Analysis Of Contact Stresses For Crane Hook Assembly Under Plasticity Condition For Different Materials Using Finite Element Method

Hussein Mohammed Hasan[1] , B.P.Chandra Sekhar[2]
[1]M.Tech student, Department of Mechanical Engineering,
ANUCET Nagarjuna Nagar,GUNTUR,INDIA
Email id: hu6343@yahoo.com
[2]Assistant Professor, Department of Mechanical Engineering,
ANUCET Nagarjuna Nagar, GUNTUR,INDIA
Email id:chandra.boyapati@gamil.com

Abstract:

In the industrial processes Crane Hook is used as lifting member. Crane Hooks are highly liable components and are always subjected to failure due to accumulation of large amount of stresses which can eventually lead to its failure. Real time pattern of stress concentration in 3D models of crane hook is obtained of different cross section (circular, trapezoidal). In the present study we assessed the contact frictional stresses for maximum load and under the plasticity of conditions of two different materials for different cross sections. The 3Dmodels were developed in solid works and the predicting of contact stresses were done in ANSYS Workbench module of 16.0 versions. By using above availabilities analyzed the contact stresses for circular and trapezoidal cross section for different materials in it trapezoidal cross-section and the structural steel is the best material comparatively to cast iron. .

Keywords

Crane hook assembly with bolt, plasticity nature, circular cross section, Trapezoidal cross section, solid works, Finite Element method

1. Introduction

Crane hooks are the components which are generally used to lift the heavy load in industries and constructional work. Recently, generally crane hook are used in constructional work such a machine is useful since they can Do the conventional digging tasks as well as the suspension works. Another reason is that there are work sites where the crane trucks for suspension work are not available because of the narrowness of the site. In general an excavator has superior manoeuvrability than a crane truck. Hooks are also available in following different cross section area. The stress concentration factors are widely used in strength and durability evaluation of structures and machine elements. A large number of research works have been performed in this field and recommendations for the engineers developed [1, 2]. However, the diversity of the loading cases, geometry and material characteristics together with the new solution methods motivates to continue the research, as it is proved by a large number of notch problem related publications that appeared during the last decade. The review of these and earlier publications allow to conclude that the specific group of the structural members, the curved beams, need a more extensive investigation since a very few articles in this field have been published yet (perhaps, there is the one and the only publication directly related to the stress concentration factors in curved beams due to the additional discontinuity of the geometry, the circular holes, under bending load [3]). The present article continues the research work [4] on the modeling of the wear damage and its influence to the stress concentration for the lifting hooks of trapezoidal cross-section

2. Literature survey

M. Shabanet. al (2013), studied the stress pattern of crane hook in its loaded condition, a solid model of crane hookis prepared with the help of ABAQUS software. Real time pattern of stress concentration in 3D model of crane hook is obtained. The stress distribution pattern is verified for its correctness on an acrylic model of crane hook using shadow optical method (Caustic method) set up. By predicting the stress concentration area, the shape of the crane is modified to increase its working life and reduce the failure rates. •

E.Narvydaset. al (2012), investigated circumferential stress concentration factors with shallow notches of the lifting hooks of trapezoidal cross-section employing finite element analysis (FEA). The stress concentration factors were widely used in strength and durability evaluation of structures and machine elements. The FEA results were used and fitted with selected generic equation. This yields formulas for the fast engineering evaluation of stress concentration factors without the usage of finite element models

3. Modeling

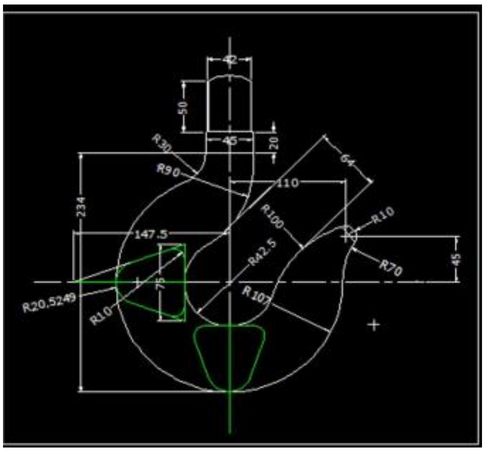

Figure 1:Dimensions of crane

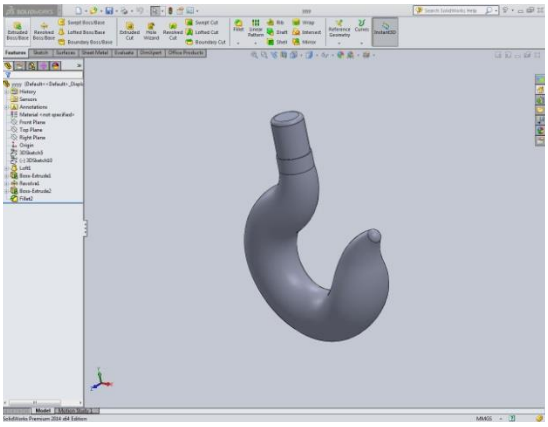

Figure 2: Circular cross section

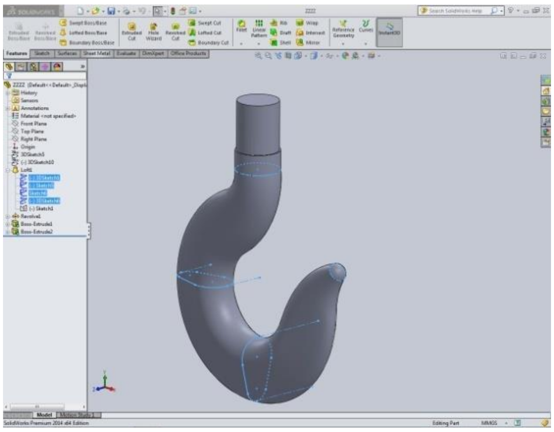

Figure 3: Trapezoidal cross section

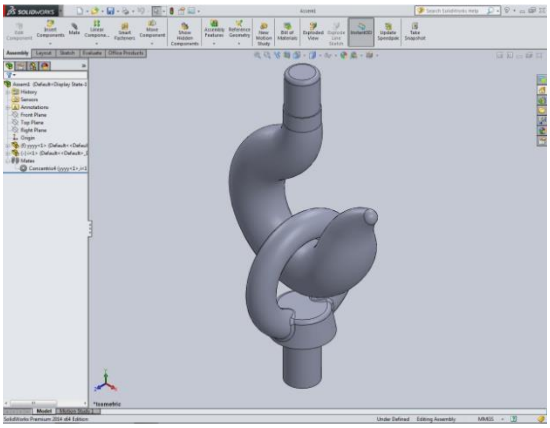

Figure 4: Assembly Model of crane hook and bolt

4. Material Properties under plasticity condition

Property of material to be deformed repeatedly without rupture by the action of a force, and remain deformed after the force is removed. The plasticity of a material is directly proportional to the ductility and malleability of the material. Ideal plasticity is a property of materials to undergo irreversible deformation without any increase in stresses or loads.

Plasticity in metals is typically a result of dislocations. In brittle materials like rock or concrete, plasticity is caused predominantly by slippage at micro cracks. Plastic materials with hardening require increasingly elevated stresses to result in further plastic deformation

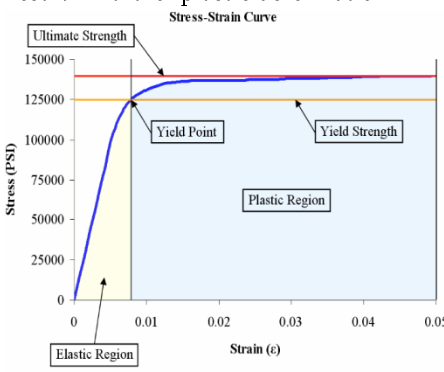

Figure5: Describes the plasticity nature

International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 06
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Object Name	*Geometry*
State	Fully Defined
Definition	
Source	J:\ \crane\MODAL1.STEP
Type	Step
Length Unit	Meters
Element Control	Program Controlled
Bounding Box	
Length X	227. mm
Length Y	434.99 mm
Length Z	168.3 mm
Properties	
Volume	2.0317e+006 mm³
Mass	15.949 kg

TABLE 1 Model (A4) > Geometry

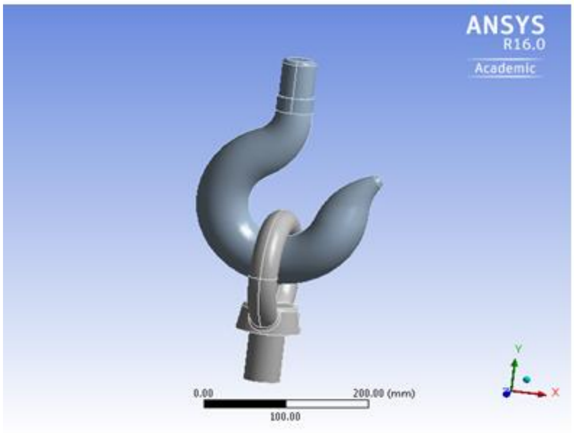


Figure 8: Imported model from solid works

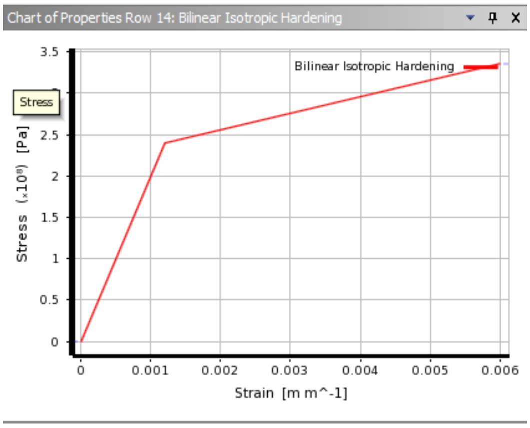


Figure6: plasticity nature of structural steel

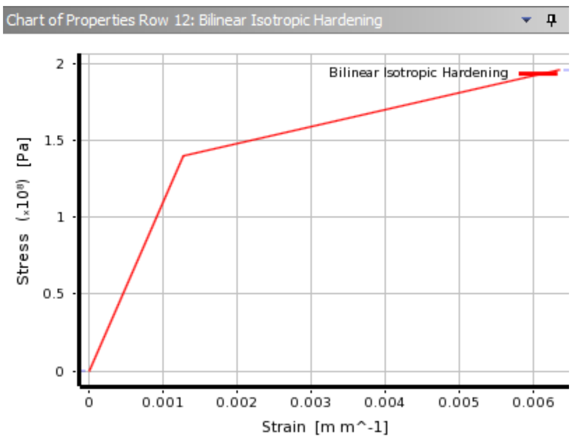


Figure 7: plasticity nature of Cast iron

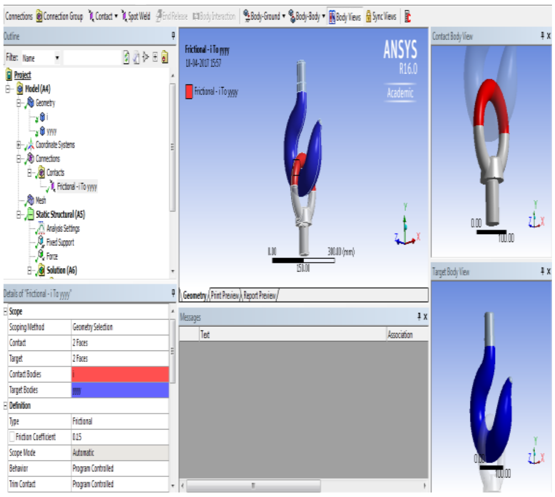
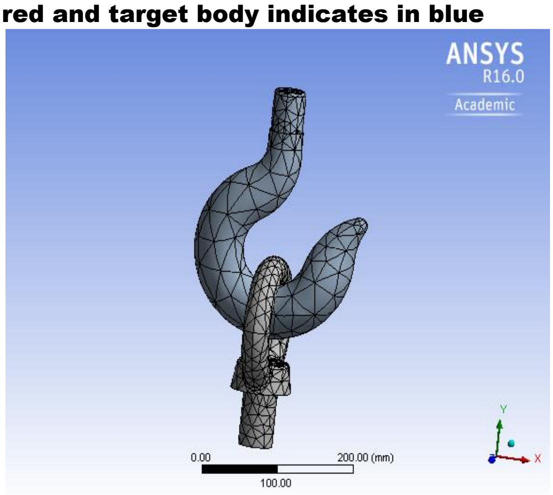


Figure 9: Contact body color indicates in red and target body indicates in blue



5. Finite Element Method Procedure

p-ISSN: 2348-6848
e-ISSN: 2348-795X
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Figure 10: Meshed Model of circular cross section with element type of solid 187

TABLE 2 Model (A4) >Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	0.401920 mm
Statistics	
Nodes	8852
Elements	5255
Mesh Metric	None

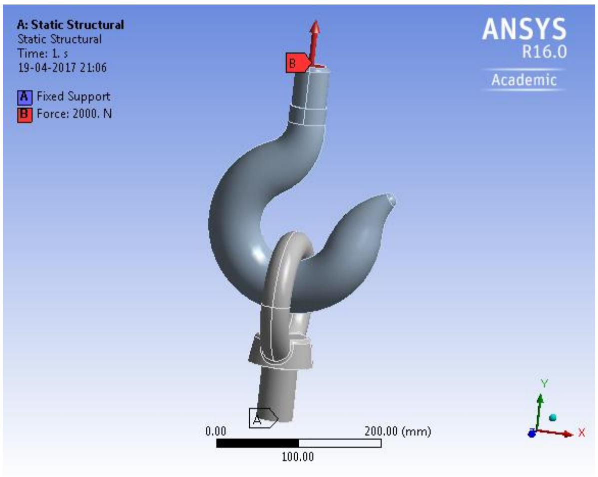

Figure 11: Boundary conditions for crane hook

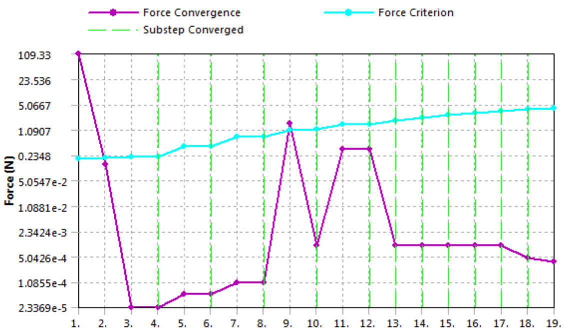

Figure 12: Force convergence of given load under plasticity condition

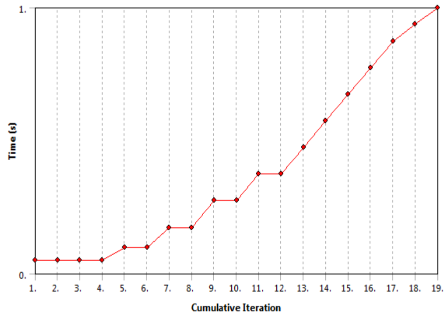

Figure 13: Iteration of load with respective time

6. Results & Discussion

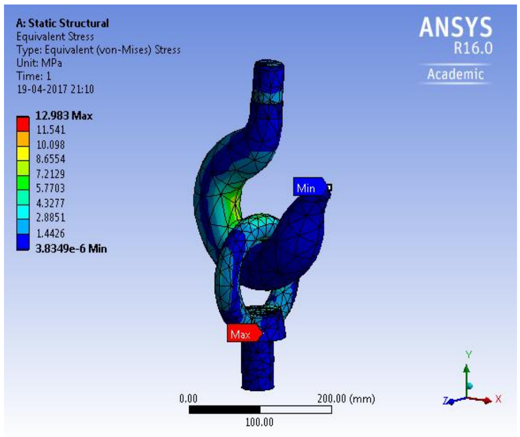

Figure 14: Maximum equivalent stresses for structural steel circular cross section

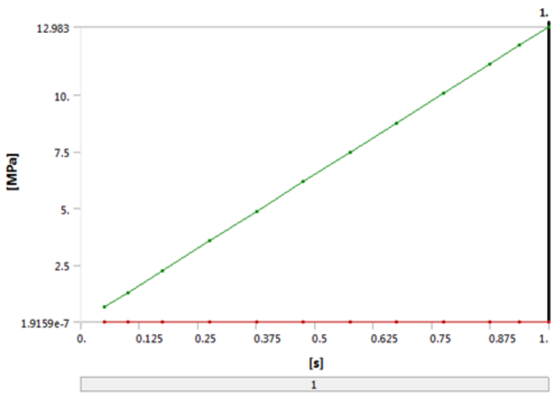

Figure 15: plot between time Vs Stresses

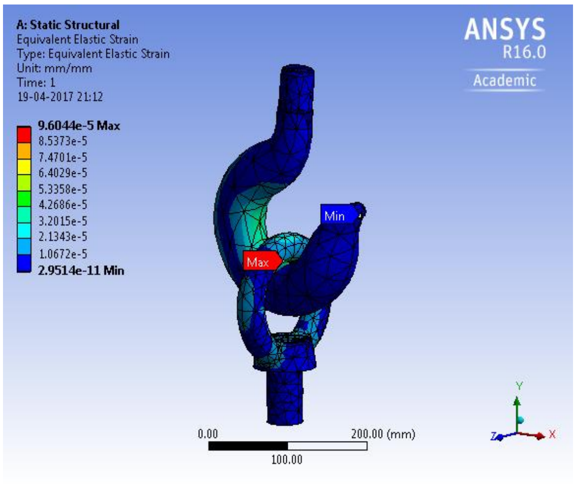

Figure 16: Equivalent strain of circular cross section

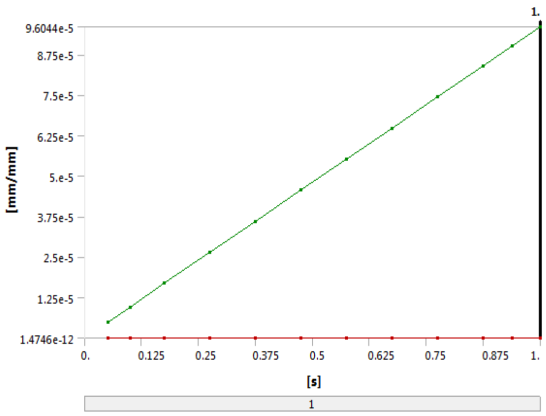

Figure 17: plot between time Vs Strain

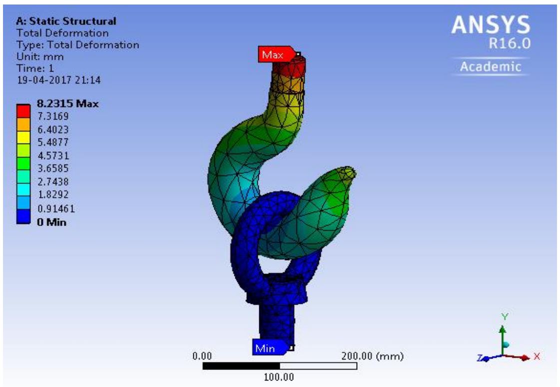

Figure 18: Total deformation of circular cross section

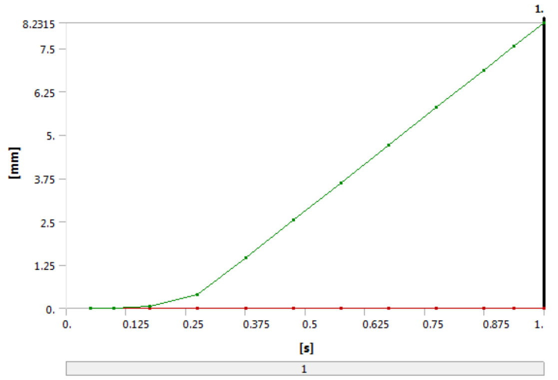

Figure 16: plot between time Vs deformation

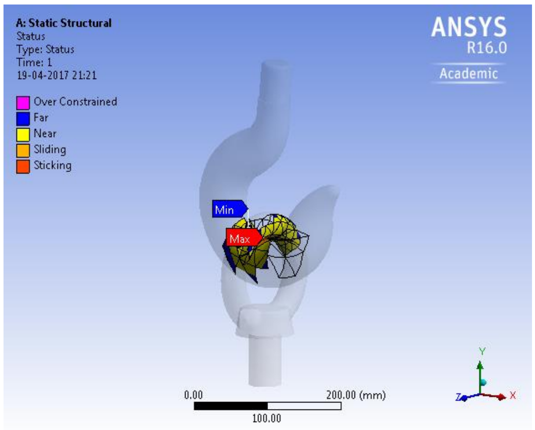

Figure 19: Status of the contact region for circular cross section

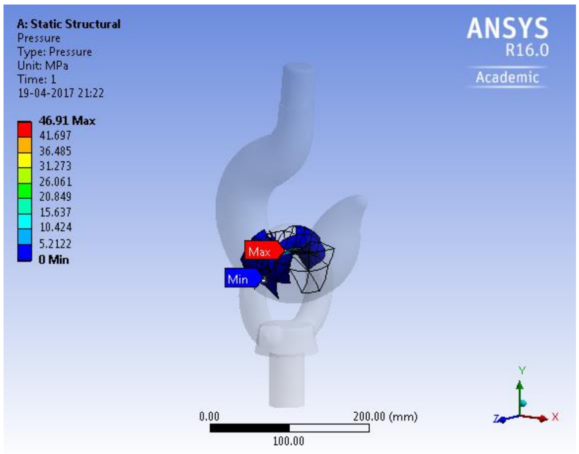

Figure 20: pressure of contact region for circular cross section

International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 06
May 2017

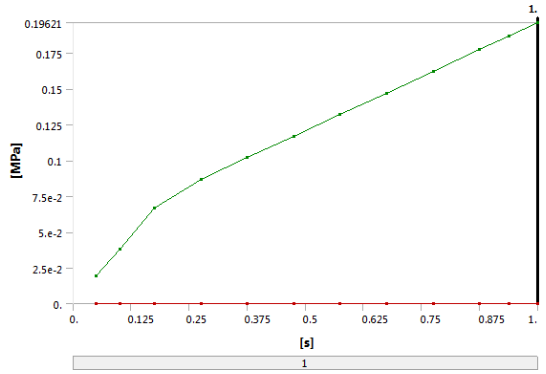

Figure 19: plot between time Vs Frictional stresses

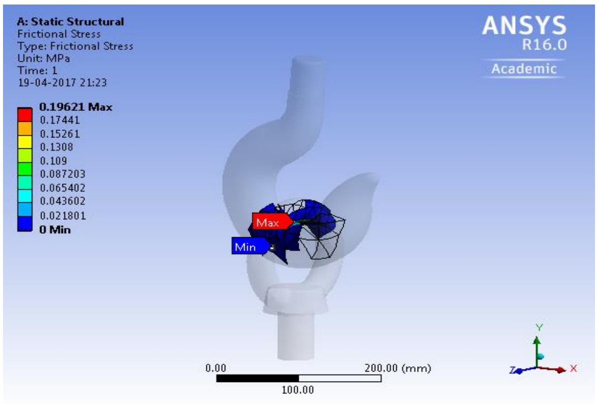

Figure 20: Frictional stresses of contact region for circular cross section

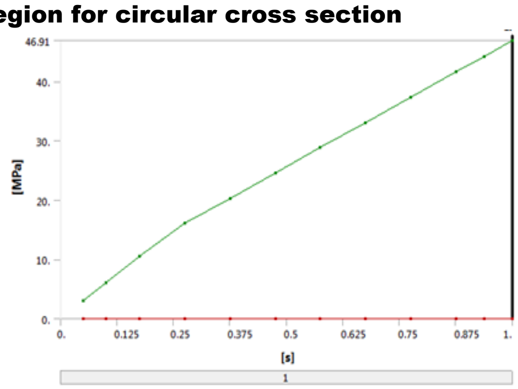

Figure 21: plot between times Vs Pressure

The above figures11 to figure 21 shows the structural steel material of circular cross section the above procedure should follow the trapezoidal cross section and also for the cast iron

	Circular cross section				
	Stress(	strain	deformatio n	pressur e	Frictional stress
Structural-steel	12.983	0.0000 9604	8.2315	46.91	0.19621
Cast iron	13.117	0.0001 76117	17.245	44.965	0.17702

Table 3 shows the Values of circular cross section for two materials

Table 4 shows the Values of circular cross section for two materials

	Trapezoidal cross section				
	tress(MPa)	strain	deformation	ressure	Frictional stress
Structural-steel	13.117	0.00001769	8.9597	45.689	0.18997
Cast iron	12.983	.0001196117	17.237	44.973	0.17707

We considered two types of cross section models and two different materials. The above table describes the total deformation and equivalent stresses ,contact pressures and frictional stresses of different models for different materials If we observe the values the stresses are all most nearer for the both cross sections and mainly we have to observe the contact pressures and frictional stresses for both cross sections comparatively structural steel having more bearable comparatively cast iron. The main objective is cross section the above tables says that the values of circular cross section and trapezoidal cross section are nearer so we can chose the trapezoidal of structural steel it can bear the stress because of contact and friction are almost same. For future scope of this work we can go with shape optimization and also we can do the parametric optimization by using design of experiments.

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