Structural Improvement in Crane Boom Rest

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Abstract:- Crane boom rests are critical components that endure both static and dynamic loads, leading to deformation and a shortened lifespan. This paper addresses these issues by proposing a redesigned model with enhanced stiffness and load-bearing capacity. The new design incorporates gussets and Styrene-Butadiene Rubber (SBR) sheets. A series of trials were conducted to analyze various stiffener configurations, with results showing a significant reduction in deformation. The optimal configuration, consisting of three L-shaped stiffeners placed at specific intervals, reduced deformation from 17.2 mm to 2.2 mm. Additionally , the integration of SBR rubber sheets further minimized deformation to 0.15 mm. These modifications demonstrate the effectiveness of the proposed improvements in enhancing the durability and performance of crane boom rests. The findings provide a robust solution for extending the operational life of crane boom rests under dynamic loading conditions. Future research can explore different rubber materials and stiffener designs to further enhance structural integrity and load-bearing capacity.

Keywords:- *Static and Dynamic Loading, Stiffener, Rubber Sheet.*

I. INTRODUCTION

A crane boom is an essential component of a crane vehicle, primarily used for lifting and transporting heavy loads in various industries, including construction, shipping, and manufacturing. The boom is an extendable arm that provides the reach and height necessary for moving materials to different locations. It is typically made from structural steel to ensure strength and durability. The base, or resting piece, of the crane boom plays a crucial role in supporting the structure when the boom is not in use. It must be capable of withstanding both static and dynamic loads. The static load is the constant weight of the boom itself when it is in a resting position. In contrast, the dynamic load occurs during operations, such as when the boom is being raised or lowered, or when it experiences impact forces upon dropping. To enhance the durability and performance of the resting piece, a redesign was implemented. This redesign includes the addition of stiffeners and rubber sheets. Stiffeners are structural elements that increase the rigidity of the resting piece, thereby reducing deformation under load. Rubber sheets serve to absorb shocks and vibrations, further protecting the structure from impact forces. These modifications aim to minimize deformation, extend the lifespan of the crane boom, and prevent premature failure.

II. DESIGN OF THE MODEL

The current boom rest model, comprising the top, middle, and base sections, is depicted in Figure 1.

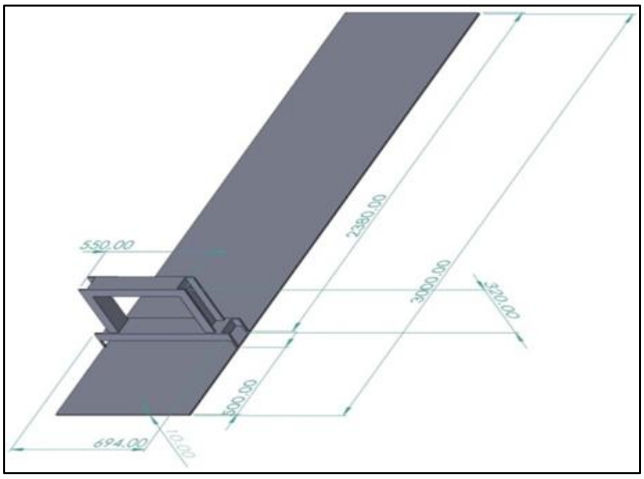

Fig 1 Dimensions of the Top, Middle and Base Sections of the Model

The part has been divided into 3 parts, top, middle and base parts separately for analysis, so that each part can get enhanced design for better strength, and load bearing capacity. The boundary conditions and loading of parts are shown in the following Figures 2, 3 and 4 respectively.

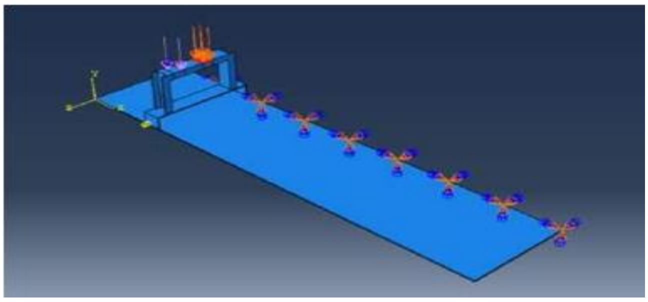

Fig 2 Boundary and Loading Condition of the Whole Model

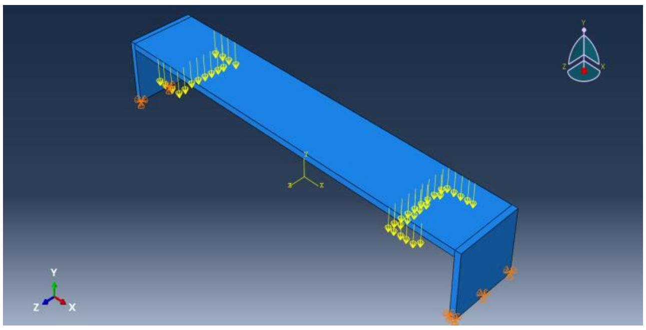

Fig 3 Loading Condition of the Middle Part

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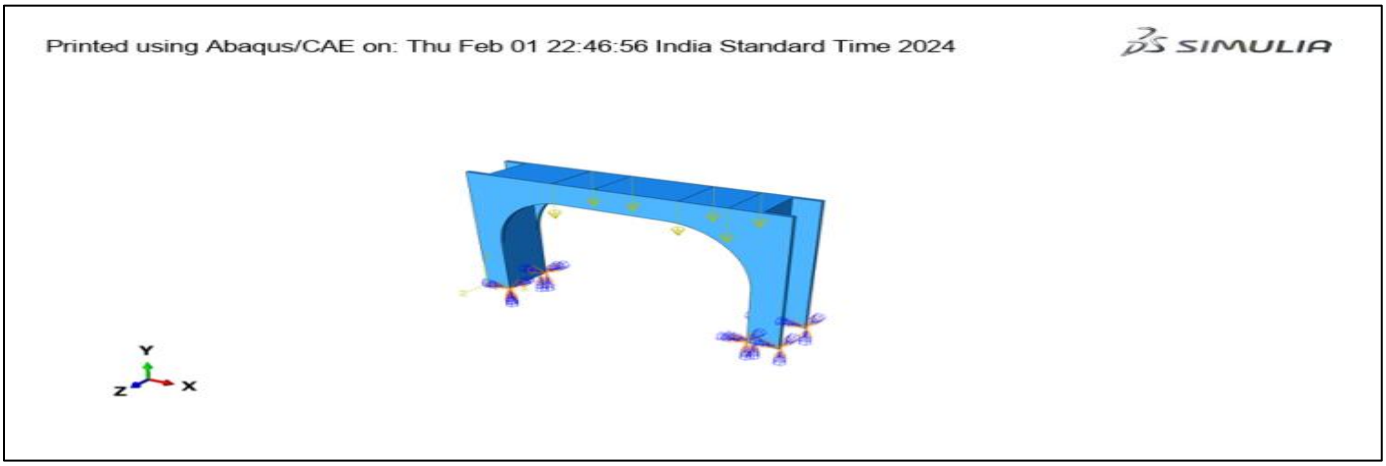

Fig 4 Boundary Condition of the Top Part

III. METHODOLOGY STRUCTURAL ANALYSIS WITH EXISTING LOAD

The following Figure 5 and Figure 6 gives the results of the static analysis of the model with 1 time the existing load.

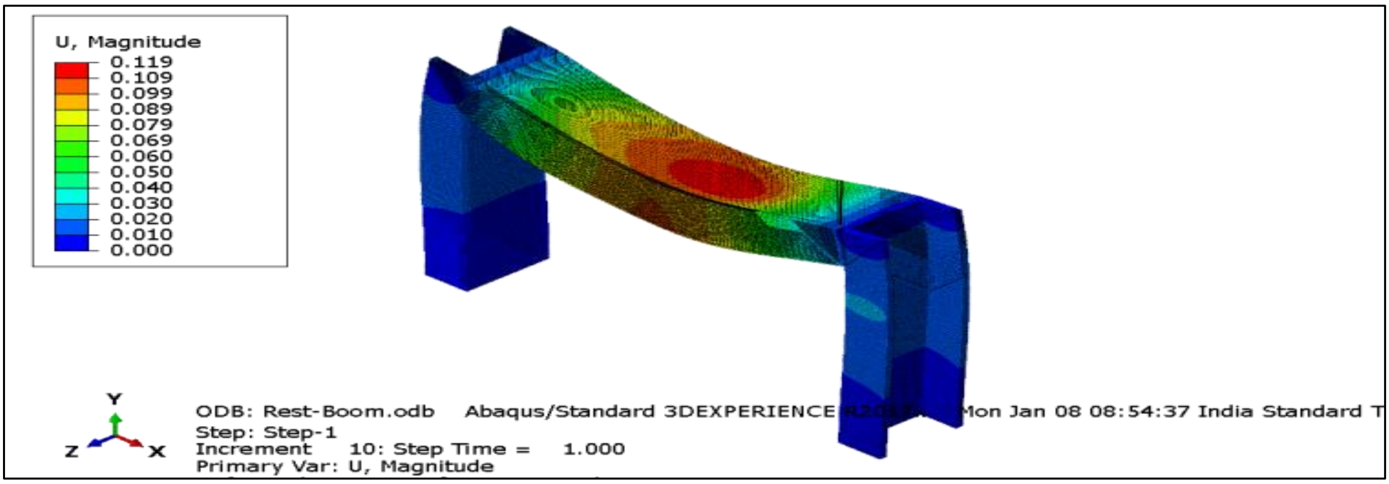

Fig 5 Structural Analysis of the Top Part with 1 Time the Load

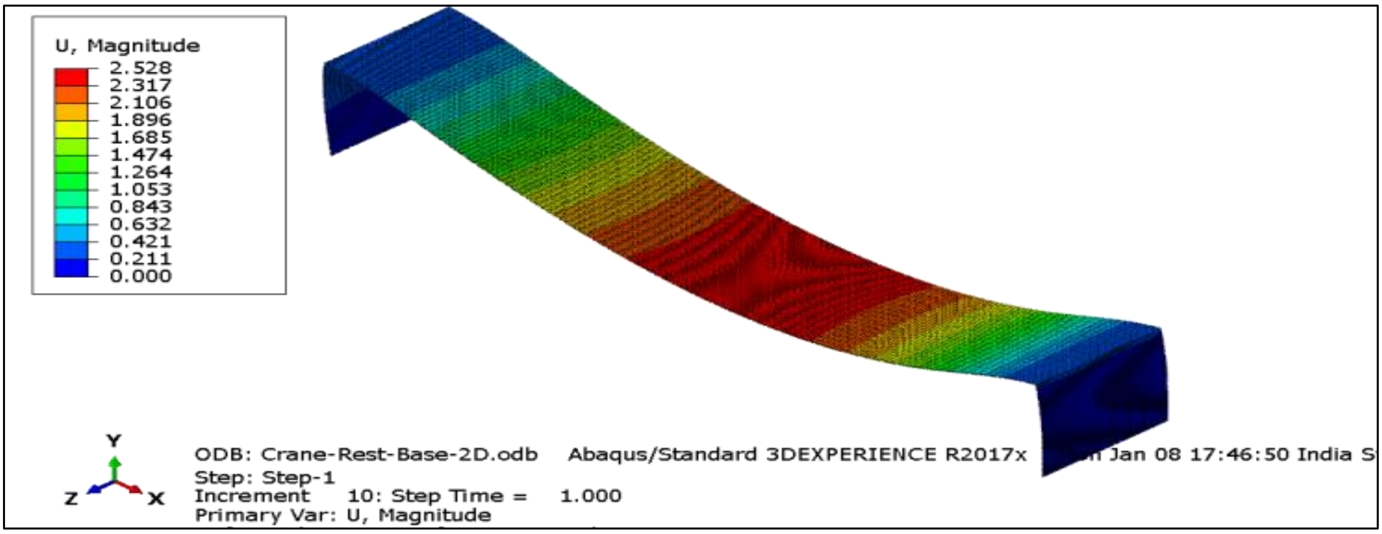

Fig 6 Structural Analysis of the Middle Part with 1 Time the Load

➢ *Without Stiffener*

The force is given over the boom rest, as mentioned in the previous sections. Quadratic Tetrahedral type of mesh was used as shown in the figure 7.

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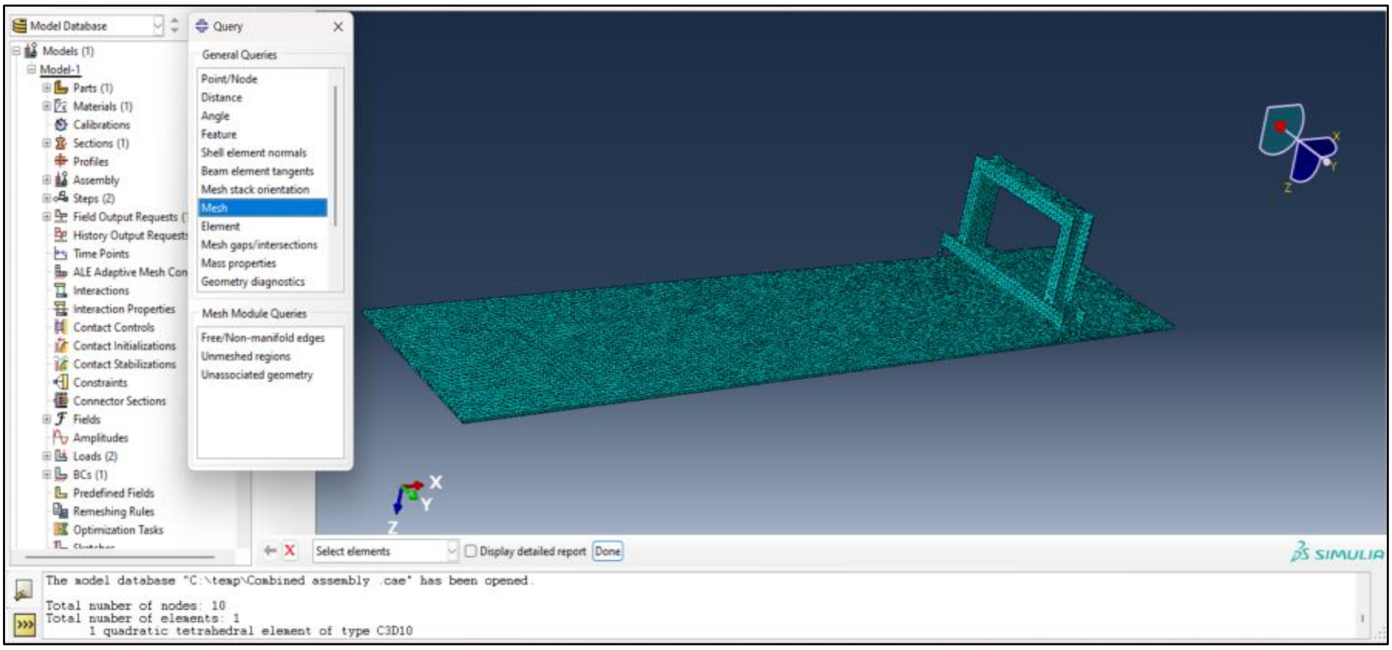

Fig 7 Quadratic Tetrahedral Type of Mesh

The mass of the assembly is 23473.28 grams. The deformation of the assembly is shown below.

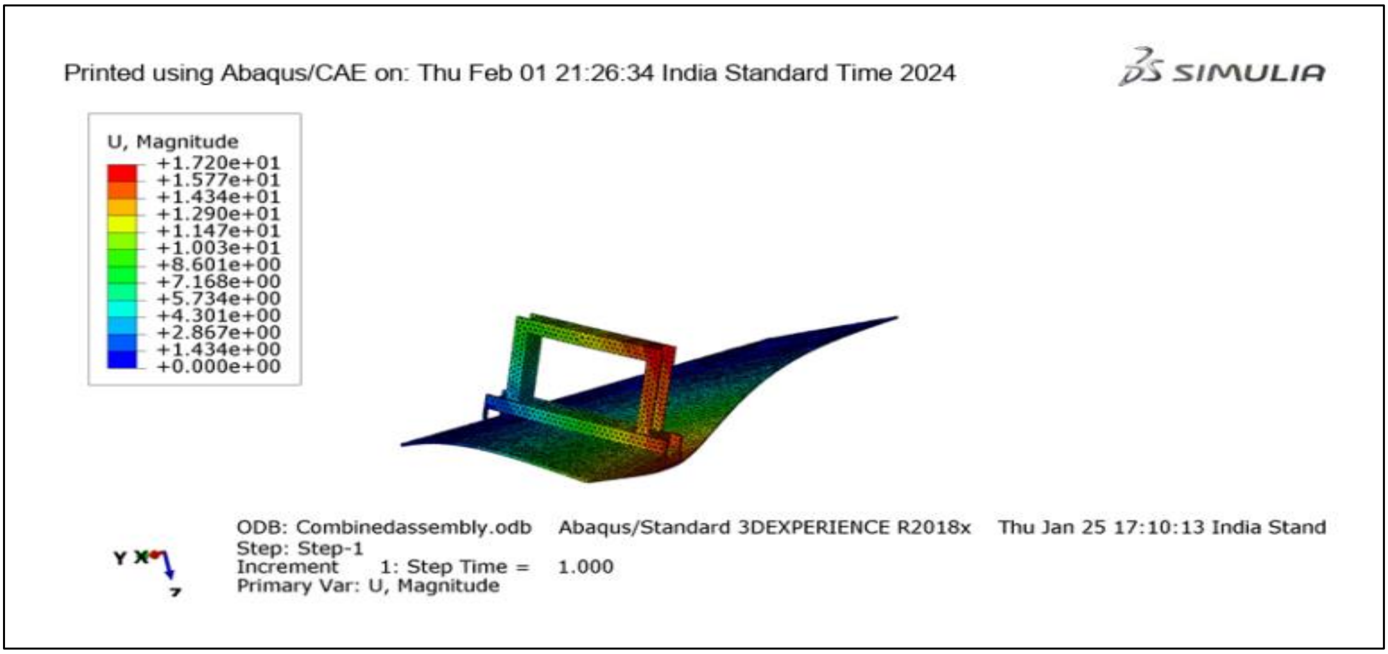

Fig 8 Result of the Structural Analysis with 1 Time the Load

Figure 8 is meshed with the Quadratic Tetrahedral type of mesh all over the body. The maximum deformation of the body is 17.2 mm. It is located directly under the boom rest.

➢ *With Stiffener*

The stiffeners are supporting structures that are added to the existing structure to reduce deformation and thus the stress.

[3] Mohebi, B., Asadi, N. and Kazemi, F.,suggested edge stiffeners reduces plastic strain. It helps in creating a longer life time for the structure by transferring the load applied over it and maintains its strength.[5]Hadianfard M.A and Khakzad A.R proved that longitudinal multiple stiffeners enhance the buckling capacity and reduce the deformation. In the following set of trails, different types of stiffeners were added to the base body. The best result that was obtained was 2.3 mm displacement from the maximum of 17 mm without any sort of stiffener added.

➢ *Trials*

Several types of stiffeners have been added and assessed for results.

Trial 1: A single stiffener of L shape at a point 560 mm away from the left end was added.

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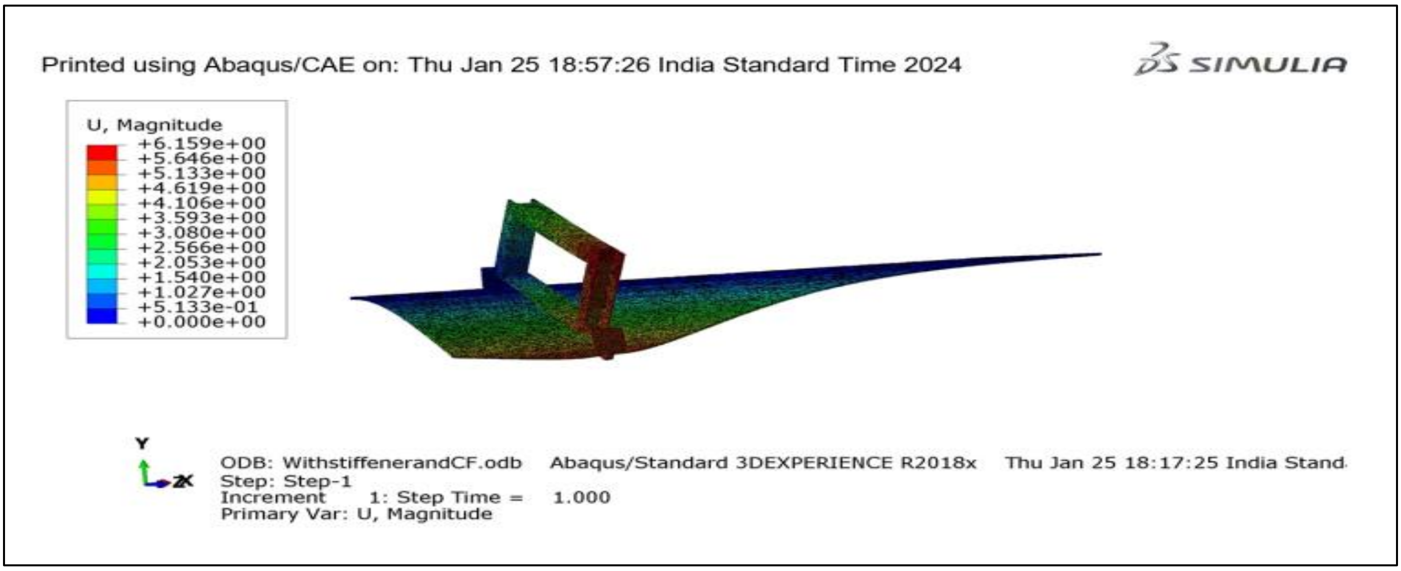

Fig 9 Trial 1

Deformation when the stiffener is added at 560mm away from left end is 6.15mm.

Trial 2: Two stiffeners of L shape, one at a point 500 mm away and the other 620 mm from the left end was added.

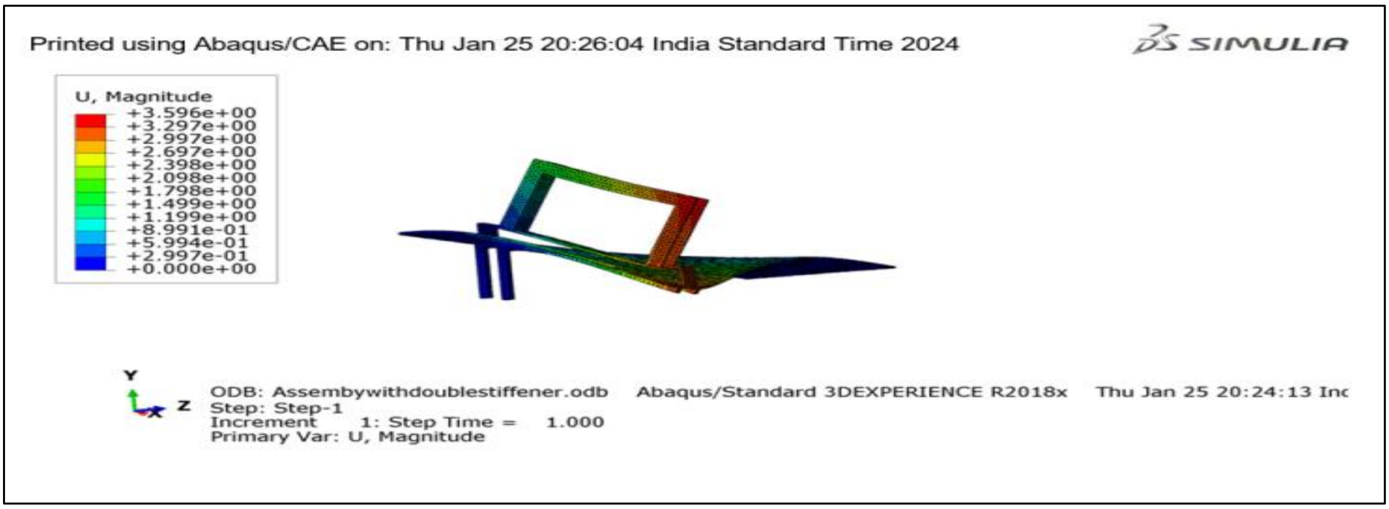

Figure 10 Trial 2

Deformation when two stiffeners are added at 500mm and 620 mm away from left end is 3.59mm.

Trial 3: Two stiffeners of L shape, one at a point 530 mm away and the other 590 mm from the left end was added.

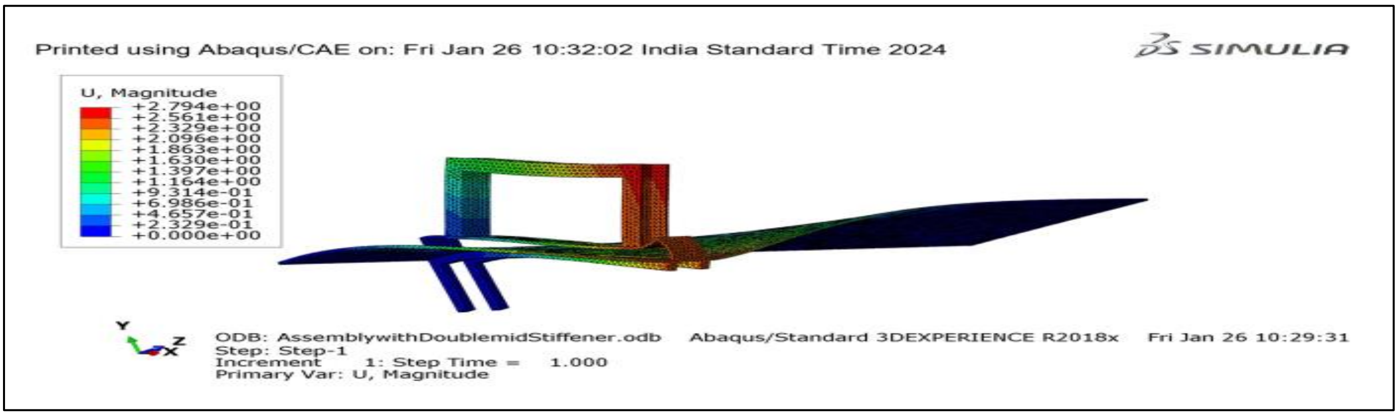

Figure 11 Trial 3

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Deformation when two stiffeners are added at 530mm and 590 mm away from left end is 2.79mm.

Trial 4: Three stiffeners of L shape, at points 500, 560 and 620mm away from the left end was added.

Figure 12 Trial 4

Deformation when three stiffeners are added at 500mm, 560mm and 620 mm away from left end is 2.24mm.

Trial 5: A single stiffener of L shape along with a gusset for full length was added, at a point 560 mm away from the left end was added.[4] Lin, P.C., Tsai, K.C., Wu, A.C. and Chuang, M.C., introduced gusset edged stiffeners to reduce deformation.

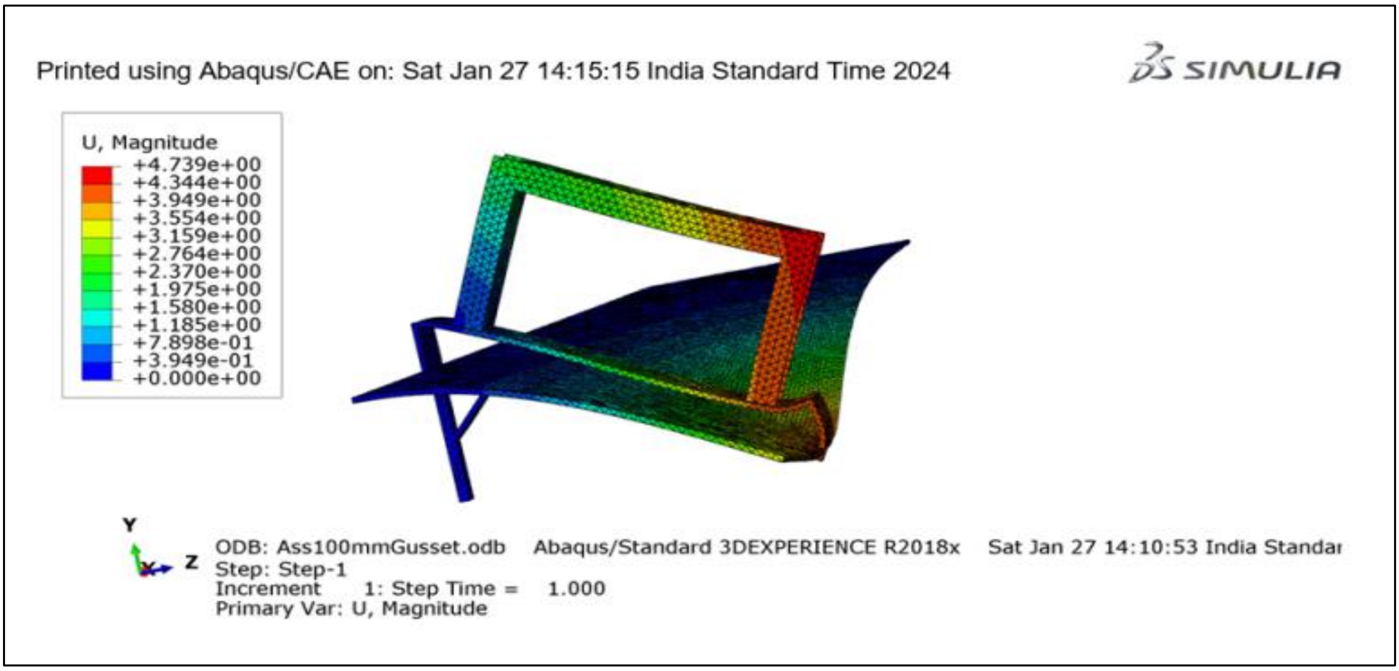

Fig 13 Trial 5

Deformation when a single stiffener is added along with a gusset at 560mm away from the left end is 4.73mm.

Trial 6: A single stiffener of L shape along with a small gusset of length 100mm was added, at a point 560 mm away from the end was added.

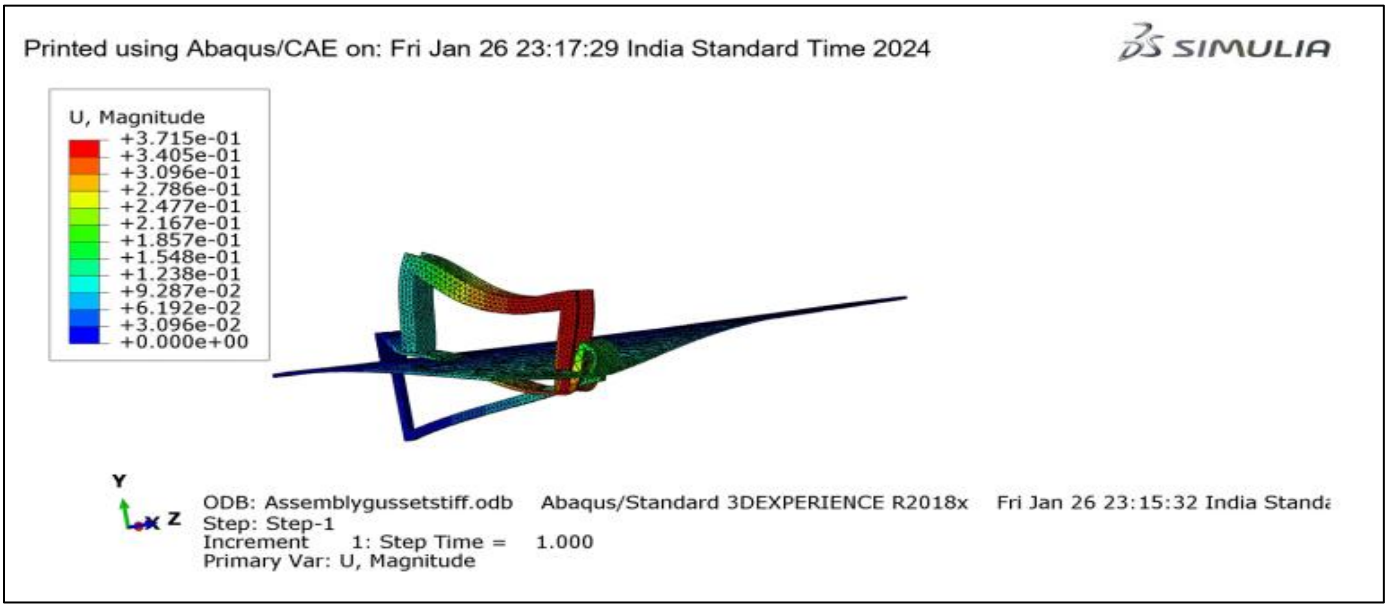

Figure 14 Trial 6

Deformation when a single stiffener is added along with a gusset of length 100mm at 560 mm away from the left end is 0.37mm.

A comparison of the results are given in the Figure 15.

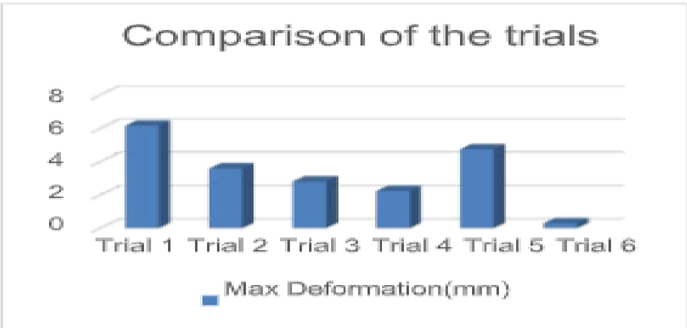

Fig 15 Comparison Chart of the Trials

Out of the 6 trials, though minimum displacement was obtained in the 6th trial, it is not possible to obtain the result practically, as the portion at the top extends below the portion at the middle.

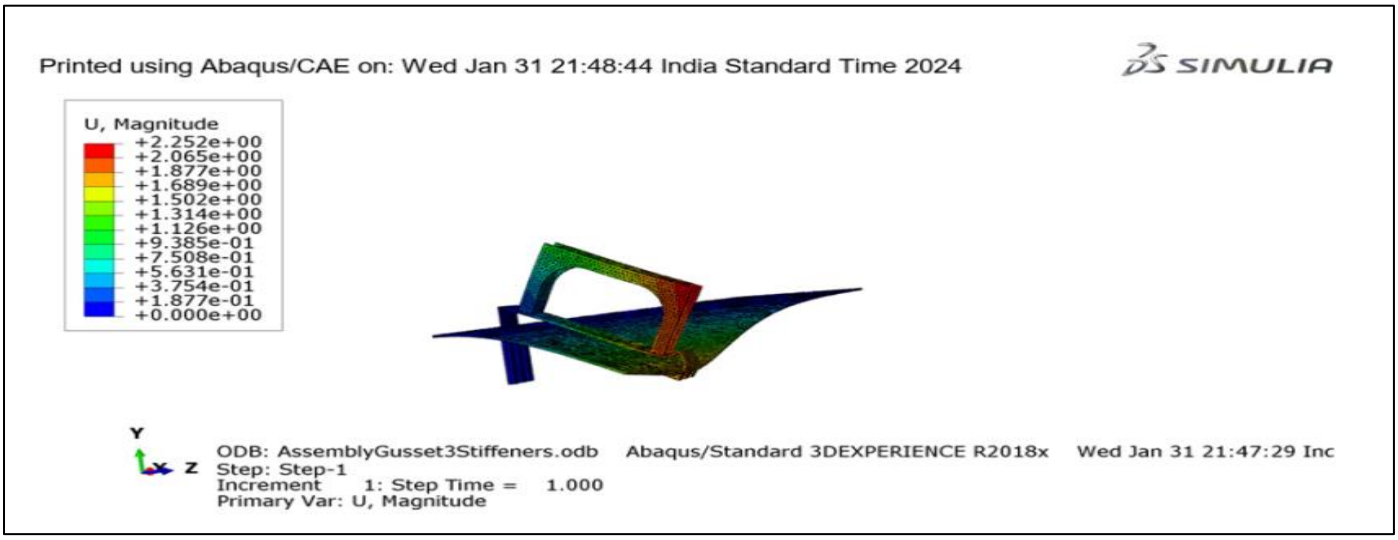

Fig 16 Final Optimized Stiffener

After comparing all the results, the model with triple L shaped stiffeners, at 500, 560 and 620 mm away from the end, gives the best result out of all designs, with 2.2 mm of deformation.

➤ *Inclusion Of Elastic Material*

In order to reduce the deformation further, a vibro-insulating material is chosen to be introduced over the top surface of the assembly. [6][2] Xu, Z.D., Chen, Z.H., Huang, X.H., Zhou, C.Y., Hu, Z.W., Yang, Q.H. and Gai, P.P.,proposed that rubber acts as vibration mitigation materials and Yoon, B., Kim, J.Y., Hong, U., Oh, M.K., Kim, M., Han, S.B., Nam, J.D. and Suhr, J.,investigated and found that SBR elastomer improves dampening properties. Comparing few vibro-insulating materials based on their dampening properties. SBR proved to exhibit better dampening when compared to others. So, it is considered to be used in this model.

The below Figure 17 shows the image of the rubber sheet used in the model, which is highlighted in pink shade.[1] Liao, X., Sun, X. and Wang, H.,suggested that deformation of rubber can be better explained using Mooney Rivlin model. Properties of SBR specified in the analysis include Mooney Rivlin model in place of plastic property, 1.34 Kg/m3 as mass density, 100 as Young's Modulus and 0.49 as Poisson's ratio.

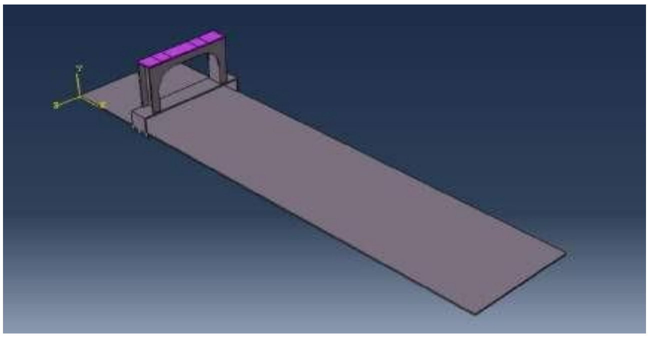

Figure 17 Usage of Rubber

The table below shows the values of the Mooney-Rivlin model for SBR sheet.

Table 1 Mooney Rivlin Values Used

Yield Stress (MPa)	**Plastic Strain**
0.05	0
54000	0.038
152000	0.1338
254000	0.221
362000	0.345
459000	0.46
583000	0.6242
656000	0.851
730000	1.4268

In step manager module, a step with non-linear geometry turned on has been created, under dynamic explicit condition. Loading and meshing conditions are same as mentioned in all the above cases.

Result of the analysis is shown in the following Figure 18. The maximum deformation of the body is around 0.15 mm in the region highlighted in red shade.

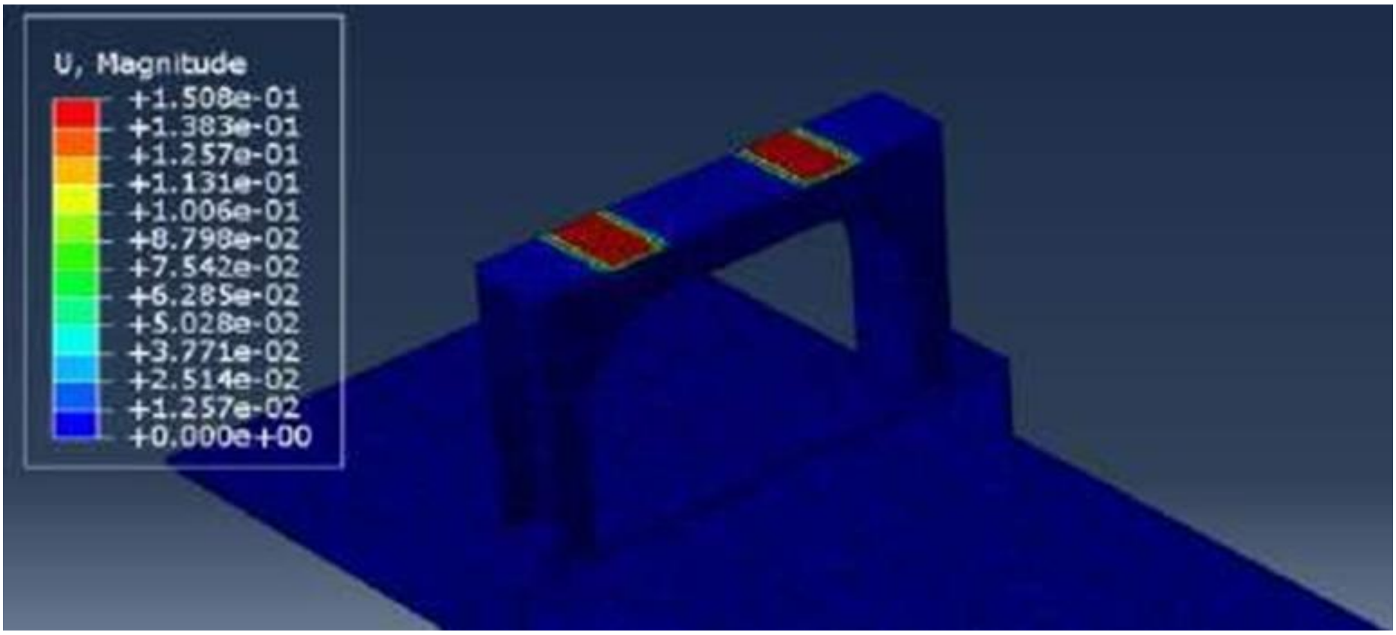

Figure 18 Result of the Structural Analysis with SBR

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IV. CONCLUSION

The structural improvement of the crane boom rest has been successfully achieved through the incorporation of stiffeners and SBR rubber sheets. The redesign has significantly reduced deformation under load, thereby increasing the lifespan and reliability of the crane boom rest. Among the six trials conducted, the configuration with three L-shaped stiffeners at specific intervals provided the best results, reducing the maximum deformation to 2.2 mm. Additionally, the inclusion of SBR rubber sheets further minimized deformation to 0.15 mm, highlighting the effectiveness of vibro-insulating materials in enhancing structural integrity. These findings provide a robust solution for extending the operational life of crane boom rests under dynamic loading conditions.

FUTURE SCOPE

In order to reduce the vibration and deformation of the crane boom rest or any other parts, one can explore with different type of rubber materials with those having better performance characteristics than the Styrene Butadiene Rubber (SBR). And experiment with different types of stiffeners to increase the structural integrity and stiffness of the boom rest.

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