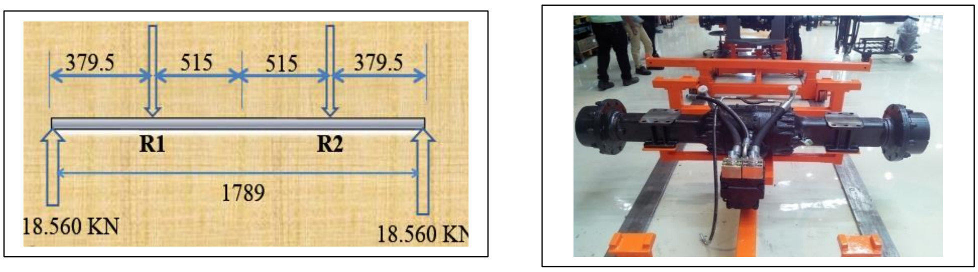


Fig 3. Axel Mounting

R1 and R2 arereaction points where Axel is fixed to the chassis $\sum Fy = 0$
And $\sum MA = 0$ using this two equation reactions R1 & R2 Can be find out.
R1 = 18.560 KN and R2 = 18.560 KN

5.2 Reaction on Frame Due to Drivers Cabin (Platform) Mounting.

Total Weight of Platform = 339 Kg
Assume Driver Weight = 75 Kg
Total Weight = 414 Kg = 4061.34 N

There are 4 support's on which Driver's Platform is mounted .By the calculation of c.g. on Creo modeling software with proportion of distance of mounts from c.g. , weight is distributed on front and rear mounts accordingly. Total weight coming on rear mount is 218.12 kg & on front mount is 195.87 kg.

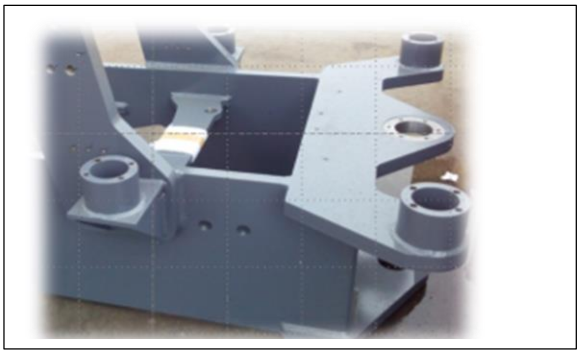


Fig 4. Platform Mounting

Reaction on each rear mount = 1.07 KN
Reaction on each front mount = 0.934 KN

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5.3 Reaction on Frame Due to Engine Mounting.

There are four mounting points on which engine is mounted and c.g. of engine installation is at center of four mounts so, we can consider equal distribution of weight on each mount.

Total Weight of Engine = 650 Kg= 650* 9.81= 6376.5 N

Fig5. Engine Mounting

On each mount reaction = 6376.5 /4 =1.595

5.4 Reaction on Frame Due to Fuel Tank & Fuel

Weight of fuel tank = 493.5 Kg
Capacity of Fuel Tank = 250 lit
Weight of Diesel (ϱ * V) = 0.8508 *250
= 212.7 Kg
Total weight =706.2 kg
Length of Fuel tank = 666.57 mm

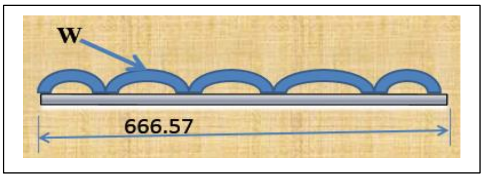


Fig 6. UDL of Fuel Tank

W = (353.1*9.81)/ 666.57 = 5.19NN/mm

5.5 Reaction on Frame Due to Radiator Assembly.

Radiator Dry weight = 88 Kg
Coolant weight = 9 Kg
Oil weight = 8 Kg
Other fitting weight = 5 Kg
Total weight assembly = 110 Kg

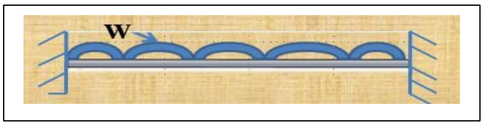


Fig 7. Radiator Assembly mounting

W = (110*9.81) /738 = 1.46 N/mm

One channel is provided between two side plates on which radiator assembly is mounted, there will be uniformly distributed load of intensity 1.46 N/mm.

5.6 Reaction on Frame Due to Hydraulic Oil Tank, Canopy.

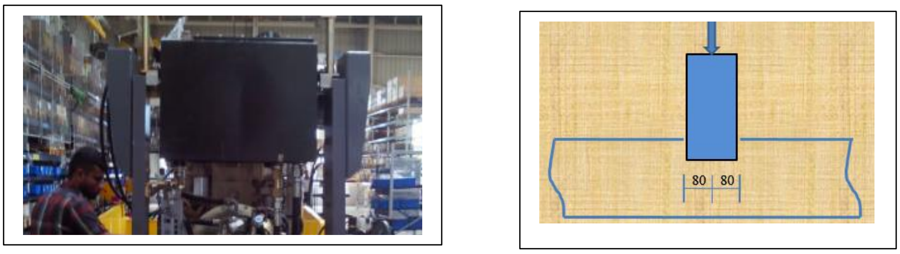


Fig 8. Hydraulic Tank Mounting

Weight of oil Tank = 53 Kg

Capacity of Oil Tank = 80 Lit = 71 Kg

Total weight = 124 Kg

Reaction on Each side Bar = (124 /2) * 9.81

Weight of Canopy = 112 Kg

Reaction Canopy @ each sidebar = 112*.5 * 9.81

= 0.549 KN

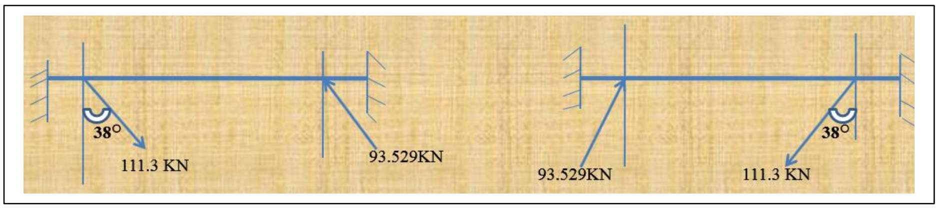
Twisting Moment Due To Canopy = 164.89 KN.MM

5.7 Reaction on Frame Due to Steering Action

Steering Cylinders are mounted on plate between the side plates of Chassis which connects with hitch next to it.

Bore Of Cylinder = Φ90
Rod = Φ 36
Maximum Working Pressure = 200 BAR

Reaction Due To maximum Working Pressure on Mounting Plate
= {(π/4 * 90 ^2) * 9.81* 200}/100
= 124.6898 KN…… (Theoretical)
During Compression = 93.529 KN………. (Actual)
During Extension = 111.34 KN……….. (Actual)



When steering Turn Right When steering Turn Left

Fig 10. Steering Action

VI. SHEAR FORCE AND BENDING MOMENT DIAGRAM

As our chassis is symmetric, half part is taken for analysis. Fuel tank is considered as separate part and in front hitch mounting plates are considered as the beam part. All the reactions due to components on chassis in y- direction are considered for shear force and bending moment calculations. In this theoretical analysis Engine load and platform loads are converted into uniformly distributed loads as in earlier case reaction at each mount was calculated that can be used in analysis software directly. Self-weight of chassis is considered at c.g. As stated earlier a hinge support is assumed at hitch so that simply supported beam with overhang on both sides can be formulated and also at axel mounting support is considered.

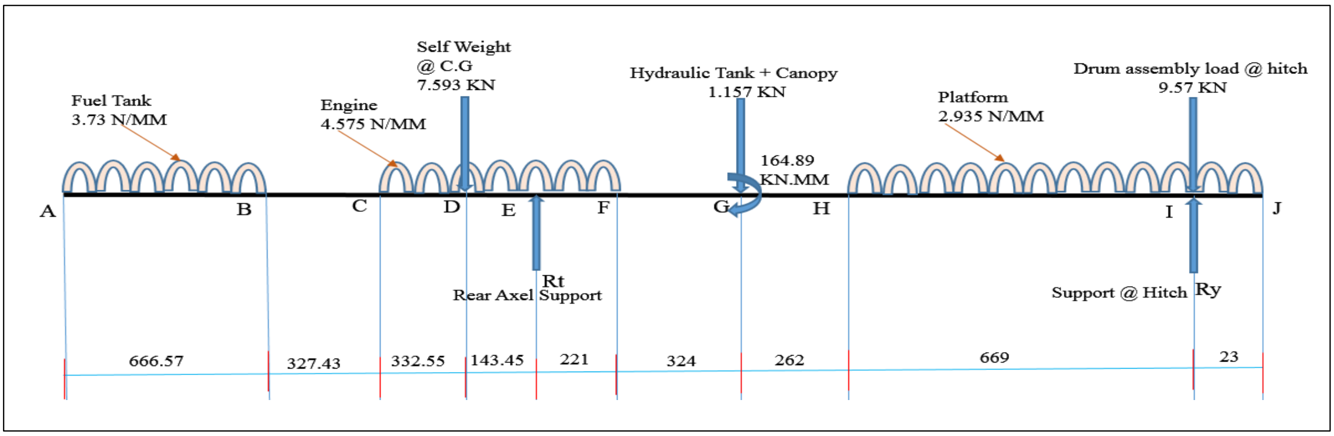


Fig 11. Simply Supported Beam

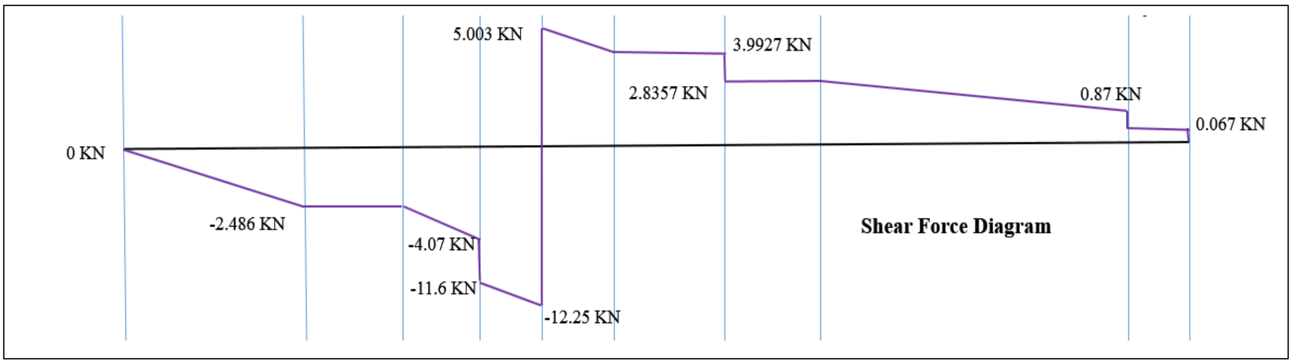


Fig 12. Shear Force Diagram

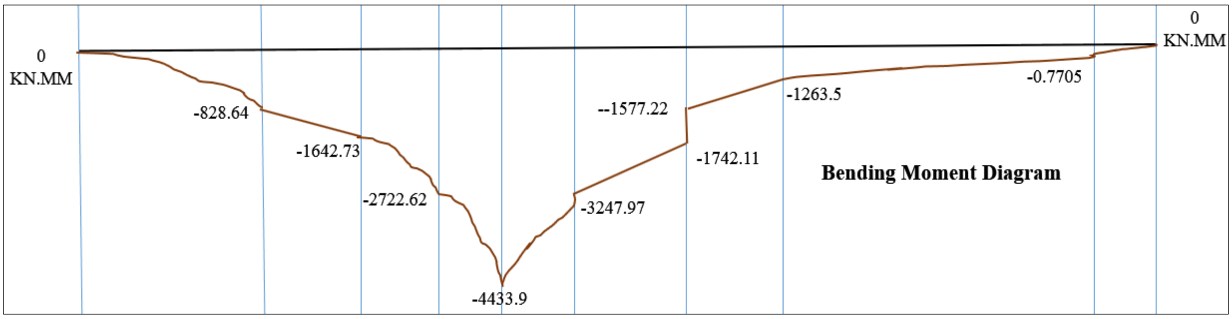


Fig 13. Bending Moment Diagram

Maximum Bending moment = 4433.9 * 1000 N.MM

Cross section of Beam is Rectangular but it varies non-uniformly in its depth along the length of the beam. Staring from fuel tank side, depth varies as 429 mm, 370 mm, 544 mm. we have an option of taking average depth or to consider minimum depth. Minimum depth is taken for calculations. We have Flexure formula ($M / I = \sigma / y = E / R$), maximum bending moment can be Calculated,

Material properties -
Structural steel = S2335Jr
Ultimate Tensile strength = 340-510 N/ mm^2
Yield strength = 175 -235 N/ mm^2
Modulus of Elasticity = 2e5 N/ mm^2
Poisson's ratio = 0.3
σ allowable = Sut / FOS = 68 – 102 N/ mm^2

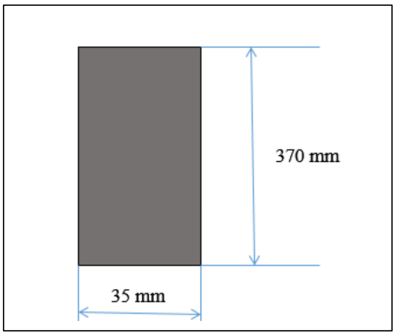


Fig 14. Beam Cross section

I = (b*d^3 / 12) = 147.7379e 6,
y = 185,
Z= I / y = 798.58 e3
Maximum bending stress (σ max) = M / z = 5.55 N / mm^2

VII. CONCLUSION

Detail static theoretical analysis is carried out. Allowable tensile strength of material is 340-510 N/ mm^2, by considering FOS as 5 allowable stress is 68-102, As shown above calculated stress is less than allowable stress hence design is safe .For more optimized results structural analysis on analysis software needs to be carry-out.

As a future scope, the Static Structural analysis on software, Dynamic analysis with all operating conditions, FEM analysis with software, Thickness optimization of different parts of the chassis base on FEM results. Optimized Chassis model creation on modeling software.

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