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Optimization of Articulated Boom through FEA

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Abstract: articulating boom lifts provide the ability to lift up, over and out with precise positioning for ultimate versatility in hard-to-access work areas.These lifts gained incredible popularity due to their unique "up-and-over" capabilities to navigate obstacles at height,rive through standard doorways, move around obstacles and access overhead work from aisles our project work is to design a boom and optimize it for required material and cost by considering different cross sections and doing a simulation in FEA software boom design is optimized and based on the results the best one is selected these booms sre used in JCB for oil filling application with hoses mounted on them.

Keywords: **Articulating Boom, Telescopic Boom, channel Cross section, self-weight, dead loads**

I.INTRODUCTION

The function of the articulating boom is to provide an access to a desired work area may be for a temporary period or permanent time There are several distinct types of aerial work platforms, which all have specific features which make them more or less desirable for different applications. The key difference is in the drive mechanism which propels the working platform to the desired location. Most are powered by either hydraulics or possibly pneumatics. The different techniques also reflect in the pricing and availability of each type. They are generally used for temporary, flexible access purposes such as maintenance and construction work or by firefighters for emergency access, which distinguishes them from permanent access equipment such as elevators. They are designed to lift limited weights usually less than a ton, although some have a higher safe working load distinguishing them from most types of cranes. They are usually capable of being set up and operated by a single person.It is proposed in this project work to optimise the articulating boom for oil filling application in JCB, Here the oil filling is done in JCB with the help of guns .these guns are attached to the hoses mounted on Boom arm .At present this boom is designed on the base of their experience and therefore it is costly and heavy, by using FEA the boom design is optimised by considering different channels sections and selecting the best based on FEA results.The Boom used in company is of 123.625 kg by using FEA need to reduce the weight. Having Vertical column Cross sections:150x150x3, Arm 1:50x50x4
Arm 2:50x50x3

2.LITERATURE REVIEW

1) In 2014 P. Sharafi, Lip H. Teh ⍰, Muhammad N.S. Hadi:presented an intuitive procedure for the shape and sizing optimizations of open and closed thin-walled steel sections using the graph theory and its depends on computational numeric problem it is time consuming and requires high end systems

2) In 2015 Jun Ye, Iman Hajirasouliha, Jurgen Becque, Kypros Pilakoutas,researched that Cold-formed steel (CFS) cross-sections can be optimised to increase their load carrying capacity, leading to more efficient and economical structural systems, but at the university of Sheffield demonstrated that CFS channels has high load carrying capacity compared to other channels but these type of channels cannot be used as they have point contact and cannot be connected to a system

3) In 2017 Mohammad Farshchin, Mohsen Maniat, Charles V. Camp, Shahram Pezeshk has developed a technique SBO (School Based Algorithm) for optimization of steel channels but it found that it required high end algorithm technique high end numeric calculation which is time consuming for a higher structures

4) 4) In 2018: Yuanqing Wang a , Xiaoling Liu a , Huiyong Ban a, ⍰, Ming Liu b , Yongjiu Shi a , Yuyin Wang s. In this paper, theoretical solutions for midspan deflections considering the influence of variable flange thickness have been deduced with the unit-load method and mathematical integration. And their reliability is compared by Finite element method.

Types of Booms:

1) Articulating Booms.

2) Telescopic Booms.

Fig.1: Normal articulating boom used for handling a welding machine [7]

1) Articulating Booms: Articulating booms are aerial work platforms with multiple boom sections that hinge or "articulate" allowing the operator to gain access to work areas over obstacles and barriers. Also referred to as

"knuckle booms" or "up-and-over booms," these versatile products are perfect for tight access and hard-to-reach areas

2) Telescopic Booms: Telescopic booms are aerial work platforms with boom sections that extend telescopically. They are also commonly known as "stick" booms because of their straight appearance. Telescopic booms offer greater horizontal outreach than any other type of aerial platform ideal for areas with limited access in construction, industrial, entertainment, road building, bridge work, painting and inspectionapplications.

Fig: 2 Articulated Boom [6]

Fig 3: Telescopic boom [5]

3. PROMBLEM STATEMENT

The Boom was manufactured based on experience It was not optimized for cost and weight Efforts were to design a boom keeping view of cost and weight so the Design and Optimization of articulated boom by considering different cross sections of the channel was considered.

4. OBJECTIVE

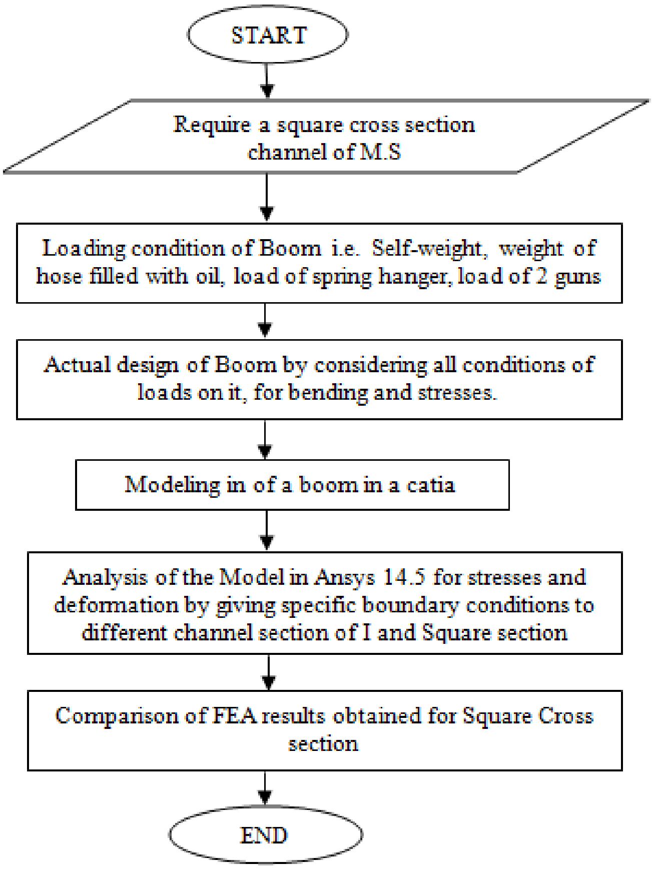
Optimize existing cross section of an articulated Boom with a view to reduce its weight and cost

The Boom handles a Gun weight 8kg and also hoses weight 12.91N/m. Weight of spring hanger: 37.27 N Weight of 15 mts pipe with oil is: 9.87 N. The length of Hose carrying oil is 15 Mts

5. METHOLOGY

In previous Method the booms were designed and manufactured based on the experience so the material cost and actual material quantity required for the manufacturing was not known

Here we are considering most of the known cross section of the channels required for manufacturing of the boom and from that by modelling FEA the Boom is optimised for material and cost.



6. DESIGN:

The Design of Boom is based on following ways

a) Cross Section Of Channels
b) Self weight (Dead Load)
c) Weight on boom i.e external dead load on channels
d) Surrounding condition i.e mounting environment Technical Data

Table-:1 Required parameters for design of Boom in catia

4	Arm 1	Sq Section	2500mm	3.33 kg/m
5	Arm2	Sq Section	2500	4.28 kg/m
6	Vertical Column	Sq Section	4000mm	7.1 kg/m

The part design and assembly is done in catia by taking into consideration all parameters like cross section and its lengths for square section of the boom. And igs file is prepared for importing in Ansys Design of Boom of Small Cross section than previous one.

Design for 1st ARM:

Loads on Arm 1 Given By:

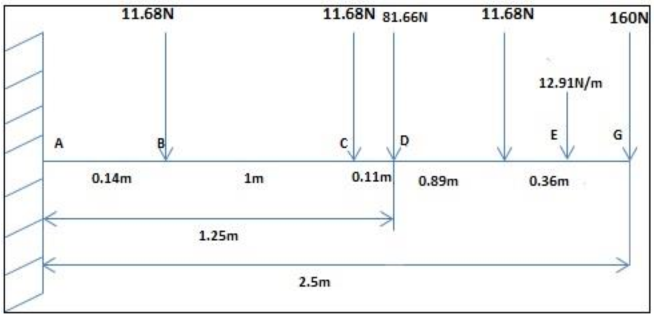


Fig:4 FBD of Arm 1

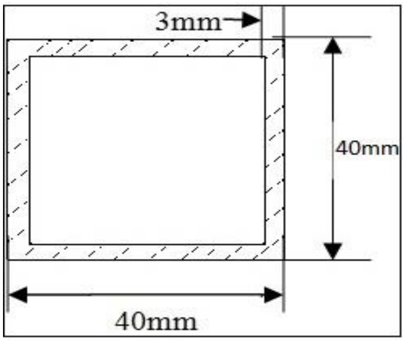


Fig:5 Cross section of Arm 1

Calculations for Arm 1:

∑ B.M at A

=583.00Nm.

Stresses= $\frac{MxY}{I} = \frac{583.00x10^3x20}{101972.00} = 114.345\ N/mm^2$

FOS= $\frac{250}{114.345}$ =2.18

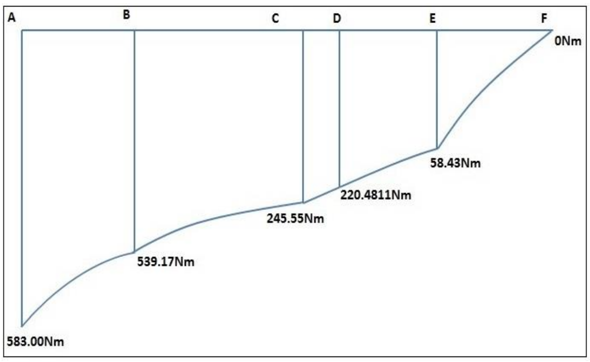


Fig: 6 BMD of Arm 1

Calculations for Arm 2:

Loads on Arm 2 Given By:

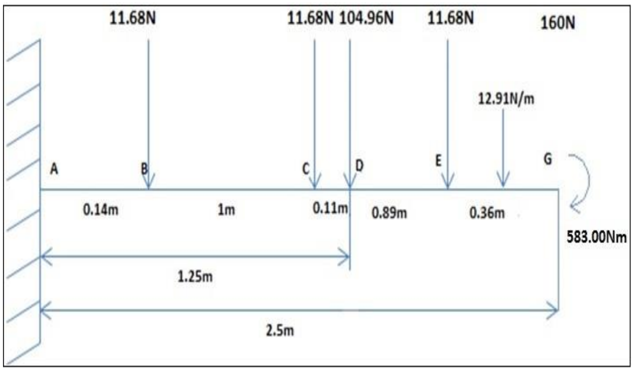


Fig:7 FBD of Arm 2

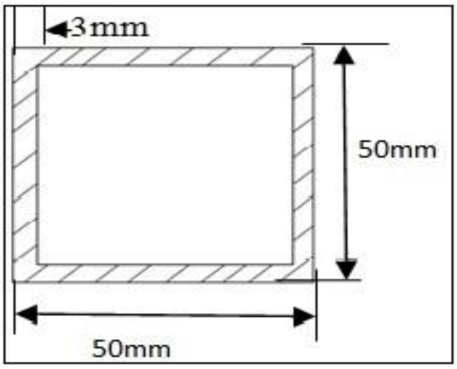


Fig:8 Cross section of Arm 2

Calculations for Arm 2:

∑ B.M at A.

=794.48Nm

Stresses= $\frac{MXY}{I} = \frac{794.48X10^3X25}{208492}$ = 95.26 N/mm^2.

FOS = $\frac{250}{95.26}$ =2.62

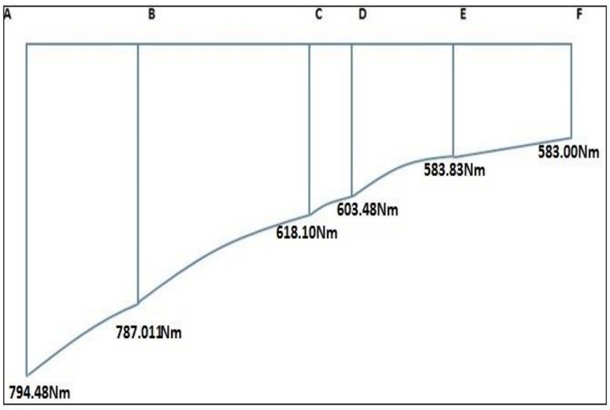


Fig: 9 BMD of Arm 2

Calculations for vertical column:

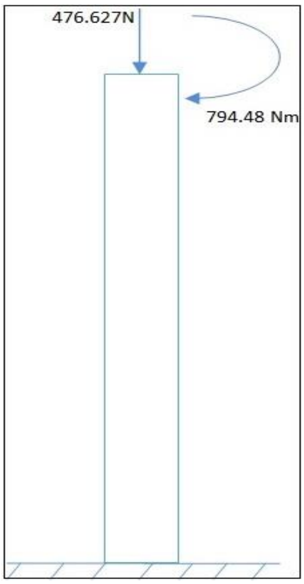


Fig: 10

Total Load on Column:

Main load

2x(11.68x3)+2x(12.91x2.5)+160+104.96+81.66

=476.627N

Total stress on column is given by:

$$\sigma = \frac{MxY}{I} + \frac{F}{I}$$

$$stress = \frac{794.84x10^3x40}{914452} + \frac{476.77}{924}$$

σ = 35.28 N/mm^2.

$FOS = \frac{250}{35.28} = 7.086.$

Maximum stresses Observed is 35.28 N/mm^2. As per our calculations it is less than our yield stress i.e 250 N/mm^2

Hence the design is safe but it needs to be validated via FEA (Ansys) so further FEA (Ansys) Will be done

Process Followed in FEA (Ansys):

The material used for following simulation is structural steel

Tensile Yield strength :250Mpa

Tensile ultimate strength:460 Mpa

Compressive Yield strength:250 Mpa

Step 1) The igs file of catia model for Square section is imported in ansys workbench for structural analysis

Step 2) It is meshed with Tetrahedral elements: Number of nodes for square are:23355 and number of elements are:12053

Step 3) In STATIC STRUCTURAL analysis the boundary conditions are given to the boom like a fixed support at bottom and required loads at specific places : dead load and self weight is also considered.

Step 4) In SOLUTION the required stresses like von mises and total deformation is taken for consideration

Step 5) solving we get a stresses and deformation for the section.

Boundary condition: loads are given at clamps of each boom arm as 11.68N , load at free end: 160N and boom base is fixed 200N force is given in direction of rotation of boom arm as a forced by human for rotation of arm, The displacement of boom arm is restricted in Y and Z direction it is free to rotate at X direction

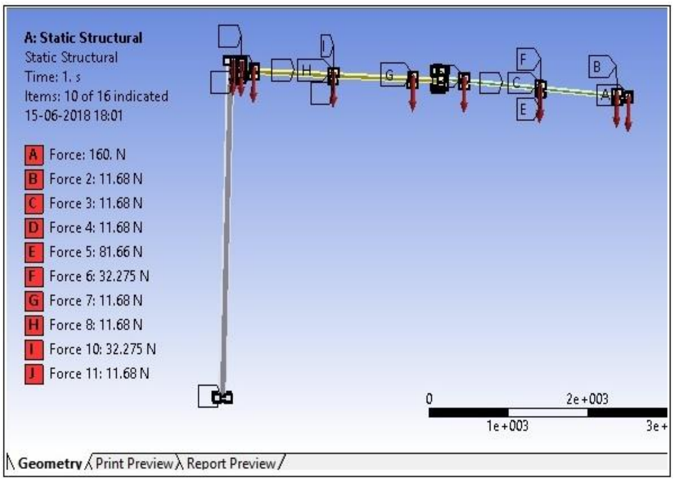


Fig 11: Square section FBD Showing forces on Boom arm and fixed at the Base.

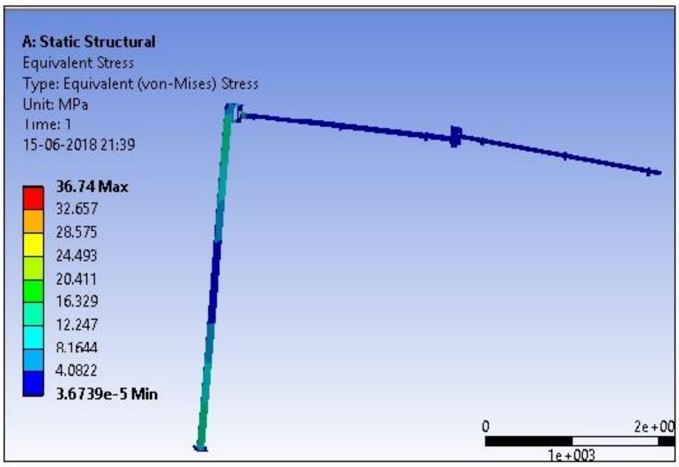


Fig:12 Stresses in Square Section

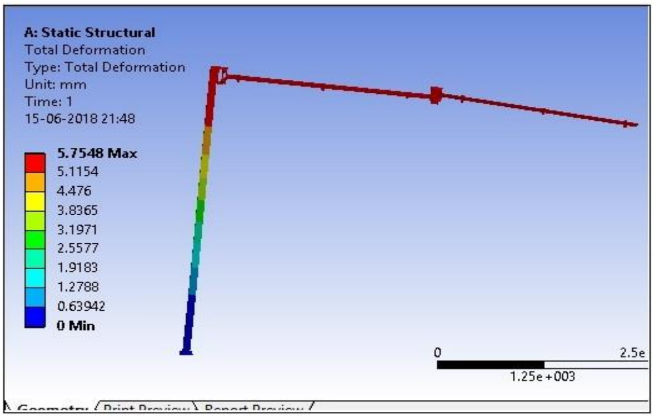


Fig:13 Deformation in Square section is 5.75mm

In Above Figures The results are shown For square cross sections Solved in Ansys 14.5.

7. RESULTS AND DISCUSSIONS.

Table -2: Comparison of Stesses

	Theoretical	Analysis (Ansys)
Stresses (Mpa)	35.28	36.74

It is found that both theoretical and analytical results matches approximately hence the boom is validated for the given results
It is Observed that boom with reduced square cross section can be used as it causes reduce in weight and as well as cost.
Now comparing with the boom of Company its weight is:123.625 kg.
And weight of Analysed Boom is 46.97Kg

W_1-W_2/W_1x100=(123.625-46.97)/(123.625)
=62.00%
Therefore Total reduction in weight is 62.00%
And in proportion will be the cost reduction by 62.00%.

8. CONCLUSION:

In this static structural analysis of boom was carried out so as to optimize the existing boom structure for weight and cost reduction so it is observed that boom will not fail even if the square cross section of Vertical column: 80x80x3
Arm 1:40x40x3
Arm 2:50x50x3
Instead of Boom Having Cross sections Vertical Column 150x150x5
Arm 1:50x50x4
Arm 2:50x50x3

9. REFRENCES

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