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Design and Analysis of Lifting Tackle Used for Heavy Loads

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ABSTRACT

The material handling system is used for the movement, protect, storage and control throughout manufacturing, warehouse and disposal. The lifting tackle is the type of material handling system is used to lift and lowering the load or material. In this paper the research work is carried on special purpose of lifting tackle which is used for heavy duty application like train Boggie. Tackle design and 3D model is generated by the use of CATIA V5 R21 software. The structural strength is analyzed by using ANSYS Workbench 19.2 version software. For this work two boundary conditions are considered, the design is as per the boundary conditions and it is validated by finite element analysis method. Results will be concluded on the basis of factor of safety.

Keywords: Material Handling system, Lifting Tackle, Finite Element Analysis, ANSYS Workbench.

I. INTRODUCTION

The material handling is most important system in the manufacturing industry. This system is use for short distance movement of the material. The system is refers to the equipment and producers related to the moving, storing and protecting of material throughout the system. The tackle is part of that system.

The lifting tackle is mostly used in the manufacturing or in workshop for handling products. Whereas some special products need special tackle for movement for example assembly line of automobile industry in that they need to special tackle for handling car body, assembly line of aircraft industry.

We focused on lifting the train boggie in the workshop of locomotive industry because this type of industry needs lifting the heavy loads with minimum space, in minimum time without unbalancing of boggie. This reduces the chances of body damage.

There are two different loading conditions like, side wall loading and underbody loading. In First condition side wall loading will be 700kg load acting on 10 different locations of centre of the beam. Under body loading with load of 835kg acting on 12 different points on middle plate hole through lifting hook and 200kg is at 10 different points.

II. LITRATURE SURVAY

The tackles are used in material handling industry from long time but as the industry grows and product varies with their applications the challenges to handle them are also increased. There are different studies has been carried out on the tackles of material handling system. The tackles are developed to reduce the physical efforts of labors. To protect them from repetitive strain injuries, overexertion etc. and to increases their productivity (Abhishekh Rehan, 2021). In older days the material handling equipment are commonly used for all purposes. Hooks are used but they are not that much feasible for every product so that some development has been carried out for special products. (Pravin Hajare 2020). The tackle has been design for lifting the V-type engine. This analysis is carried for 300kg load with safety and economy considerations (Prof. Girirshkumar N. Jagdale 2019). Some studies carried out on car manufacturing industry for car roof lifting tackle. To improvise the lifting stability of car bodies with the help of tackle (Nayeem Mulla 2017). The study refers to steel industry also where the tackles are used to hold the armor plate. They develop two types of different tackles used for the industry (E. J. Reddy 2021).

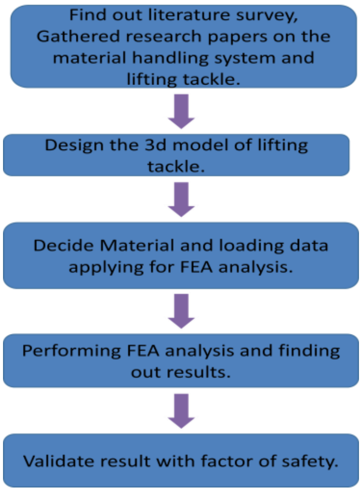
III. PROBLEM STATMENT

Now days, we use heavy crane for lifting boggie which causes unbalancing while lifting, damage to boggie, it takes more space for movement of crane, over tension boggie holding belts.

IV. OBJECTIVE

i. *To design the lifting tackle in the CATIA V5 R21 Version software*
ii. *Study on the different material suitable for sustaining the load capacity to lift or moving that load and locate*.
iii. *The finite element analysis of static structure analysis on the ANSYS Workbench 19.2 version software.*
iv. *Evaluate the equivalent stress (von-misses stresses) and total deformation.*
v. *Validation of results with calculated factor of safety.*

V. METHODOLOGY



VI. CAD DESIGN

Computer aided design is used for the creation, modification, optimization and analysis of the design. CAD software is used to increase the productivity of designer, improve the quality of design and to create the database for manufacturing. In our study we use CATIA V5 R21 software for creation of tackle. The tackle has 350 different parts which is create through part design and sketch base features tools. The geometry has a four main sub-assembly which is design through the assembly design.

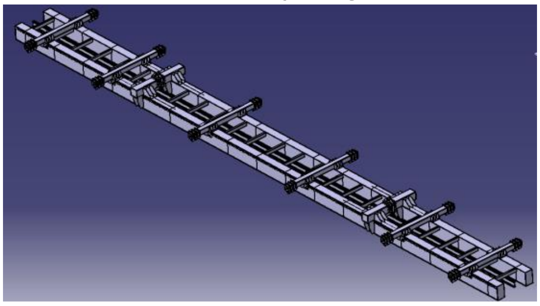
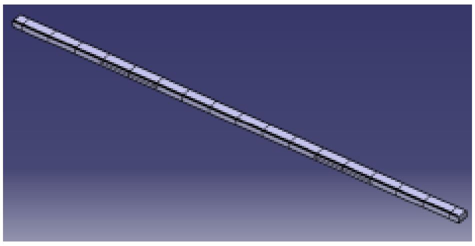


Fig. 1. Full-Assembaly.



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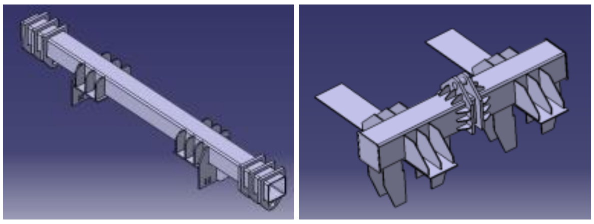

Fig. 2. Sub-Assembaly.

VII. FINITE ELEMENT METHOD

Finite element analysis is a method of numerical method for solving problem of the engineering and mathematic physics. FEA area of interest includes the structural analysis, fluid flow, mass transfer, dynamic analysis, heat transfer and electromagnetic potential. The analytic solution of this problem generally requires the solution to boundary value problem for partial differential equation. FEM formulation of the problem results in the system of algebraic equation. Following are the steps in the FEA.

i. *Material*
ii. *Discretization (Mesh)*
iii. *Boundary Conditions*
iv. *Solve (Solution)*
v. *Interpretation of result*

A. *Material*

IS_2026 is a product standard of Bureau of Indian Standards (BIS). This grade is primarily specifying the standards for the high tensile structural steel for the hot rolled. This type of standers is specially used for structural purpose.

TABLE I. MATERIAL

Material Property	***Magnitude***
Density (kg/m3)	7850
Young's Modules (MPa)	200000
Poisson's Ratio	0.3
Yield Strength (MPa)	250
Tensile Strength (MPa)	410
Allowable stress (MPa)	200

b. *Discretization (Mesh)*

All the components have been meshed with SOLID186 elements. SOLID186 is used for the three-dimensional modeling of solid structures. The element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, stress stiffening, large deflection, and large strain capabilities

SOLID186 Homogeneous Structural Solid is well suited to modeling irregular meshes (such as those produced by various CAD/CAM systems). The element may have any spatial orientation. It can be adjusted itself in the required shape (Tetrahedral, pyramidal, prism etc.) depend upon the complex geometry of the part. Representation of solid 186 elements with different shapes is given below in Fig.

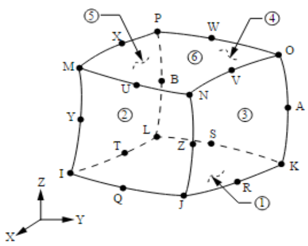

Fig. 3. General representation of solid 186.

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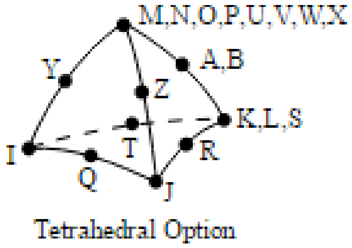


Fig. 4. Tetra-hedral shape of solid 186.

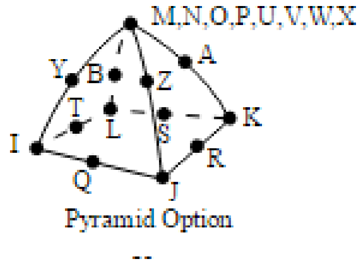


Fig. 5. Pyramidal shape of solid 186.

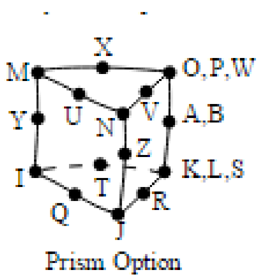
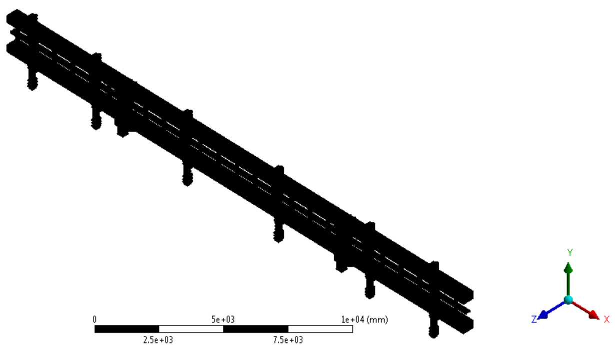
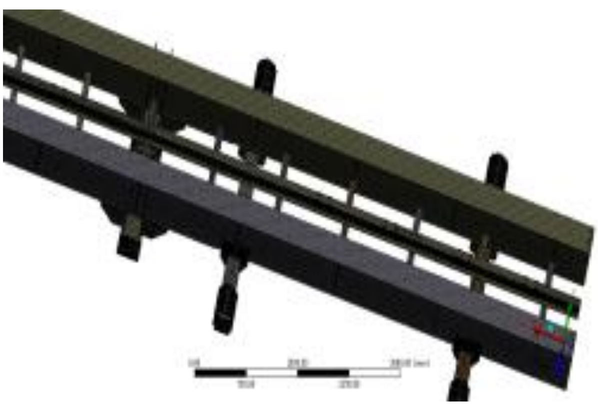


Fig. 6. Prism shape of solid 186.





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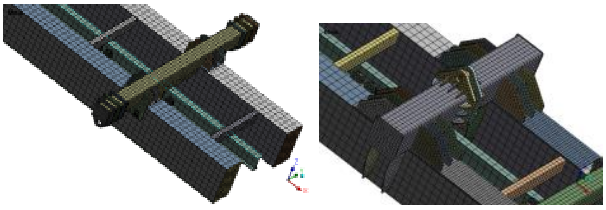


Fig. 7. Mesh.

The above figure shows meshing of the lifting tackle with mesh count, total number of node is 21,61,593 and total number of element is 4,03,997.

c. Boundary Condition

Condition-I (700 kg load at 10 different locations)-: Remote Force = 6864.2 N at location in downward direction, Self weight, Remote Displacement in ZDirection.

Condition-II (835 kg Point Load at 12 different location& 200kg at 10 locations)-: Point Load = 835 kg at 12 different location and 200 kg at 10 location, Self-weight, Remote Displacement in Z-Direction

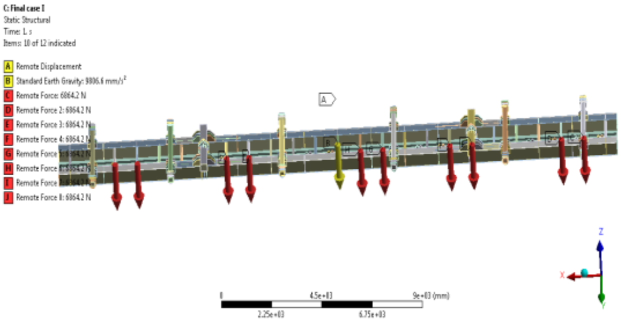


Fig. 8. Boundary Condition I

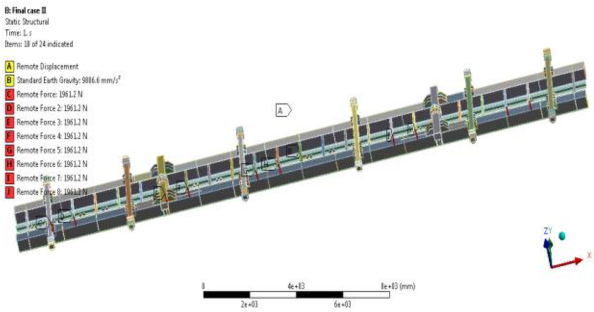
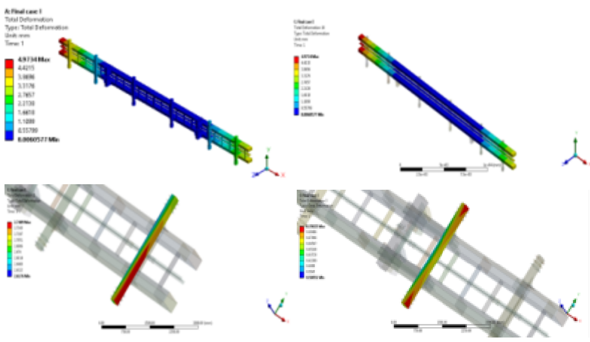


Fig. 9. Boundary Condition II

d. Results

Case I-: Total Deformation in structure and member



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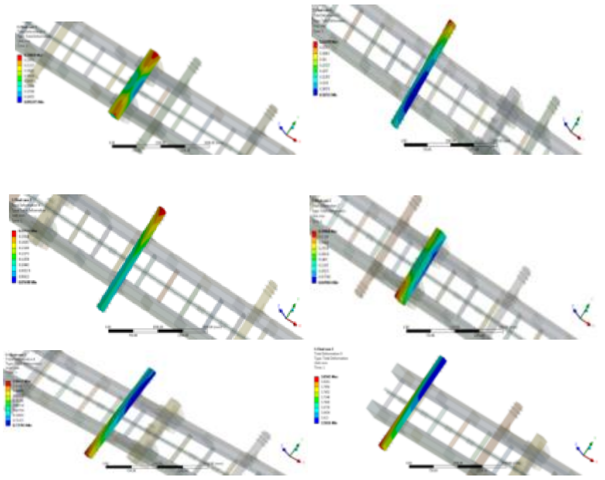


Fig. 10. Total Deformation For Case I

Case I -Equivalent Stress in structure and member

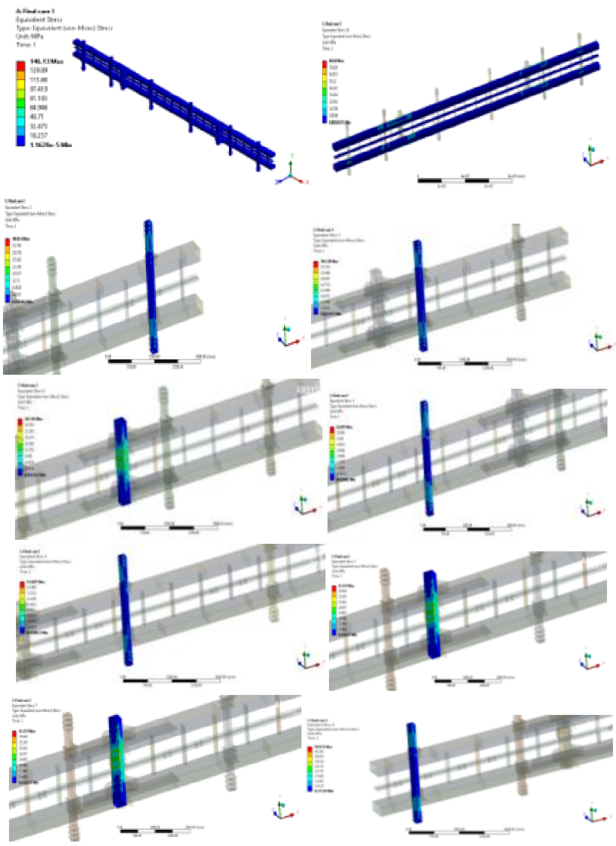
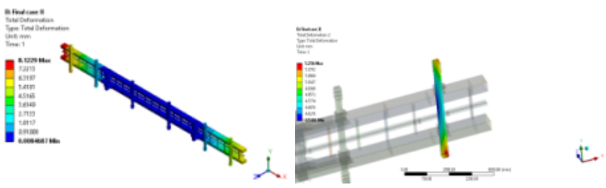


Fig. 11. Equvalent Stress For Case I

Case II-: Total Deformation in structure and member



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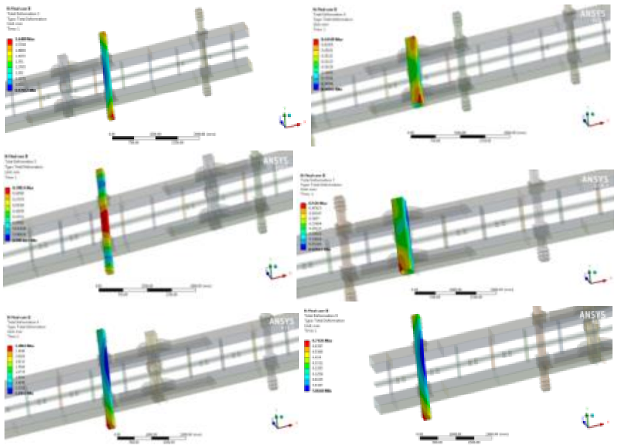

Fig. 12. Total Deformation For Case II

Case II-: Equivalent Stress in structure and member

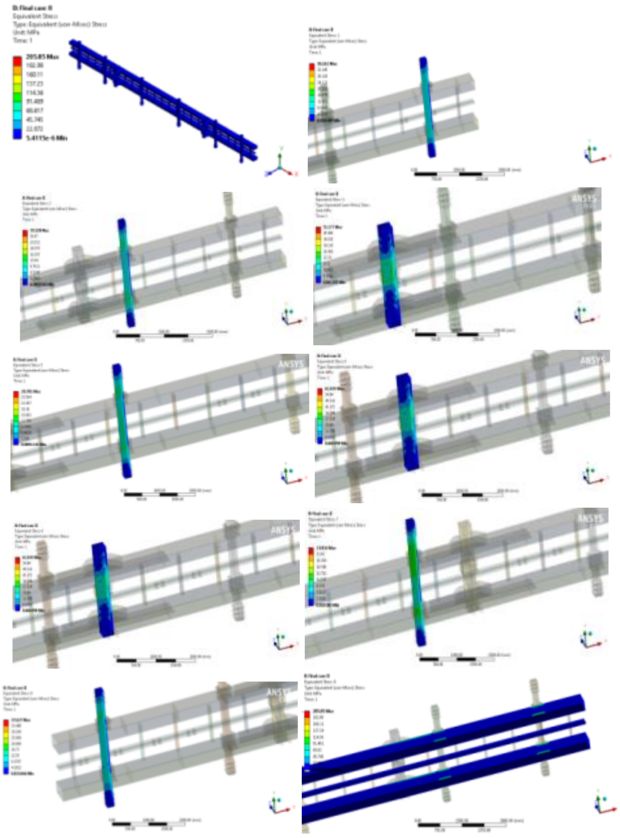

Fig. 13. Equvalent Stress For Case II

Condition- I

Classification	***Total Deformatio n (mm)***	***Equivalent stress (MPa)***
Total Structure	4.9734	146.13
Member_1	2.7489	40.27
Member_2	0.70825	30.138
Member_3	0.24910	28.743
Member_4	0.16195	6.6395
Member_5	0.15933	9.1607
Member_6	0.79868	32.473

Classification	***Total Deformatio n (mm)***	***Equivalent stress (MPa)***
Member _7	1.0642	44.368
Member _8	3.8565	50.933
Member _9	4.9734	88.68

FOS for Condition I = 250 / 146.13 = 1.71

Condition- II

Classification	***Total Deformatio n (mm)***	***Equivalent stress (MPa)***
Total Structure	8.1229	205.85
Member_1	5.256	36.162
Member_2	1.6489	29.328
Member_3	0.44349	51.177
Member_4	0.29813	32.519
Member_5	0.46081	28.781
Member_6	0.526	61.845
Member _7	2.2863	24.845
Member_8	6.7426	37.627

FOS for Condition II= 250 / 205.85 = 1.22

VIII. CONCLUSION

The stress induced in the structure for condition I and Condition II is 146.13Mpa and 205.85Mpa respectively.
The total deformation in the structure for condition I and Condition II is 4.9734mm and 8.1229mm respectively.
From result it observed that stress induced in the structure do not excide the prescribed limit also the total deformation observed in the structure also within limit.
The structure can full the entire requirement. The factor of safety observed above 1.2 for given material. From this point we conclude that, the design is safe at both the conditions.

REFERENCES

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first..."

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