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Telescopic Boom for Mobile Cranes: Design and Analysis

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ABSTRACT

Here, the telescopic boom design, automatic boom extension rope system, and self-compensating rope mechanism are all explained. Finite element software was utilised to ensure that the boom models were accurate, using CAD to create them. Weak spots in the components that had been examined were filled with stiffener plates. To limit the risk of boom failure, two rope alternatives have been selected for this study that minimise human involvement in the extension process.

String Mechanism, Finite Element Analysis, and Telescopic Boom are all explored in this study.

INTRODUCTION

With the use of wire ropes, chains, and sheaves, cranes are able to raise and lower objects as well as carry them from one location to another. The pick and carry crane's telescoping boom assembly is its most critical component. Anywhere from three to 10 components may be used in this configuration. A crane with five boom sections and two rope control systems is involved in this project. Throughout the design and analysis, maximum loading circumstances were taken into consideration. It might be one of the following reasons:

- Access to a wider range of options
- Adjusting the rope may be done in two ways:
- Boom cross-sectional measures are shown in Figure 1.
- For the optimal weight/strength ratio, you may want to choose the right materials.
- Boom parts may be made in SolidWorks
- ANSYS software is used to simulate the boom components.
- Stiffener plates should be used in regions where research demonstrates they are essential.
- According to sectional failures, boom length is established.
- It's possible to categorise the assembly's components into the following:
- The album's opening song is titled Mother Boom.
- There are two boom parts in the centre (3 in number)
- Suggestions for the 3rd section
- Rope mechanisms are utilised to stretch the booms.

Typically, the extensions are operated by separate levers. As a consequence, the weight of the booms is unevenly distributed among them. A hydraulic cylinder that could extend two booms at the same time was designed by J.L. Grove in 1968, which was subsequently modified for five booms in this study. Using a system of pulleys, drums, and a single piston, each boom segment may be moved in relation to the previous portion. It aids in the uniform distribution of the boom's weight. Having a separate hydraulic system for each boom is also superfluous. The first intermediate element will be pushed by the mother boom's hydraulic piston, and the rope tension will result in the movement of the other booms. Each boom travels a different distance depending on how far the hydraulic piston extends. Mechanics are shown through diagrams in Figure 1.

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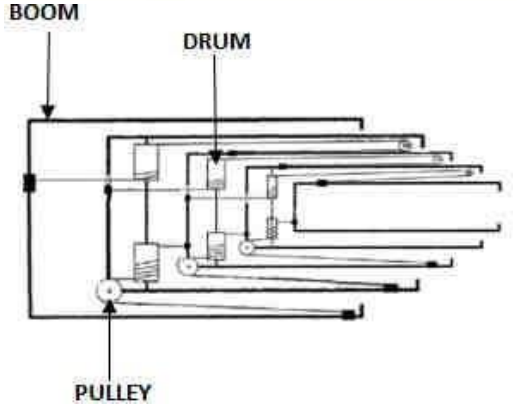
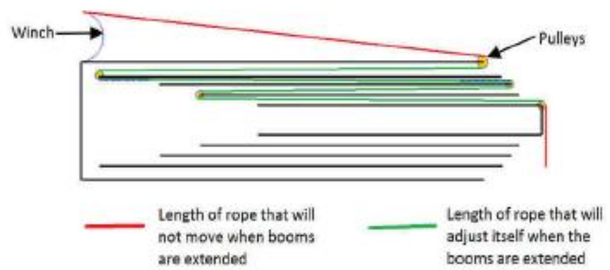


Using a rope, the booms may be extended as shown in Figure 1.

For self-compensating rope, there is an installation mechanism. For a long time, extending the boom components required the operator to physically extend the rope. If the operator makes a mistake, the rope tension might increase. A pulley mechanism is used to alleviate this issue. While extending a boom component, the operator is required to physically stretch the rope. As a result, rope tension might rise if an operator commits an error. This issue is solved by using a pulley system.



An illustration of the self-compensating rope device may be seen in Fig. 2.

COST ANALYSIS FOR PROJECTS

The calculations were based on SAE J1078, which covers failure modes for boom components such as bending, shearing, and tensile. Multiple iterations were made by altering the material, thickness of the metal sheets, and cross section of the metal sheets after the completion of the design calculations[3].

The following are some of the most important design considerations:

The material's yield strength

The thickness of the metal sheets is the second factor to take into account. Dimensions of the cross-section (height and width) TABLE 1 summarises the results of these calculations in terms of boom section size. The cross section of anything varies as the material or thickness is altered.

Table 1: Boom section dimensions derived from calculations

Part	Material yield Strength (MPa)	Thick-ness (mm)	Height (mm)	Width (mm)
Tip Boom	410	8	150	110
Boom 4	410	8	242	208
Boom 3	410	8	334	300
Boom 2	410	8	426	393
Mother Boom	410	8	520	486
Tip Boom	250	8	185	150
Boom 4	250	8	277	242
Boom 3	250	8	370	333

Sheet metal's composition

Material selection is dependent on a number of factors, including the availability, machinability, weldability, yield strength, and cost of the material under discussion. To put it another way,

selected is mild steel IS2062 E-250 and its properties[4] are as given below:

Ultimate tensile strength (min.)	410 MPa
Yield Strength (min.)	230-250 MPa
Percentage Elongation	23
Bend Test	25 mm
Mass Density	7.85 kg/m3
Poisson's Ratio	0.29

Fig. 3 shows the variation in weight of material used with change in material used. The graph is plotted for two different thicknesses of 8mm and 10mm respectively. The graph has yield strength (N/mm^2) on X-axis and weight(kgs) on Y-axis.

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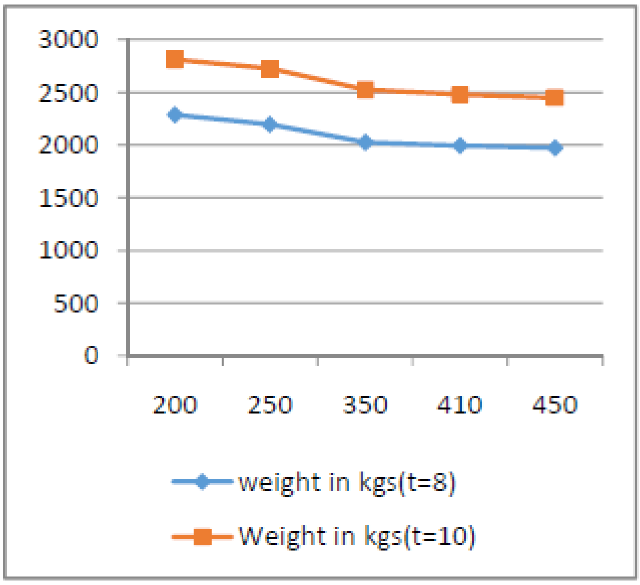


Each material change is shown graphically in Fig. 3 as a bar graph representing the overall weight of the boom.

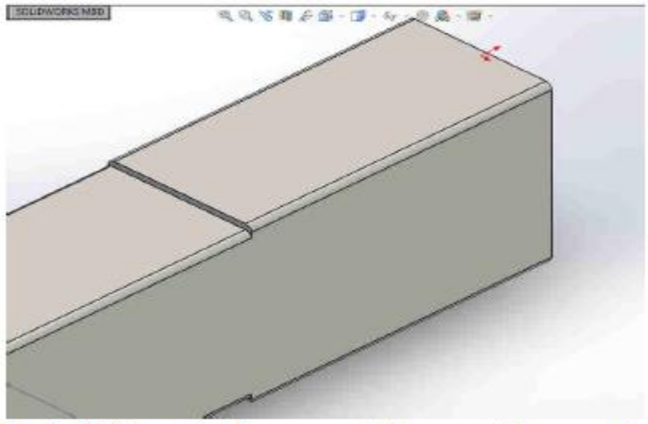
Metal sheet thickness

This is due to the concentrated load at the connection and the lack of fatigue strength in the boom, which necessitates a thickness of at least 4mm for weldability reasons. When the weight of the material is taken into consideration, the thickness of the check should not be more than 12 mm. When a material is thicker, its cross-sectional area is less, as shown in Table 1. The plates picked have a total thickness of 10 millimetres. Cross-sectional booms.

SAE J1078 is used to calculate the cross-sectional dimensions of each boom. Cross-sectional area, yield strength, and material thickness were all considered while determining the tip section's parameters (height and width). The cross-sectional dimensions of the remaining booms were calculated taking into account clearances. An allowance of 1.5" to 2" is made between the boom sections in order to accommodate mechanisms and bearing pads. This set of measurements was double-checked using SAE J1078.

STIFFENERS

In order to prevent the web from buckling or deteriorating, a bar, angle, channel, or other attachment is often used. The Analysis part of the paper compares stiffer and non-stiffened regions. Stiffeners shield critical boom components. Appendix 4 depicts the boom stiffeners, as seen in Figure 4. After ANSYS software analysed the model, stiffener locations were discovered. Figures 11 and 12 show the intermediate boom before and after the stiffener plates were placed (Von Mises stresses). Figures 13 and 14 illustrate how stiffener plates were added to the intermediate boom to make it more rigid. When stiffener plates are fitted, they reduce deformation and stress dramatically.



The boom section's intermediate boom has a stiffener connected to both the top and bottom of the boom section.
It's a Good Material for Keeping Things Safe.

Each boom is supported by a bearing pad or wear pad as a safety measure. In certain cases, there may be an adaptable cushioning element that may be tailored to each pad element's specific loading or stress requirements. 150x30x150 mm t. mm thick bearing pads are offered. When calculating thickness, the distance between booms is critical. [7] On the surface of the boom, there is a 2 mm groove that enables the boom assembly to move freely. Nylon 6,6 is used to make these pads. With the bearing in the middle, booms are shown in Figure 5.

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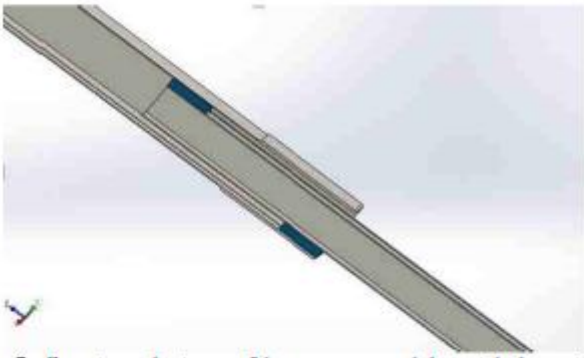

Figure 5 shows a cross-section of the boom assembly with bearings.

ANALYSIS

Instead of assessing the whole telescopic boom assembly as a whole, each boom was evaluated individually[8]. This was done to ensure that there would be no more problems and to make it as easy as possible to locate the source of the problem. The booms were believed to be completely extended in order to locate critical regions. Introducing a New Class of Models The boom models were created in SolidWorks'13. The selected material was ISC2048 E-250. Design calculations yielded the booms' matching measurements. Figure 6 shows a boom model with a tip portion.

Figure 6 shows a model of the tip piece. loading and unloading, as well as a variety of other situations

The research was conducted with the aid of ANSYS16.2 software. In this case, the previous boom's overhang is considered to be permanent. Next boom's overhang is employed to distribute loads. With the boom's reflexes, it may be possible to provide the boom in front of it a greater amount of force. The self-weight of the boom is determined by its centre of gravity. According to the manufacturer's specs, the crane can lift 14 metric tonnes and carry a payload of 1.5 metric tonnes when fully extended.

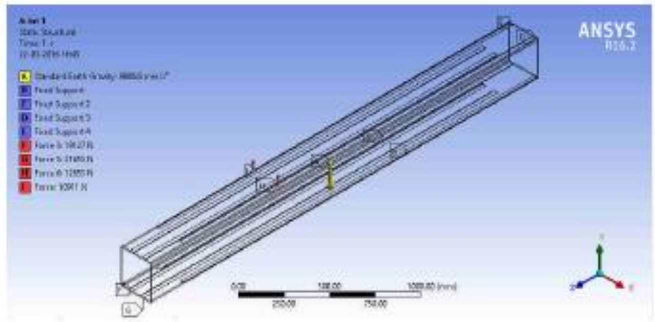

Fig.7: Boundary and loading conditions for intermediateboom without using stiffener

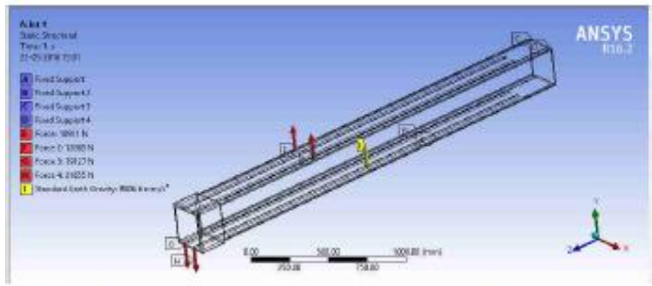

Figure 8: Intermediate boom stiffener boundary and loading conditions

Figures 7 and 8 depict the boom under boundary and loading circumstances before and after stiffener addition, respectively.

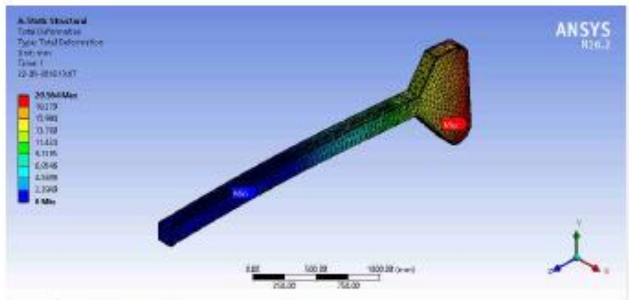

Fig.9: Total deformation of tip section

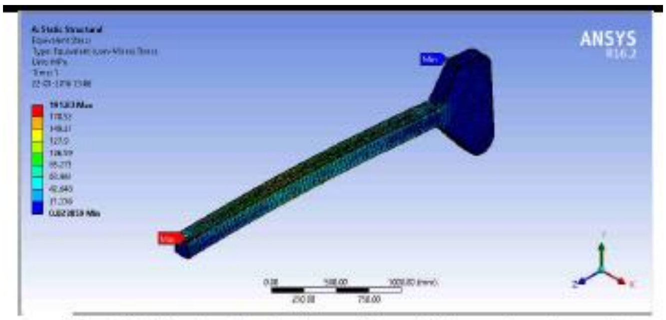

Fig.10: Equivalent stress (Von-Mises stress) on tip section

Figures 11 and 13 depict the co-stresses, whereas Figures 12 and 14 show the co-stresses with and without stiffeners, respectively.

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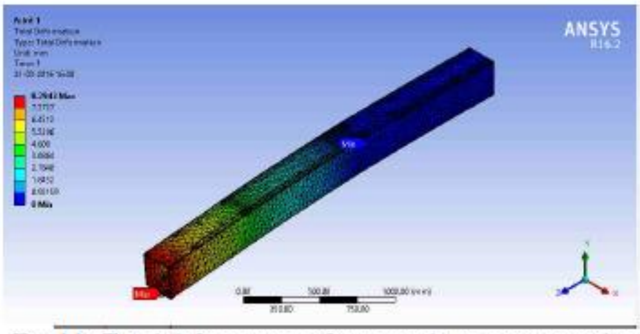


Fig.11: Total deformation of intermediate section without using stiffener

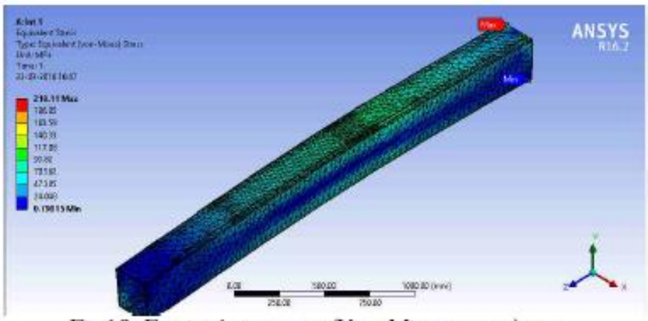


Fig12. Equivalent stress (Von-Mises stress) on intermediate section without using stiffener

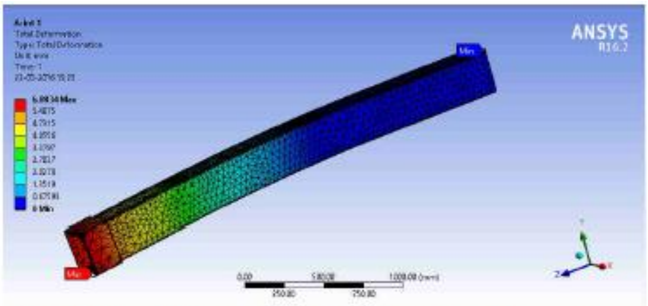
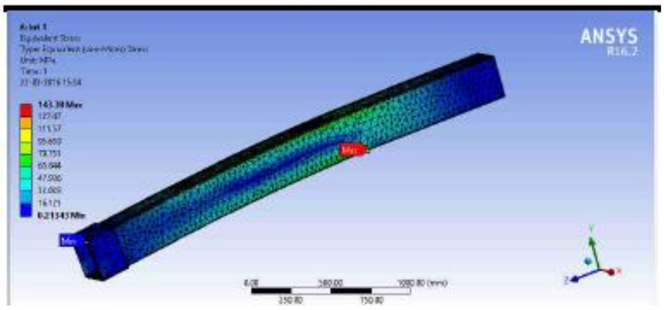


Fig.13: Total defomation of intermediate section using stiffener



A stiffener in the intermediate segment reduces the equivalent stress (also known as the Von-Mises stress)

If the stiffeners hadn't been employed, the boom's centre would have distorted by 8 millimetres. When the stiffener was applied, the distortion was decreased to 6.08mm. Without stiffeners, the maximum equivalent stress in the middle boom section was estimated at 210 MPa. After applying the stiffener, the stress decreased to 143.38 MPa.

CONCLUSION

According to a paper, CAD and FEA may be used to build crane booms that can be analysed using a variety of methods to ensure smooth operation. Future research and design projects may benefit from using this strategy. There are no minor attachments such as a pulley, a spring or a hook in analytical models for the sake of ease of use. Because the total load is much larger, these components have minimal influence on the loading factor. ANSYS16.2 was used to do finite element analysis on the SolidWorks'13 boom parts. Plates that hold the structure in place.

It was less stressful and anxiety-inducing to get accepted after an examination. Do not waste time and money by using deflections in areas that are not essential. The maximum stresses were lower than expected.

The tensile and yield strengths of the materials specified in the design The design is capable of lifting a total of 14 tonnes. The cross-section forms of mobile crane booms may be explored in the future in order to discover the best possible design.

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