Design and Analysis of Lifting Tackle Used for Heavy Loads

Mr. Mangesh Jadhav[1], Dr. Kuldip Rade[2]
[1]M.Tech, Mechanical engineering Department, Bharati Vidyapeeth College of Engineering Pune-43
[2]Department of Mechanical Engineering, Deemed University, Pune District, Maharashtra, India.
mangesh.772772@gmail.com
karade@bvucoep.edu.in

Abstract

In this paper we discuss lifting tackle, used for heavy duty application that is, lifting train bogie. Currently the train bogie is lifting and lowering with the help of heavy crane. Because of this crane some big problem has been faced while lifting. Problems like, while lifting the bogie which causes imbalance, bogie damage, it takes more space for crane movement. The tensions are generated in the belt while lifting the bogie which causes the accident because of heavy tension in the belt. To avoid this problem we need to develop the tackle for lifting and lowering the bogie.

We need to simulate the structure of tackle as well as we wants to weigh optimization of existing structure by maintaining structural strength, stability as per loading contrition. The 3D model of lifting tackle is generated by using CATIA V5 R18 software and optimization and structure strength can be analyze by using ANSYS (19.2 version) software. The main focus of our project is to optimize the weight as well as maintain structural strength of the tackle.

Keywords: *Material Handling, FEA, ANSYS Workbench, Tackle.*

1. Introduction

Material handling is the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption and disposal.[1] The lifting tackle is the type of the material handling system. Lifting equipment is any work equipment for lifting and lowering loads, and includes any accessories used in it. In current industry there are many special purpose tackle for compete the particular purpose only. [2]

In this paper, firstly we develop the 10 Tons tackle and then we optimize it with 8.5 Tons weight. There are two type of loading conditions. First is side wall loading conation in that 700 Kg Load at 10 different locations and second is underbody loading condition in that 835 Kg load at 12 different location and 200 Kg load at 10 Locations.

2. Objective

- Design the 3D model of lifting tackle in CATIA V5 R18 software.
- Performing FEA analysis on that tackle with ANSYS Workbench software.
- Optimizing the structure as per first iteration results.
- Performing second iteration FEA analysis on modified tackle with ANSYS Workbench software.
- Manufacture both the tackle and conduct the testing.
- Validate all the results.

3. Problem Statement

Now days, we use a heavy crane to lift the bogie which causes imbalance while lifting, bogie injury, it takes up more space for crane movement. The tensions are generated in the belt while lifting the bogie which causes the accident because of heavy tension in the belt. [5]

In the current working industry, customer required to design, analysis of lifting tackle and optimization. The purpose of FEA analysis is to maintain the structural strength of a tackle as well as to focus on optimization of exciting tackle with maintaining structural strength as per customer requirement. [4]

The main focus of the project is to reduce the material where the less stress concentration occurred.

4. CAD Design

In CATIA, you can create assembly models using two types of approaches. The first approach to design is a bottom-up approach and the second a top-down approach.

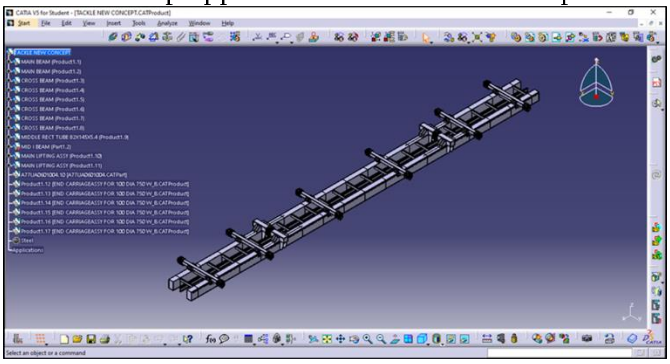
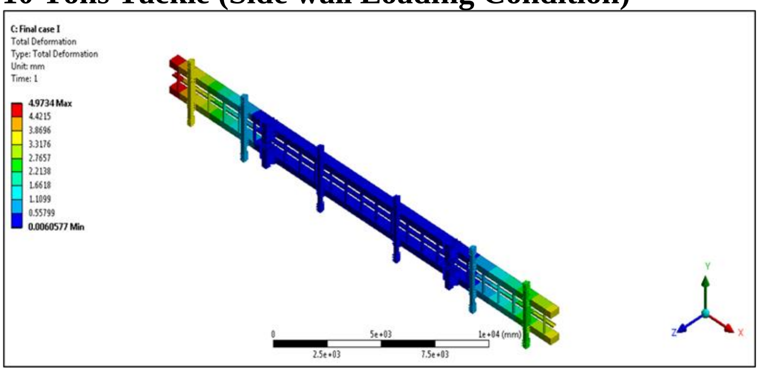


Figure 1. CAD Model of Tackle

5. Finite Element Analysis

To Finite Element Analysis we use ANSYS Workbench software. We perform two iteration for Tackle 10 Tons and 8.5 Tons. The material used for the analysis is IS_2062 for both the tackle. There are two types of boundary conditions, first is side wall loading conation in that 700 Kg Load at 10 different locations and second is underbody loading condition in that 835 Kg load at 12 different location and 200 Kg load at 10 locations. Meshing has been done with node count 2161593 and element count 403997. The results are shown below as per the weight of tackle and boundary condition.

5.1. Results for 10 Tons Tackle (Side wall Loading Condition)



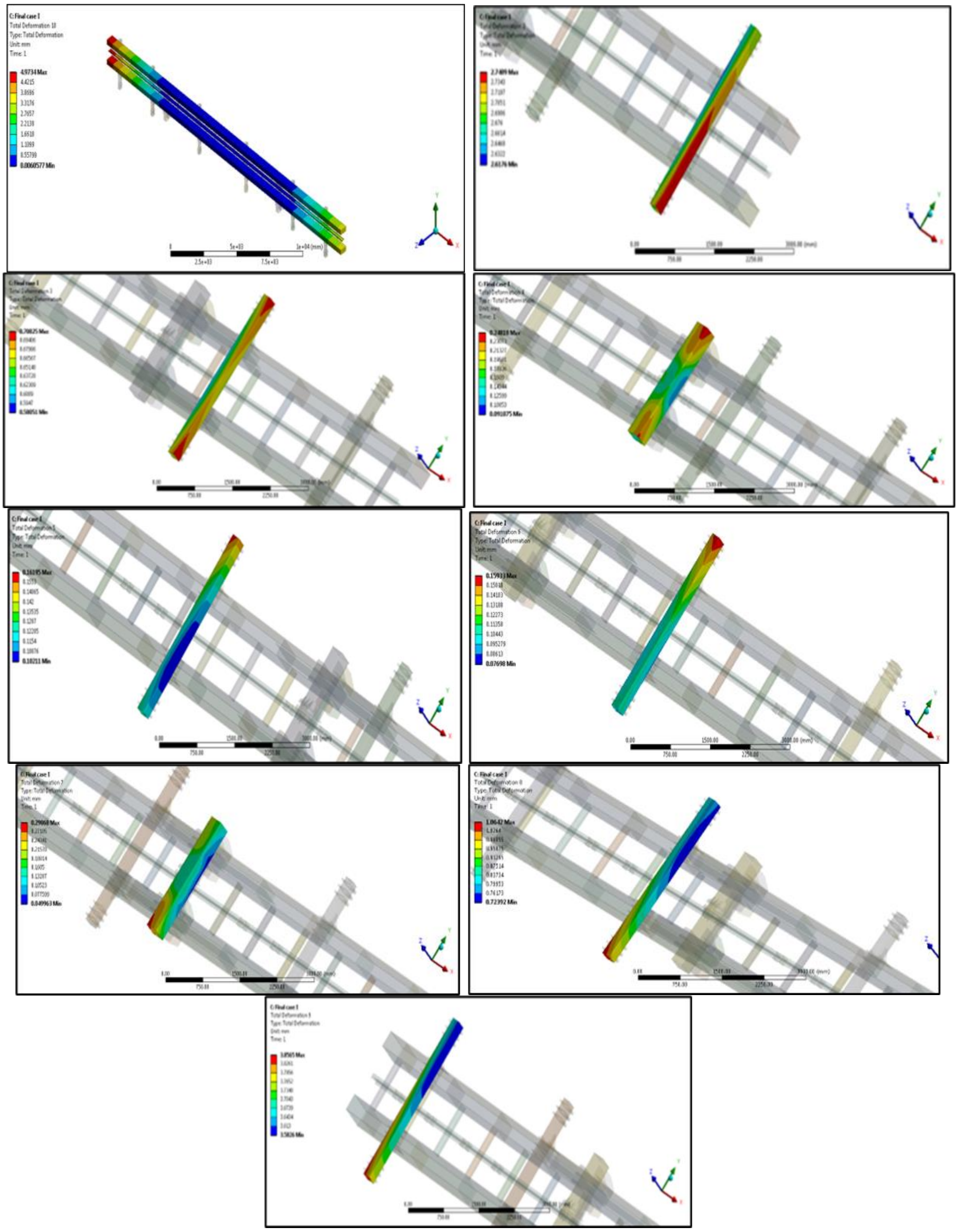
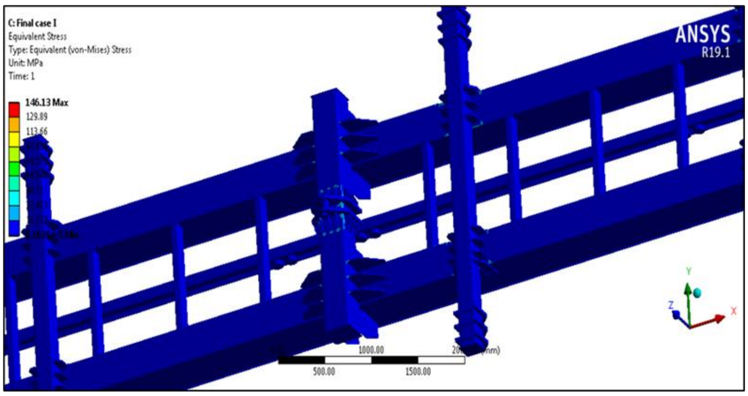


Figure 2. Total Deformation of 10 Tons Tackle for Side Wall Loading



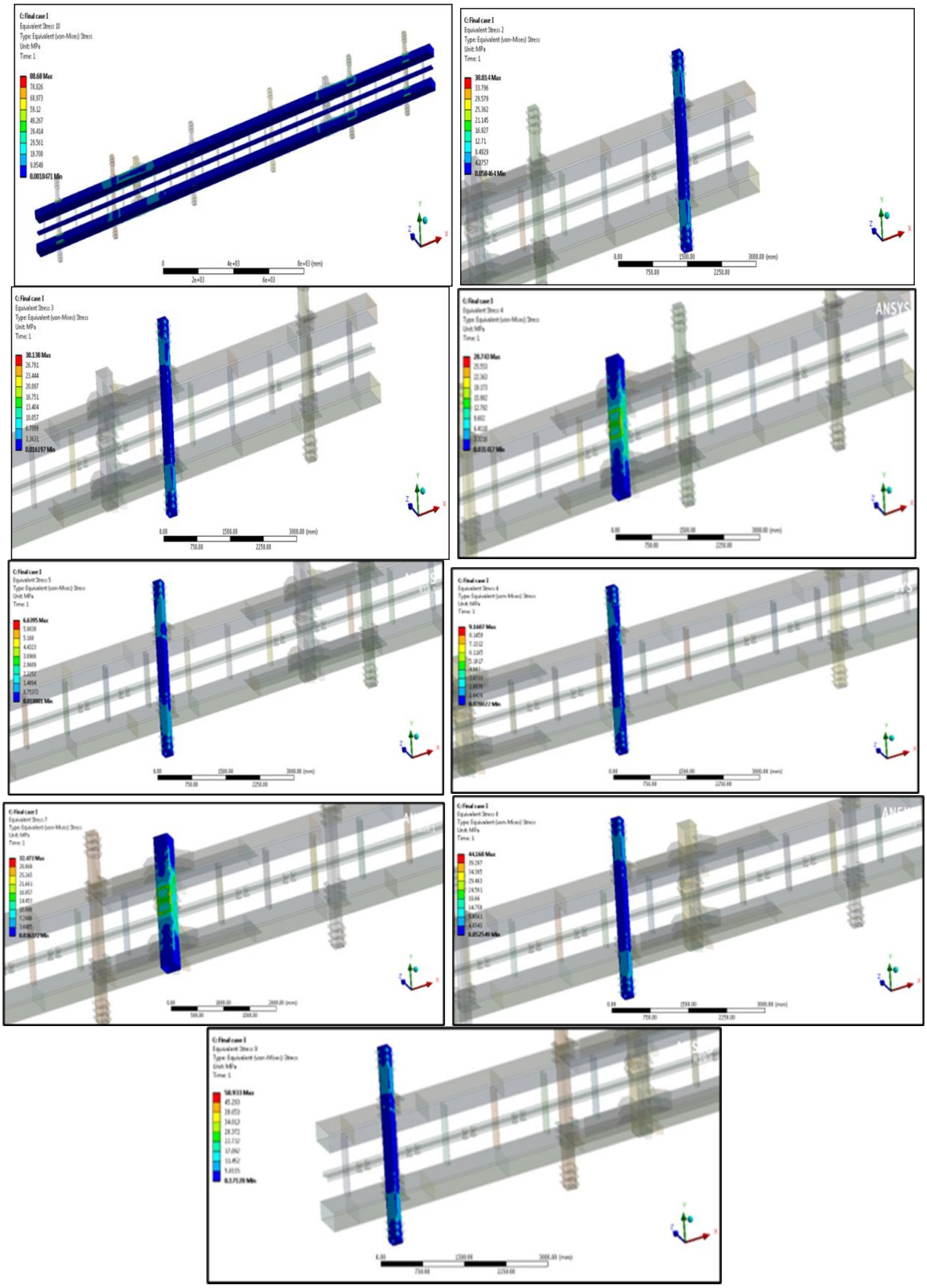


Figure 3. Maximum Equivalent Stress of 10 Tons Tackle for Side Wall Loading

5.2. Results for 10 Tons Tackle (Underbody Loading Condition)

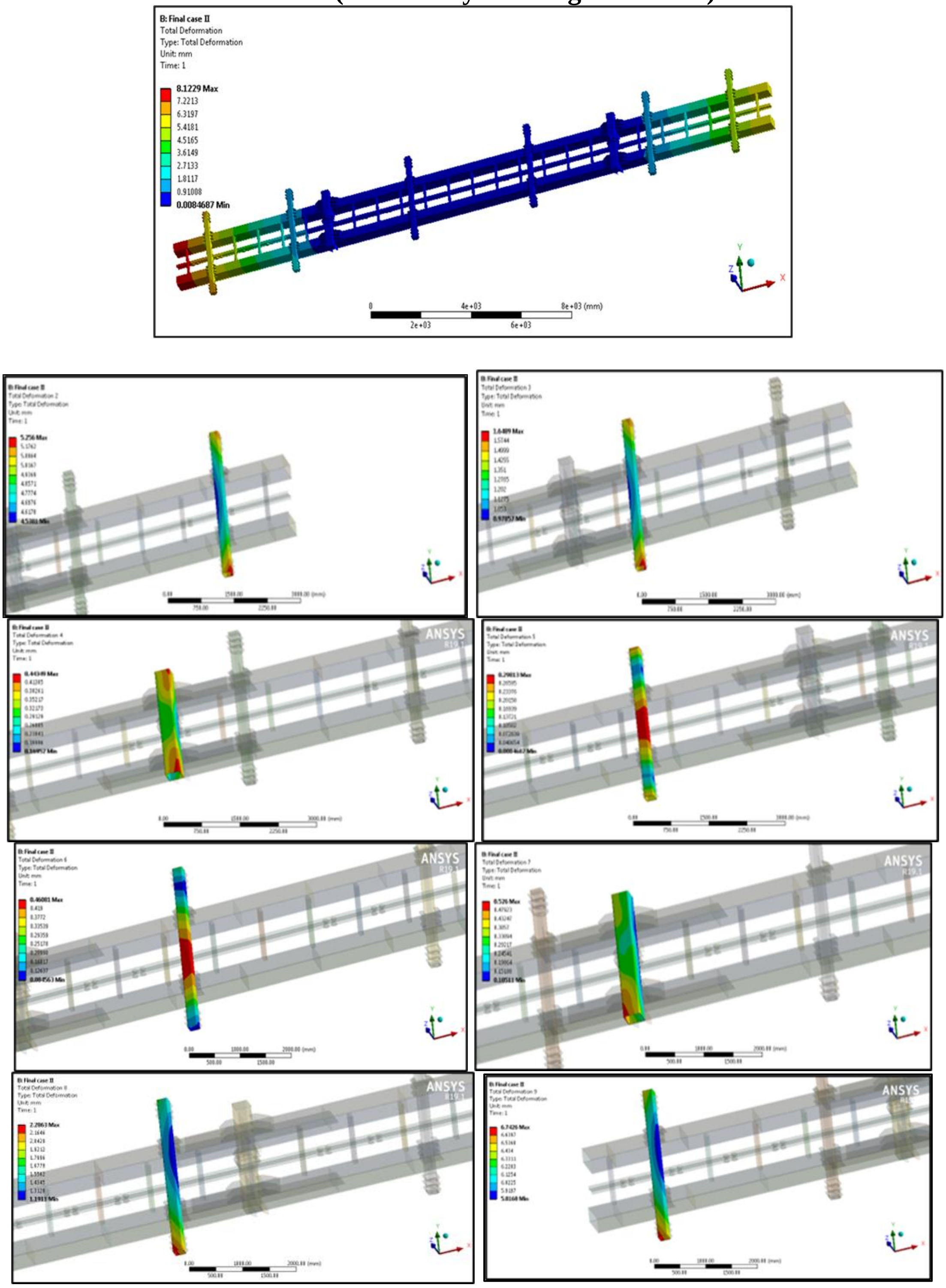


Figure 4. Total Deformation of 10 Tons Tackle for Under Body Loading

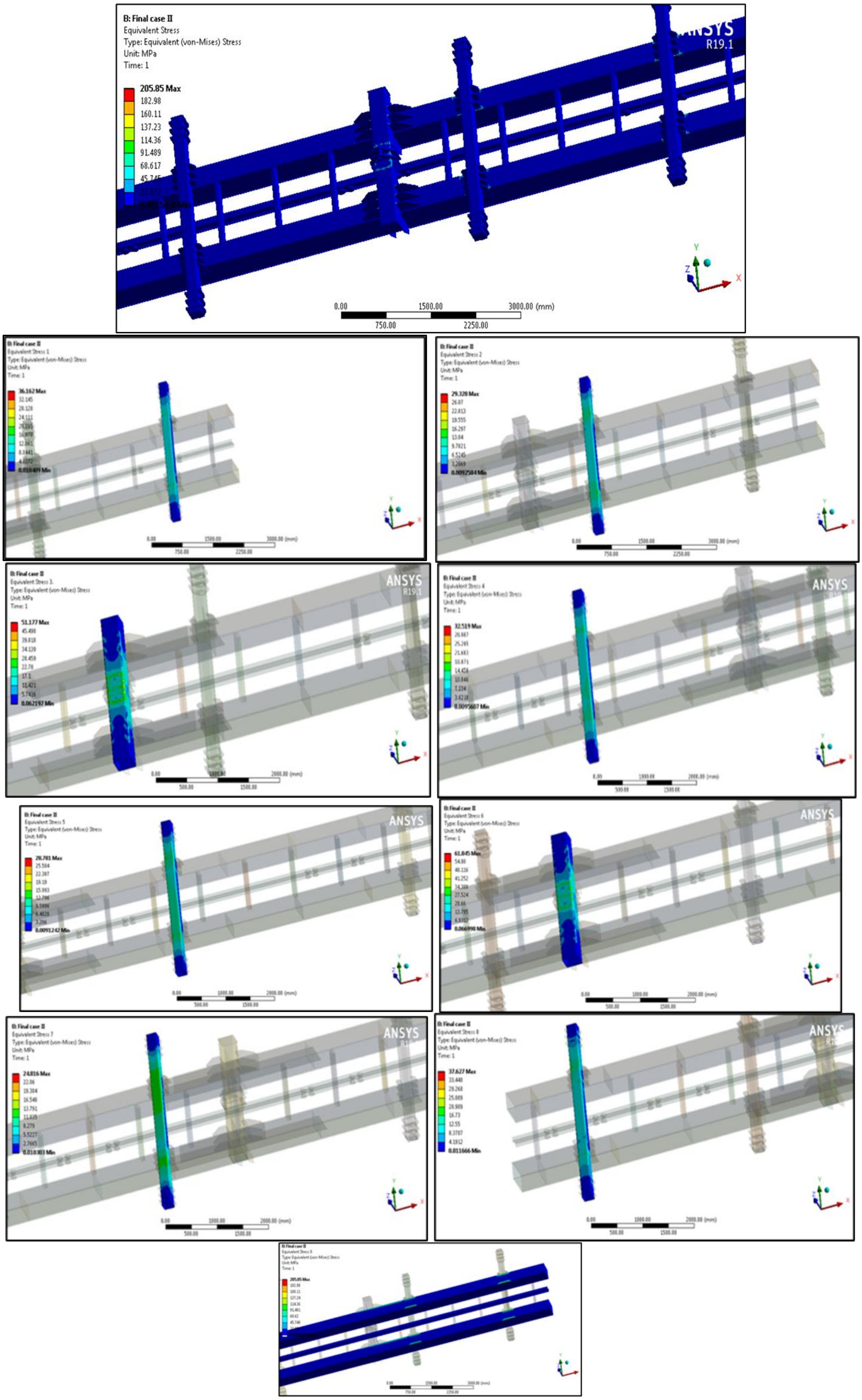


Figure 5. Equivalent Stress of 10 Tons Tackle for Under Body Loading

5.3. Results for 8.5 Tons Tackle (Side wall Loading Condition)

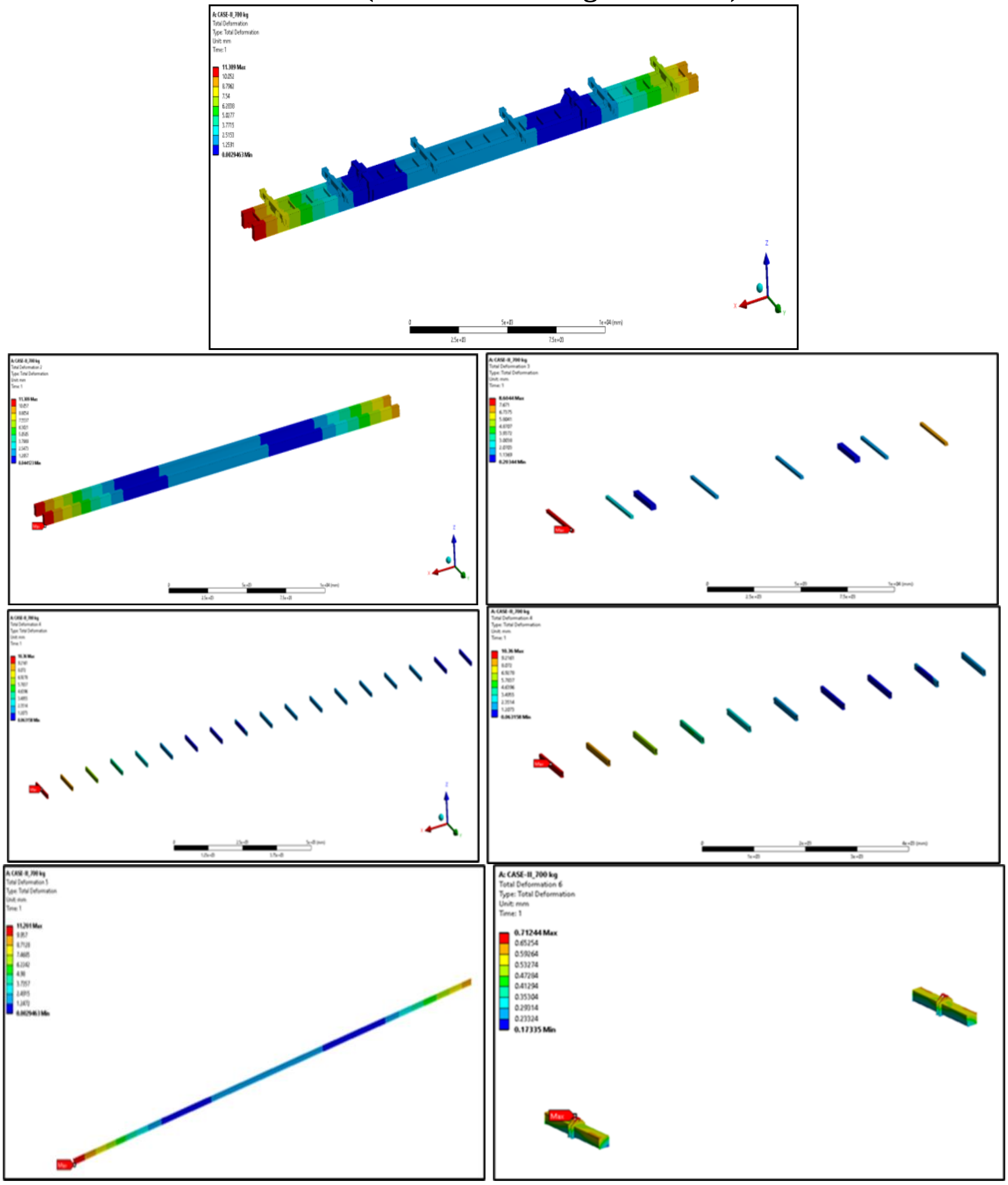
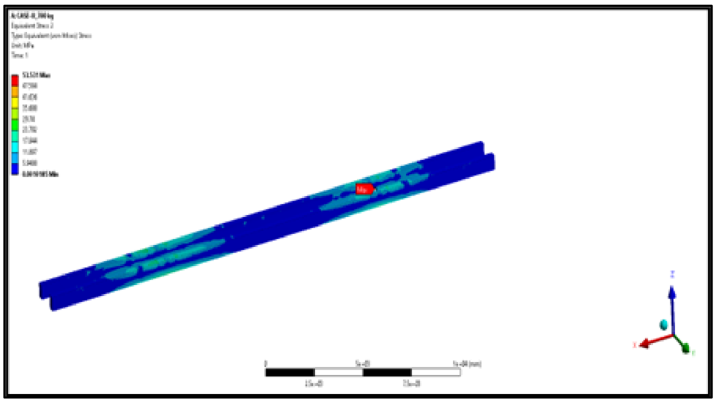


Figure 6. Total Deformation of 8.5 Tons Tackle for Side Wall Loading



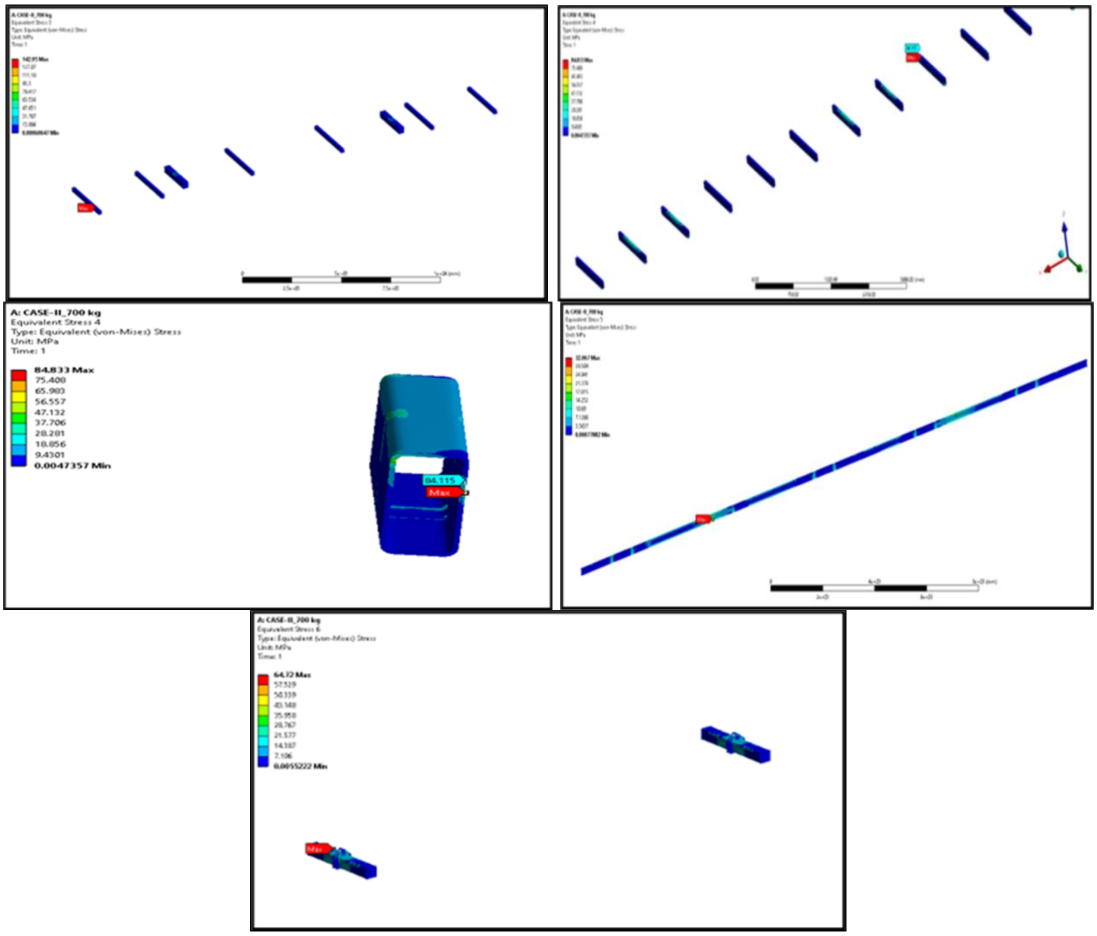
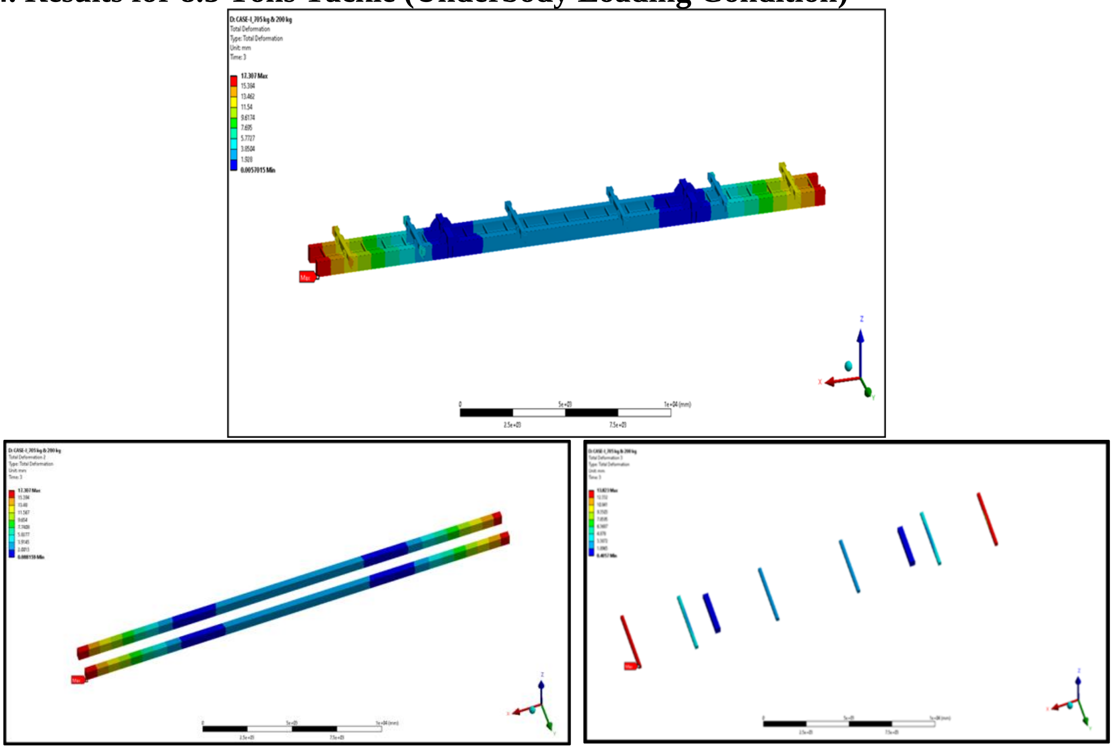


Figure 7. Equivalent Stress of 8.5 Tons Tackle for Side Wall Loading

5.4. Results for 8.5 Tons Tackle (Underbody Loading Condition)



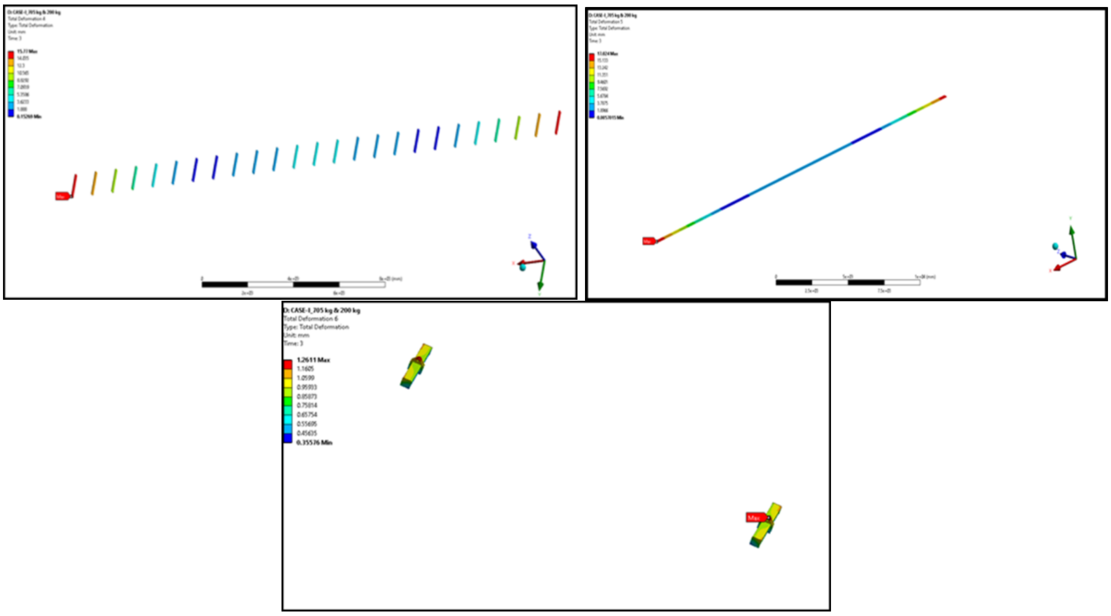
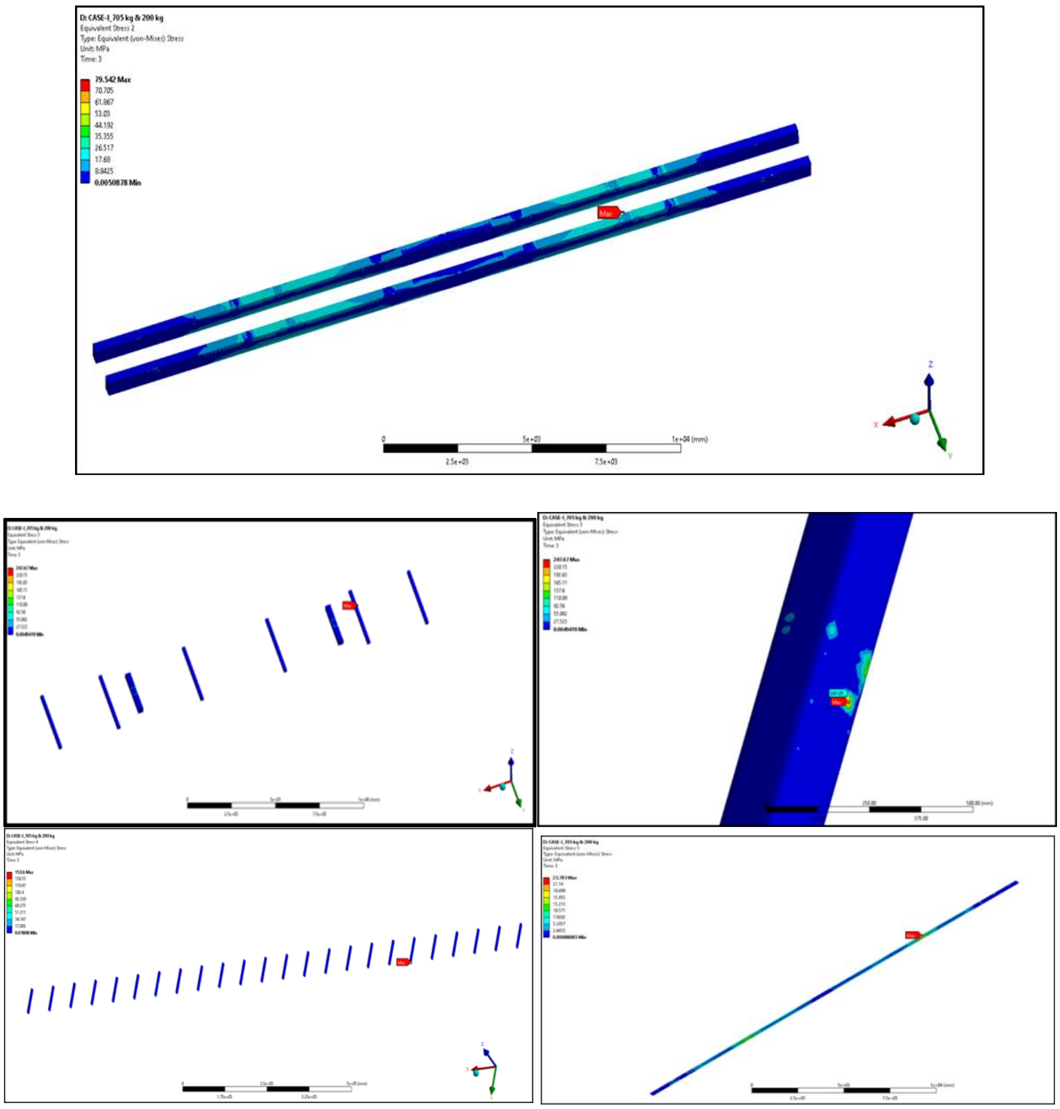


Figure 8. Total Deformation of 8.5 Tons Tackle for Under Body Loading



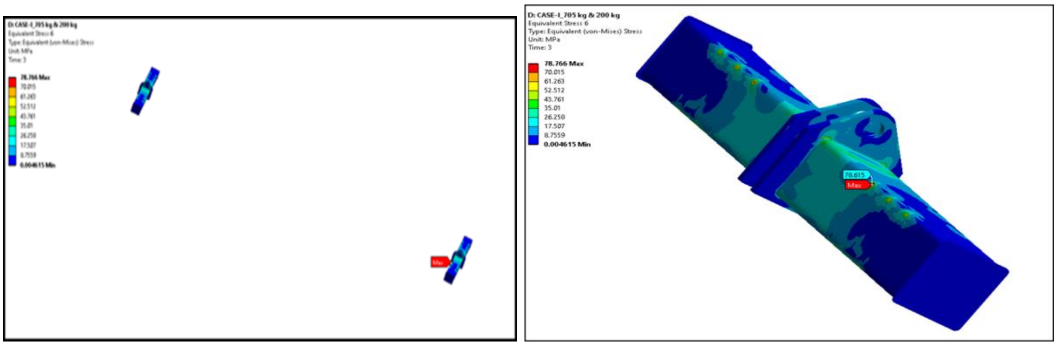


Figure 9. Equivalent Stress of 8.5 Tons Tackle for Under Body Loading

6. Results and Discussion

The tackles consist of number of parts like Rectangular Tubes, Plates, and Beams. There are around 400 numbers parts in the main assembly of the tackle and 4 sub-assemblies. There are two loading cases one is side wall conditions and other is under body condition and the results are as follows.

6.1. Result Summary for 10 Tons Tackle

Table 1. Result Summary for 10 Tons Tackle

Part Name	Side Wall Load		Under Body Load	
	Total Deformation	Equivalent Stress	Total Deformation	Equivalent Stress
Member_2	4.9734	146.13	8.1229	205.85
Member_3	2.7489	40.27	5.256	36.162
Member_4	0.70825	30.138	1.6489	29.328
Member_5	0.24910	28.743	0.44349	51.177
Member_6	0.16195	6.6395	0.29813	32.519
Member_7	0.15933	9.1607	0.46081	28.781
Member_8	0.79868	32.473	0.526	61.845
Member_9	1.0642	44.368	2.2863	24.845
Member_10	3.8565	50.933	6.7426	37.627

Factor of Safety = Allowable Stress / Induced Stress
= 250 / 146.13
= 1.71 …. (For Case I)

Factor of Safety = Allowable Stress / Induced Stress
= 250 / 205.85
= 1.21 …. (For Case II)

6.2. Result Summary for 8.5 Tons Tackle

Table 2. Result Summary for 8.5 Tons Tackle

Part Name	Side Wall Load		Under Body Load	
	Total Deformation	Equivalent Stress	Total Deformation	Equivalent Stress
Member_2	11.309	171.24	17.307	206.75
Member_3	11.309	53.531	17.307	79.54
Member_4	8.6044	142.95	13.823	128.41
Member_5	10.36	84.833	15.77	153.6
Member_6	11.201	32.067	17.024	23.783

Factor of Safety = Allowable Stress / Induced Stress
= 250 / 171.24
= 1.45 …. (For Case I)

Factor of Safety = Allowable Stress / Induced Stress
= 250 / 206.75
= 1.20 …. (For Case II)

7. Testing & Validations

The tackle has been manufacture and the testing is carried out for the members with tensile test for the given loading conditions. The lifting test is carried out for tackle with the loading condition, 835 kg Load at 12 different location and 200 kg at 10 locations. Following table shows the results for the tensile test and lifting test.

7.1. Tensile Test and Lifting Test for 10 Tons Tackle

Table 3. Testing Summary for 10 Tons Tackle

Part Name	Tensile Test					Lifting Test		
	Length	Weight	Density	Load Applied	Deflection in Member	Applied Load	Holding time with 100% load	Remark
Member _2	25000.0	2296.1	7850.0	5010.0	13.36	12020.0	60.0	Safe
Member _3	3200.0	150.2	7850.0	1670.0	2.74	12020.0	360.0	Safe
Member _4	2200.0	156.92	7850.0	2070.0	2.25	12020.0	720.0	Safe
Member _5	25000.0	604.13	7850.0	2000.0	3.97	12020.0	1440.0	Safe
Member _6	2200.0	156.92	7850.0	1670.0	1.15	12020.0	60.0	Safe

7.2. Tensile Test and Lifting Test for 8.5 Tons Tackle

Table 4. Testing Summary for 8.5 Tons Tackle

Part Name	Tensile Test					Lifting Test		
	Length	Weight	Density	Load Applied	Deflection in Member	Applied Load	Holding time with 100% load	Remark
Member _2	25000.0	2296.1	7850.0	5010.0	14.69	12020.0	60.0	Safe
Member _3	3200.0	150.2	7850.0	1670.0	3.151	12020.0	360.0	Safe
Member _4	2200.0	156.92	7850.0	2070.0	2.55	12020.0	720.0	Safe
Member _5	25000.0	604.13	7850.0	2000.0	4.445	12020.0	1440.0	Safe

Member _6	2200.0	156.92	7850.0	1670.0	1.27	12020.0	60.0	Safe

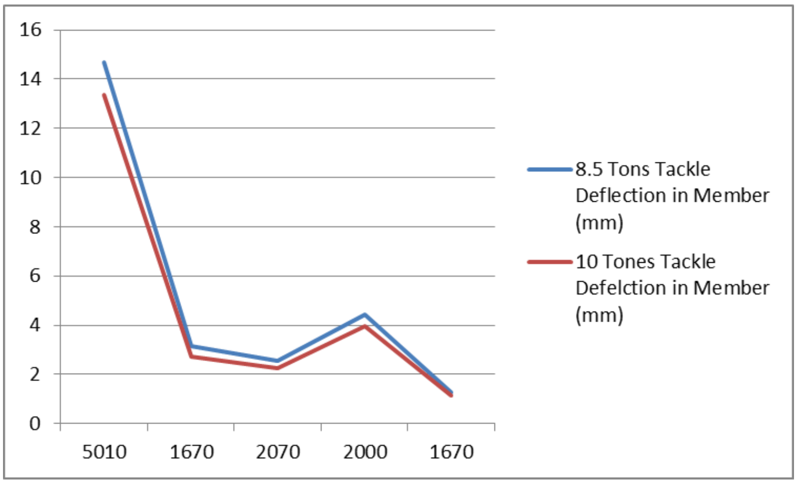


Figure 10. Testing Results Summary

From the above results, all the deflection results are under acceptance criteria that is Deflection > L/325 from the IS: 800 standards.

Conclusion

The analysis is performed for two types of loading conditions. First is side wall load and other is under body load condition. The first iteration is for 10 Tons and after development it will be for 8.5 Tons. From the Iteration first 10 Tons Tackle, Total Deformation and Maximum Von- Mises Stress is 4.97 mm & 146.13 MPa respectively for Case I and for Case II for Total deformation is 8.12mm and stress is 205.8MPa. The second iteration is for 8.5 Tons tackle and the results for Cast I is 11.03mm total deformation and 171.24 MPa Maximum equivalent von-Mises stress. For case II is 17.30 mm total deformation and 206.75 MPa Maximum equivalents Stress.

The validation of results is with the help of factor of safety. The factor of safety is above 1.2 for both the tackle (10 Tons & 8.5 Tons) and both the conditions. Hence, from FEA results and post processing we can conclude that 8.5Tons and 10 Tons tackle is safe for the side wall loading condition and under body condition.

From the testing and validation results, we achieve the 15% of reduction with given loading conditions.

References

[1] *Abhishek Rehan, Pawankumar R Sonawane. Design and Optimization of Lifting Tackle. International Journal of Advance Research, Idea and Innovation in Technology IJARIIE-ISSN (O)-2395-4396 Vol-7 Issue-4. 2021.*

[2] *E.J. Reddy, G.K. Reddy, D. Rajendra. International Journal on Technical and Physical Problem of Engineering. IJTPE ISSN 2077-3528 Volume 13 Issue 46 Number 1 Page 23-28, 2021.*

[3] *Pravin Rajendra Hajare, S. M. Jadhav. Experimental Stress Analysis and Optimization of Crane Lifting Tackle. International Research Journal of Engineering and Technology (IRJET) Volume 07, Issue 08, 2020.*

[4] *Girishkumar N. Jagdale, Amrut G. Habib, Shashankar M. Hebbal, Pradip G. Karale (2019). Optimized Parametric Analysis of Lifting Tackle. International Journal for Scientific Research and Development Vol. 06, Issue12, 2019.*

[5] *Pappuri Hazarathaiah, K. Venkateswarlu, M. Sreenivasulu. Design and Analysis of Lifting Hook with Different Materials. Journal of Emerging Technologies and Innovative Research JETIR Volume 5, Issue 4, 2018.*

[6] *Nayeem Mulla, Dr.B. S. Manjunath. Design and Strength Analysis of Roof Lifting Tackle Arrangement. International Research Journal of Engineering and Technology (IRJET) Volume 04, Issue 05, 2017.*

[7] *Girishkumar Nagnath Jagdale, Rajratna A. Bhalerao, Dhanajay K. Patel. Design and Analysis of Lifting Tackle for V Engine. International Journal of Technical Research and Applications IJTRA Volume 4, Issue 4, 2016.*

[8] *Journal of Algebraic Statistics Volume 13, No. 2, p. 1156-1164https://publishoa.com ISSN: 1309-3452 1164[4]P S Chakraborty, G Majumder and B Sarkar (2006). Performance evaluation of material handling system for a warehouse. Journal of Scientific & Industrial Research Vol. 66, April 2007, pp. 325-329, 2022.*

[9] *Zakarya Soufi, Pierre David, Zakaria Yahouni. Field studies analysis for new Material Handling System Design approach. Research Square Company Commands Russia's Invasion Ukraine, 2021.*

[10] *Qi Hao, Weiming Shen. Implementing a hybrid simulation model for a Kanban-based material handling system. Integrated Manufacturing Technologies Institute, National Research Council Canada, 800 Collip Circle, London, Ontario, Canada N6G 4X8, 2007.*

[11] *S. Senthil1, G. Gurusaravanan, K. Amudhan, S.Chelladurai4. A Framework for Evaluation of Material Handling Equipment. International Journal of Mechanical Engineering and Research, 2013.*

[12] *Jessica O.MATSON, John A.WHITE. Operational research and material handling. School of lndustrtal and Systems Engineering, Georgta lnstttute of .,echnology, Atlanta, GA 30332, U.S A. 1982.*

[13] *HSED, Safe use of lifting equipment, lifting operations and lifting regulations 1998, revised in 2014.*

[14] *NIOSH, Manual material handling, California department of industrial relations, 2007, issue-131.*

[15] *Michael G. Kay, Material handling equipment, Fits Dept. Of Industrial and Systems Engineering North Carolina State University, 2012.*

[16] *J. Bilbao, E. Bravo, O. Garcia, C. Rebollar, C. Varela, "Designing and Projecting a Wind Generator Based on the Emplacement: Power Coefficient", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 45, Vol. 12, No. 4, pp. 91-96, December 2020.*

[17] *G.K. Reddy, B. Sravanthi, "Design and Analysis of a Propeller Blade Used for Marine Engine", International Journal of Scientific Research in Science, Engineering and Technology, Vol. 6, pp. 440-445, 2019.*

[18] *Arcelor Mittal Global R&D - East Chicago Laboratories, "A Case Study on the Fracture of Sinter Machine Pallet Axles", Engineering Failure Analysis, Vol. 42, pp. 345-352, 2014.*

[19] *N. Genc, S.J.M. Shareef, "Design Dual Axis Sun Power Tracking System Using Arduino", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 29, Vol. 8, No. 4, pp. 34-38, December 2016.*

[20] *G.N. Jagdale, R.A. Bhalerao, D.K. Patel, "Design and Analysis of Lifting Tackle for V Engine", International Journal of Technical Research and Applications, Vol. 4, pp. 72-76, 2016.*

[21] *N. Mulla, B.S. Manjunath, "Design and Strength Analysis of Roof Lifting Tackle Arrangement", International Research Journal of Engineering and Technology, Vol. 4, pp. 2601-2604, 2017.*

[22] *B.Suneel, B. Phani Shankar "Structural And Model Analysis Of Dual Hook Joint" International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, October 2015.*

[23] *Patel Ravin B,., Patel Dixit H.,Patel hirak "Design And Analysis Of Crane Hook With Different Material" Department of mechanical engineering " ISSN:2319-7900.*

[24] *Sayyedkasim Ali1, Harish Kumar2, Shishir Agrawal3, "Stress Analysis of Crane Hook with Different Cross Section Using Finite Element Method" International Journal of Science and Research (IJSR) ISSN (Online): 2319-706.*

[25] *Patel Hirak, Design and analysis of crane hook with different material, International journal of advanced computer technology (IJACT), 2319-7900, 2015.*

[26] *Ajeet Bergaley, Structural analysis of crane hook with finite elements method, International journal of science and modern engineering (IJISME), volume 1, Issue 10, 23196386, 2013.*

[27] *X. Jun Kang, B.J. Zhao, B. Long, "Design of SandBlasting Lifting Equipment", Advanced Materials Research, Vol. 1006, pp. 211-216, 2014.*

[28] *E.J. Reddy, C.N.V. Sridhar, V. Pandu Rangadu, "Knowledge Based Engineering: Notion, Approaches and Future Trends", American Journal of Intelligent Systems, Vol. 5, pp. 1-17, 2015.*

[29] *Chetan N. benkar, Dr.N.A. Wankhade, Finite element stress analysis of crane hook with different cross- section, may 2014.*

[30] *M. Amareswari Reddy1, M.N.V Krishnaveni2, B. Nagaraju3, M RajaRoy4, "Static Analysis of Crane Hook with T-Section Using ANSYS", International Journal of Engineering Trends and Technology (IJETT) – Volume 26 Number 2- August 2015.*