A PROJECT REPORT

ON

"AN EXOSKELETON DEVICE, CHAIRLESS CHAIR"

Submitted by

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In partial fullfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. MOHD. SIRAZUDDIN KHAN

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

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ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

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CERTIFICATE

This is to certify that the project entitled

"AN EXOSKELETON DEVICE, CHAIRLESS CHAIR"

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Project Guide	**Internal Examinar**	**External Examiner**
(Prof.Mohd. Sirazuddin Khan)	(Prof.______)	

Head of Department	**Principal**
(Prof. Zakir Ansari)	(Dr.Adbul Razzak Honutagi)

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

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Date: ___________

ACKNOWLEDGEMENT

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Table of Contents

List of Figures

ABSTRACT

The project title is design and develops the lower body exoskeleton. It is a mechanical ergonomics device that is designed around the shape and function of the human body, with segments and joints corresponding to those of the person it is externally coupled with. It's like a chair that isn't there, but magically appears whenever you need it. In industrial, it is known as the Chair-less Chair and worker in industrial can wear it on legs like an exoskeleton. The purpose of our design revolves around the concept of enhancing the human body through the use of a lower body exoskeleton. This exoskeleton system is designed to be appropriate mechanism with human lower extremity and it operates synchronously with the human realizes .The aim of exoskeleton actuator system is to provide forces against to external load carried by user during walking, sitting, and standing motions.

Although lower body exoskeletons already exist on the market, they still have shortcomings that prevent widespread use among the general public. Our method of achieving our goal consists of splitting up into smaller groups; allowing us to complete work more efficiently. The objectives of this project are to study, analyse, and develope a new mechanism that assist the human locomotion, to learn in details about how the lower body exoskeleton works and understand the concepts involved.

CHAPTER 1

INTRODUCTION

It's an innovative and forward-thinking concept the ability to sit anywhere and every-where with the aid of a chairless chair. The concept was first conceived two years ago by Keith Gunura, co-founder and CEO of NOONEE and since then the company has developed its Chairless Chair and entered talks with a number of leading manufacturers. Designed for static and dynamic industrial market applications, the Chairless Chair aims to increase user's health, comfort, and productivity. It's like a chair that isn't there, but magically appears whenever you need it. It's called the Chairless Chair and you wear it on your legs like an exo skeleton: when it's not activated, you can walk normally or even run. Like a chair that is now there. Standing for hours on end causes a lot of distress to lower limbs, but most workers get very few breaks and chairs are rarely provided, because they take up too much space. So we thought that the best idea was to strap an unobtrusive chair directly to you.

1.1PROBLEM DEFINATION

The world is getting compact day by day. With the development in technology it has become very important to ensure that the most used devices are also compact and small in size, so it is the need of the hour to manufacture something like "Exoskeleton based hydraulic support" or "Wearable Chair" or "Chairless Chair".

This exoskeleton based support would be useful to people whose current job requires them to stand for long hours. This new and modernized "chair" will ease the aches in the thighs and back. It is especially of great use to the elderly , workers in assembly line , trekkers and military who don't always have the option of pulling a chair to rest themselves on the go !

The prime requirements of an effective project organization therefore are:-

1) Autonomy

2) Group functional integration

3) Small group size

4) Common work location for all project members

5) Team spirit among group members.

All the foregoing requirements are mutually reinforcing, and conjoin together towards effective implementation of this innovative and time-bound project. Factors in consideration of project:-

1) Compatibility with the objective, plan.

2) Availability of needed scientific and engineering skills in R & D.

3) Critical technical problems likely to emerge.

4) Market prospects and potential of the proposed new product.

5) Availability of production skills needed.

6) Financial return expected

CHAPTER 2

LITERATURE SURVEY

In this paper we are very much interested in the wearable devices which help in increasing the efficiency of the human and decrease the rate of fatigue of human during work. The device discussed here is the passive device. This device is known as Chairless Chair which helps the wearer to work effectively at any location in a sitting posture. Stress Analysis on a Chairless Chair 701 H. Zurina and A. Fatinhas worked on the Design and Development of Lower Body Exoskeleton. In his paper an attempt has been made to evaluate the possibility of using the Chairless chair that will help in increasing the energy efficiency and offer weight support when the user feels tired rather than continuously taking on the weight

[2]. Other than that, in term of ergonomics, and the objectives to give comfort to user has achieved by give choices to user to choose their comfort degree level from 45° to 90°. Apart from the benefit of his experiment it can be conclude that his design still confront with some problems that need to fix in future so that the objective to give an ergonomic chair to user can be achieved. The experiment testing has been conducted for our prototype to our group member with weight of 80kg and height around 170cm. From the result of experiment testing, it can be observed that for height and weight, the Chair less chair doesn't give any effect in lack or over measure in its height dimension. It suit the user which prove that this chair can be wear by people from any height range. He tester were required to use the chair while do some work, it was observed that, he had difficulties in changing the degree level.

[3]. Aditya Bhalerao and Sandesh Kamblehave worked on Pneu portable chair for employees to seat while working. By referring to human seating and walking characteristic a leg mechanism has been conceived with as kinematic structure whose mechanical design can be used by employees as an wearable exoskeleton. As per the Specified Design parameters the body can suitably carry around the 100Kg of Human Body weight. In the later part to reduce the cost, Oil was also brought in the weight sustaining mechanism thus providing better results. These type of device with ergonomical background can be easily upgraded with the use of more advanced technologies and culminating various facilities into one body and be constantly modified .A basic idea of how a exoskeleton using Pneumatic or Hydraulic Cylinder can be used to reduce the fatigue by using simple kinematic mechanisms. In this Particular Machine due to certain restrictions not much advancement has been made and it is similar to a tailor made clothing which is just suitable for one single person and may not fit properly to other user. Although as mentioned with advanced 702 Dittakavi Tarun, et al techniques it can be made more generalized for more no, of people to use it

[4]. It has several major applications in real time scenario where it can be worn in the crowded trains or public places with space constrains. Also it can be worn by Traffic Police who work for long hours and are exposed to fatigue for a prolong period of time. Figure 3: Mechanism of Pneu Portable Chair Cyril Varghese and Vedaksha Joshi has worked on the Exoskeleton Based Hydraulic Support was successfully fabricated and it was found to be suitably safe

[5]. Under fluctuating load during walking as well as under Dead Load when the user sits/rests on it. (Tested the Extra Large Size Variant for a user weighting 116 kgs for a span of 43 days) The entire cost of making the EBHS is Rs 8540 ($ 126.84) thereby making is very economical for the general public as well as for Industrial use and also for the Military. When in full scale production , the EBHS will be available in three sizes , From 5ft to 5"5" : Regular Size , From 5"5" to 6ft : Large Size ,From 6ft to 6"5" : Extra Large Size . The EBHS being extremely light in weight causes very little hindrance while walking and the user can easily get used to it. Figure 4: Schematic Diagram of Hydraulic Mechanism Stress Analysis on a Chairless Chair 703 Noone has worked on the lower limb exoskeletons called Chair less Chair. This product is also known as a "mechatronic device" worn on the legs, which allows the user to walk or run when not activated

[6]. Once the device is activated, it uses a portable variable damper to engage and hold the person's body weight, relieving the stress on leg muscles and joints. The user just needs to move into the desired pose, this activates the device. This device is based on research from the Bio-Inspired Robotics laboratory at ETH Zurich. A belt secures the wearable to the hips and its straps wrap around the thigh. Since it is the chair that can carry the person's body weight, the stress on leg muscles and joints is relieved. The device runs for about 24 hours on a single 6V battery and an aluminum and carbon fiber frame keeps the overall weight of the Chair less Chair at just two kilograms, so it doesn't burden the wearer with too much excess weight. Production-line trials started in Germany with BMW in September and with Audi later in the year 2015. The user can sit comfort in the places where the people are densely crowded using this device. This device is totally controlled by a mechatronic system.

CHAPTER 3

METHODOLGY

Literature of design: -

Initial survey of design was done on internet and actual visit to the manufacturing companies which make the hydraulic machineries. This whole thing was then clubbed to the process of designing.

Preliminary Design: -

A preliminary design was made which was based on operation to be performed and literature study. This design was later been validated by our guide considering all the parameters.

Improvements in design : -

The design which was made in preliminary stage went through certain changes when fabrication process was carried out. Due to some technical reasons the component which was fabricated was changed and in turn there was a change in the design.

Finalized Design: -

The manufacturing setup thus went through some changes in its design and the final setup was made as per the design

Procurement of Components (Buying):-

According to our design, we selected a pneumatic piston cylinder which is being used in car rear opening. It is contains air as major part with small amount of hydraulic oil in it for maintaining pressure

We also bought MS sheet metal for the frame of the structure. A 20cm*20cm Styrofoam was also purchased along with fibre material belt for locking.

Operations Done For Big components :-

For the pneumatic cylinder, reducing its pressure was important for the smooth operation of it. Therefore we drilled the piston n removed all the air and oil so that the piston is free to slide up and down with minimum efforts

Secondly the sheet metal was cut and bend accordingly to acquire the required shape and size. The machines used were speed cutter and hammers. Next, the links were joined by arc welding.drill machine was used to make slots in the required areas.

Lastly, we prepared the shoe locker by making a U-shaped clip for holding the heels of the shoes. We provided bolts to grip the shoes properly

Assembly of components:-

Starting from the bottom, we fixed the shoe locker tightly on the shoes. Then the piston part of the cylinder is fixed at an offset from the shoe. It is fixed tightly with the help of washers. The top part of the cylinder is connected to the links with bolts. And then connected to the hip and thigh rest.

3.1 MATERIAL SELECTION

To prepare any machine part, the type of material should be properly selected, considering design, safety and following points. The selection of material for engineering application is given by the following factors:-

- Availability of materials
- Suitability of the material for the required components
- Suitability of the material for the desired working conditions
- Cost of the materials

In addition to the above factors the other properties to be considered while selecting the material are as follows :-

Mechanical Properties: These properties are color, shape, density, thermal conductivity, electrical conductivity, melting point etc.

Physical Properties: The properties are associated with the ability of the material to resist the mechanical forces and load.

Strength : It is the property of material due to which it can resist the external forces without breaking or yielding.

Stiffness : It is the ability of material to withstand the deformation under stress.

Ductility: It is the property of material due to which it can be drawn into wires under a tensile load.

Malleability: It is the property of material which enables it to be rolled into sheets

Brittleness: It is the property of material due to which it breaks into pieces with little deformation.

Hardness : It is the property of material to resist wear, deformation and the ability to cut another material.

Resilience : It is the ability of the material to store energy and resist the shock and impact loads.

Creep : It is the slow and permanent deformation induced in a part subjected to a constant stress at high temperature. We have selected the material considering the above factors and also as per the availability of the material.

The materials which cover most of the above properties are :-

MILD STEEL :-

Why steel in particular?

Mild steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed, for example as structural steel.

In the States, "mild steel" refers to low carbon steel; typically the AISI grades 1005 through 1025, which are usually used for structural applications. With too little carbon content to through harden, it is weldable, which expands the possible applications.

Properties :

Tensile strength = 44.54 kgf/mm

Yield strength = 28 kgf/mm

Hardness = 170 BHN

3.2 CALCULATION FOR DESIGN

Design of link:-

t = thickness of arm in cm.

Fb = 160 N/mm2

B = width of arm in cm = 4.5 x t Bending moment at 25 mm from center of shaft,

W = maximum force applied by human = 30 kg M = W x L M = 300 x 25 =7500 Nmm

And section modulus = Z = 1/6 Bt2 Z = 1/6 x 4.5 x t x t2 Z = 1/6 x 4.5 t3

Z = 0.75 t3 mm3

Now using the relation,

Fb = M / Z 160

= 7500/ (0.75 t3) t

= 3.9 mm.= 4 mm

B = 4.5 x 4 = 18 mm

So we select section 18 x 4 mm for pivote line Design of welded joint

Checking the strength of the welded joints for safety.

The transverse fillet weld welds the side plate and the edge stiffness plates, The maximum load which the plate can carry for transverse fillet weld is

P = 0.707 x S x L x ft

Where, S = size of weld, L = contact length = 30mm

The load of shear along with the friction is 60 kg = 600N

Hence,

600 = 0.707 x 3.15 x 30 x ft

Hence let us find the safe value of "ft"

Therefore

ft = 600/ 0.707 x 3.15 x 30 ft = 8.9 N/mm2

Since the calculated value of the tensile load is very smaller than The permissible value as ft=21 N/mm2 . Hence welded joint is safe.

Design of bolts:-

For Bolted Joint we used M10 Bolts

do = 10mm

dc = do x 0.84 dc = 8.4mm

Shear Area A = ∏ / 4 X (8.4) 2

A = 55 mm2

τ = F A

τ = 500 /55

τ = 9.09 N/ mm2

τ on bolt < τ i.e. 9.09 N/ mm2 < 80 N/ mm2

Design is Safe.

.

3.3 MARKET SURVEY

We did a lot of market survey for our project. During our visit to market and industries we communicated with different type of working people in the , Workshop, Industries and small scale Shops. It gave us a bright idea about components available in market. We also had opportunity to interact with Engineer. Among many shops and industries visited by us we enlist few of them below.

- Bharat wire ropes ltd.
- Systematic Group of Companies
- Railway workshop
- Paramount forge
- ARAI PUNE.
- AUTO VISTA
- For materials and equipment's
- BHARAT BAZAAR
- LOKHAND BAZAAR
- KAMOTHE HARDWARES

PHASE1: COMPONENTS AVAILABILITY

- After finalizing our project we had to check the market for availability of components according to our needs.
- We checked for hydro-pneumatic piston cylinder, M.S sheet, Bolts - Nuts metallic strips, etc.

PHASE 2: OPTIMIZING BUDGET

- After visiting above mentioned companies and shops we tried to figure out what stuff should be bought from which place

PHASE 3: BUYING

- We started with the pneumatic piston cylinder
- We managed to buy a second hand pneumatic piston cylinder which saved our 6000-9000 rupees .
- Next major component we bought was material for our frame ,We bought sheet metal at the rate of 50rs/kg. and 20rs more for Bending
- We bought a dozen pair of Bolts-nuts of the required sizes

3.4 COST ESTIMATION

Cost estimation may be defined as the process of forecasting the expenses that must be incurred to manufacture a product. These expenses take into a consideration all expenditure involved in a design and manufacturing with all related services facilities such as pattern making, tool, making as well as a portion of the general administrative and selling costs.

TYPES OF COST ESTIMATION:-

1) Material cost
2) Machining cost

1) Material cost :-

Material cost estimation gives the total amount required to collect the raw material which has to be processed or fabricated to desired size and functioning of the components.

a) Raw material cost :-

Raw Material	Bharat Bazar cost (Rs)
20 mm gauge MS Plate	30/kg
Pneumatic piston Cylinder	500/unit * 2
Metallic strips	100/kg
Nut Bolt and Washer	100
Total	**1230**

2) Machining cost :-

Operation	Hours	Cost
Cutting	1	100
Welding	1 hour	200
Drilling	½ hour	50
Grinding	1 hour	50
Painting	1 hour	400
Total Cost	**4 ½ hours**	**800**

Total cost = Raw Material cost + Machining Cost + other expenses

= 1230 + 800 +70

= 2100

This total cost can be reduced if this machine made in mass production because the machining cost would be very less and material cost would be less if bought in bulk.

3.5 MANUFACTURING

Manufacturing engineering or manufacturing process are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the product design, and materials specification from which the product is made. These materials are then modified through manufacturing processes to become the required part.

Manufacturing takes turns under all types of economic systems. In a free market economy, manufacturing is usually directed toward the mass production of products for sale to consumers at a profit. In a collectivist economy, manufacturing is more frequently directed by the state to supply a centrally planned economy. In mixed market economies, manufacturing occurs under some degree of government regulation.

Modern manufacturing includes all intermediate processes required the production and integration of a product's components. Some industries, such as semiconductor and steel manufacturers use the term fabrication instead.

Basically manufacturing is the process of combining various components by various operations so as to get the final product or machine. In our manufacturing the components required are as follows:-

1. Pneumatic piston cylinder
2. Thigh rest
3. Hip rest
4. Shoe gripper
5. Links
6. Bolts – Nuts

3.5.1 PNEAUMATIC PISTON CYLINDER

A Pneumatic cylinder(s) (sometimes known as air cylinders) are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, something forces a piston to move in the desire direction.

Like hydraulic cylinders, something forces a piston to move in the desire direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved.[1] :85 Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage.

Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement. For example, in the mechanical puppets of the Disney Tiki Room, pneumatics is used to prevent fluid from dripping onto people below the puppets.

Fig 3.1 PNEUMATIC PISTON CYLINDER

3.5.2 HIP REST:-

This is rear part of the device which supports the hip region of the body while sitting. The cushioning effect is given by using Styrofoam wrapped with leather clothing. The user can feel the essence of a normal office chair.

Fig 3.2 HIP REST

3.5.3 THIGH REST:-

This is the part of the device which takes the max overall load and which is directly connected to the pneumatic piston cylinder. The cross sectional area of thigh rest is more than the hip rest as it is curved along the length of the thighs. Two belts strips are attached on the upper and lower side of this part to grip up with the thighs properly.

Fig 3.3 THIGH REST

3.5.4 SHOE LOCKER:-

For proper gripping with any types of shoes worn by the user, we designed a simple shoe locker that could be tightened with the help of bolts without damaging the shoe.

Fig 3.4 SHOE LOCKER

CHAPTER 4

DESIGN ANALYSIS

CONTENTS

Units

TABLE 4.1

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4)

Geometry

TABLE 4.2
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\24shakil\Desktop\Assem2.STEP
Type	Step
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	227.31 mm
Length Y	613.33 mm
Length Z	482.44 mm
Properties	
Volume	3.6602e+005 mm³
Mass	2.8732 kg
Scale Factor Value	1.
Statistics	
Bodies	17
Active Bodies	17
Nodes	35578
Elements	15156
Mesh Metric	None
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No

Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\24shakil\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 4.3
Model (A4) > Geometry > Parts

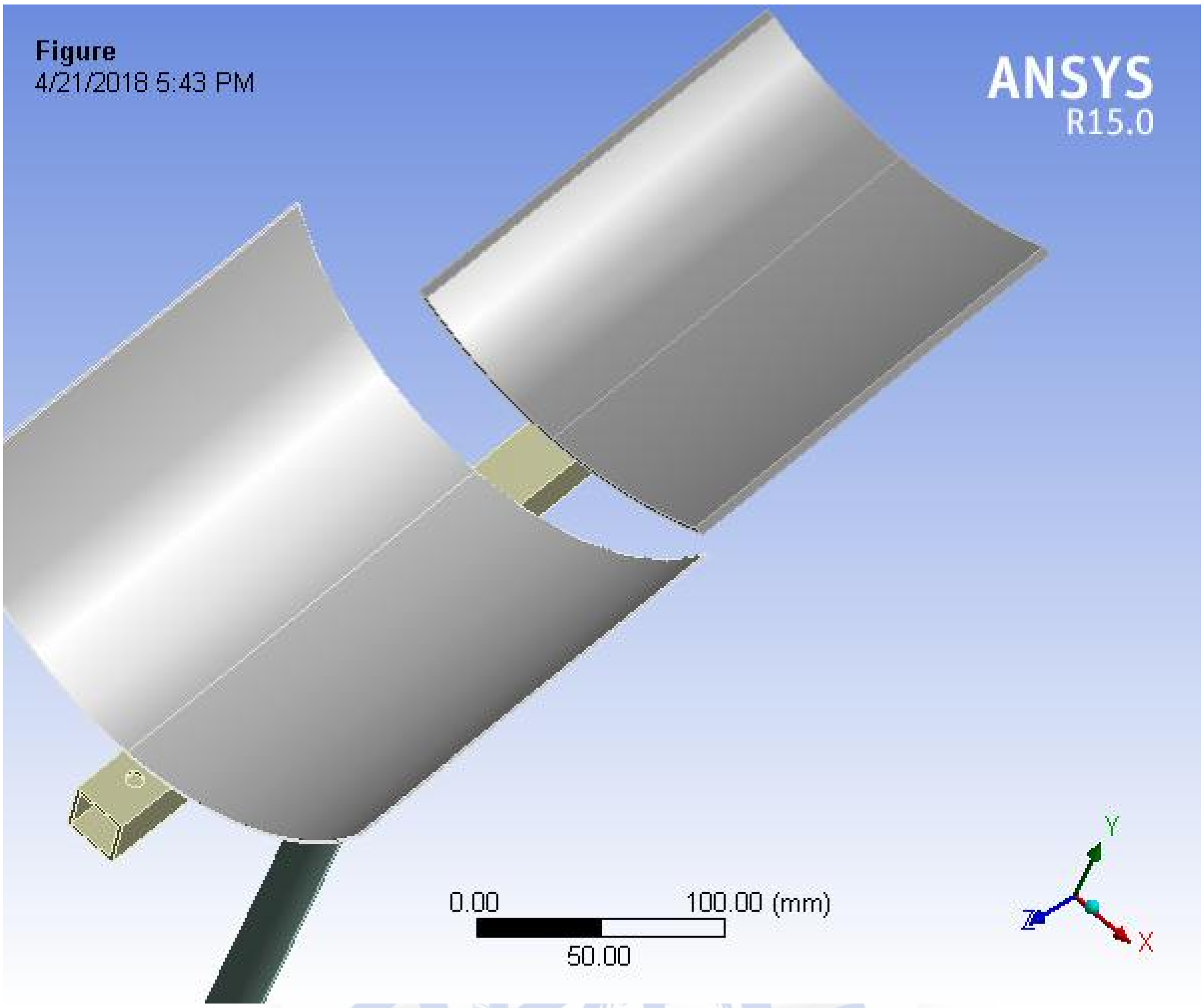
Object Name	*formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 20 --20WC*	*formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 20 --20WC*	*formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 35 --22WC*	*formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 50 --50WC*	*formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 50 --50WC*	*Part5*	*Part5*	*Part6-1*	*Part6*	*Part4-2*	*Part4-1*
State	Meshed										
Graphics Properties											
Visible	Yes										
Transparency	1										
Definition											
Suppressed	No										
Stiffness Behavior	Flexible										
Coordinate System	Default Coordinate System										
Reference Temperature	By Environment										
Material											
Assignment	Structural Steel										
Nonlinear Effects	Yes										
Thermal Strain Effects	Yes										
Bounding Box											
Length X	25.5 mm		40.5 mm	55.5 mm		41. mm		25. mm	157. mm	4. mm	13. mm
Length Y	15.011 mm			17.674 mm	15.011 mm	20. mm		135.44	73.671	32.492	25. mm

<table>
<tr><td></td><td colspan="3"></td><td></td><td></td><td colspan="2"></td><td>mm</td><td>mm</td><td>mm</td><td></td></tr>
<tr><td>Length Z</td><td colspan="3">13. mm</td><td>18.786 mm</td><td>13. mm</td><td colspan="2">205. mm</td><td>421.82 mm</td><td>208.02 mm</td><td>17. mm</td><td>13. mm</td></tr>
<tr><th colspan="12">Properties</th></tr>
<tr><td>Volume</td><td colspan="2">1724.2 mm³</td><td>2478.2 mm³</td><td colspan="2">3232.1 mm³</td><td colspan="2">14128 mm³</td><td>78718 mm³</td><td>66775 mm³</td><td>1829.9 mm³</td><td>1469.5 mm³</td></tr>
<tr><td>Mass</td><td colspan="2">1.3535e-002 kg</td><td>1.9454e-002 kg</td><td colspan="2">2.5372e-002 kg</td><td colspan="2">0.1109 kg</td><td>0.61794 kg</td><td>0.52418 kg</td><td>1.4364e-002 kg</td><td>1.1535e-002 kg</td></tr>
<tr><td>Centroid X</td><td colspan="2">-325.48 mm</td><td>-326.09 mm</td><td colspan="2">-326.42 mm</td><td>-346.07 mm</td><td>-304.22 mm</td><td colspan="4">-325.15 mm</td></tr>
<tr><td>Centroid Y</td><td colspan="2">-528.35 mm</td><td>-102.35 mm</td><td>-125.64 mm</td><td>-58.027 mm</td><td colspan="2">-528.34 mm</td><td>-31.69 mm</td><td>29.634 mm</td><td>-524. mm</td><td>-498.63 mm</td></tr>
<tr><td>Centroid Z</td><td>71.999 mm</td><td>-1.3414e-003 mm</td><td>-9.3565e-004 mm</td><td>86.929 mm</td><td>105.05 mm</td><td colspan="2">89.596 mm</td><td>6.7727 mm</td><td>-144.77 mm</td><td>2.0445e-013 mm</td><td>1.8359e-013 mm</td></tr>
<tr><td>Moment of Inertia Ip1</td><td colspan="2">0.19643 kg·mm²</td><td>0.24272 kg·mm²</td><td colspan="2">0.28901 kg·mm²</td><td colspan="2">353.65 kg·mm²</td><td>9550. kg·mm²</td><td>1910.4 kg·mm²</td><td>1.1773 kg·mm²</td><td>0.80889 kg·mm²</td></tr>
<tr><td>Moment of Inertia Ip2</td><td colspan="2">0.87755 kg·mm²</td><td>3.1157 kg·mm²</td><td colspan="2">7.5169 kg·mm²</td><td colspan="2">13.958 kg·mm²</td><td>109.92 kg·mm²</td><td>1040.4 kg·mm²</td><td>0.3944 kg·mm²</td><td>0.3442 kg·mm²</td></tr>
<tr><td>Moment of Inertia Ip3</td><td colspan="2">0.87753 kg·mm²</td><td>3.1157 kg·mm²</td><td colspan="2">7.5169 kg·mm²</td><td colspan="2">360.01 kg·mm²</td><td>9550. kg·mm²</td><td>2917.9 kg·mm²</td><td>1.5334 kg·mm²</td><td>0.80889 kg·mm²</td></tr>
<tr><th colspan="12">Statistics</th></tr>
<tr><td>Nodes</td><td colspan="2">1035</td><td>1084</td><td colspan="2">1172</td><td colspan="2">1246</td><td>6324</td><td>3874</td><td>254</td><td>565</td></tr>
<tr><td>Elements</td><td colspan="2">517</td><td>538</td><td colspan="2">594</td><td colspan="2">506</td><td>3110</td><td>558</td><td>27</td><td>271</td></tr>
<tr><td>Mesh Metric</td><td colspan="11">None</td></tr>
<tr><td></td><td colspan="11"></td></tr>
</table>

TABLE 4.4
Model (A4) > Geometry > Parts

Object Name	*Part4*	*Part3*	*Part2*	*Part1-2*	*Part1-1*	*Part1*
State	Meshed					
Graphics Properties						
Visible	Yes					
Transparency	1					
Definition						
Suppressed	No					
Stiffness Behavior	Flexible					
Coordinate System	Default Coordinate System					
Reference Temperature	By Environment					
Material						
Assignment	Structural Steel					
Nonlinear Effects	Yes					
Thermal Strain Effects	Yes					
Bounding Box						
Length X	10. mm	22. mm	25. mm	3. mm		227.31 mm
Length Y	330. mm	363. mm	54.171 mm	119. mm		121. mm
Length Z	10. mm	25. mm	118.52 mm	54.301 mm		220.7 mm
Properties						
Volume	25918 mm³	45177 mm³	24663 mm³	8420. mm³		63980 mm³
Mass	0.20346 kg	0.35464 kg	0.1936 kg	6.6097e-002 kg		0.50224 kg
Centroid X	-325.15 mm	-325.12 mm	-325.15 mm	-343.65 mm	-306.65 mm	-325.15 mm
Centroid Y	-342.34 mm	-278.74 mm	-115.93 mm	-75.184 mm		1.8795 mm
Centroid Z	2.1275e-013 mm	1.0978e-006 mm	50.704 mm	100.45 mm		121.1 mm
Moment of Inertia Ip1	1826.6 kg·mm²	33.795 kg·mm²	206. kg·mm²	77.173 kg·mm²		1891. kg·mm²
Moment of Inertia Ip2	2.4857 kg·mm²	3790.1 kg·mm²	32.531 kg·mm²	73.666 kg·mm²		2474.5 kg·mm²
Moment of Inertia Ip3	1826.6 kg·mm²	3791.2 kg·mm²	209.31 kg·mm²	3.6064 kg·mm²		3965.5 kg·mm²
Statistics						
Nodes	890	4769	1337	370	349	8856
Elements	140	2440	593	39	36	4170
Mesh Metric	None					

FIGURE 4.1
Model (A4) > Geometry > Figure



Coordinate Systems

TABLE 4.5
Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Connections

TABLE 4.6
Model (A4) > Connections

Object Name	*Connections*
State	Fully Defined
Auto Detection	
Generate Automatic Connection On Refresh	Yes
Transparency	
Enabled	Yes

TABLE 4.7
Model (A4) > Connections > Contacts

Object Name	*Contacts*
State	Fully Defined
Definition	
Connection Type	Contact
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Auto Detection	
Tolerance Type	Slider
Tolerance Slider	0.
Tolerance Value	2.0319 mm
Use Range	No
Face/Face	Yes
Face/Edge	No
Edge/Edge	No
Priority	Include All
Group By	Bodies
Search Across	Bodies

TABLE 4.8
Model (A4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region*	*Contact Region 2*	*Contact Region 3*	*Contact Region 4*	*Contact Region 5*	*Contact Region 6*	*Contact Region 7*	*Contact Region 8*	*Contact Region 9*	*Contact Region 10*	*Contact Region 11*
State	Fully Defined										
Scope											
Scoping Method	Geometry Selection										
Contact	9 Faces	2 Faces	9 Faces	2 Faces			9 Faces	2 Faces	9 Faces	2 Faces	
Target	3 Faces	2 Faces	3 Faces	2 Faces			5 Faces	4 Faces	3 Faces	2 Faces	4 Faces
Contact Bodies	formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 20 --20WC					formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 35 --22WC		formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 50 --50WC			
Target	Part5				Part4-	Part3	Part2		Part1-	Part1-	Part6-

Bodies		2			2	1	1
Definition							
Type	Bonded						
Scope Mode	Automatic						
Behavior	Program Controlled						
Trim Contact	Program Controlled						
Trim Tolerance	2.0319 mm						
Suppressed	No						
Advanced							
Formulation	Program Controlled						
Detection Method	Program Controlled						
Penetration Tolerance	Program Controlled						
Elastic Slip Tolerance	Program Controlled						
Normal Stiffness	Program Controlled						
Update Stiffness	Program Controlled						
Pinball Region	Program Controlled		Radius	Program Controlled			
Pinball Radius			3. mm				
Geometric Modification							
Contact Geometry Correction	None						

TABLE 4.9
Model (A4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region 12*	*Contact Region 13*	*Contact Region 14*	*Contact Region 15*	*Contact Region 16*	*Contact Region 17*	*Contact Region 18*	*No Separation - Part4 To Part3*	*Contact Region 20*	*Contact Region 21*
State	Fully Defined									
Scope										
Scoping Method	Geometry Selection									
Contact	9 Faces	2 Faces	1 Face			3 Faces		2 Faces	1 Face	
Target	3 Faces	2 Faces	1 Face		2 Faces	3 Faces		2 Faces	1 Face	
Contact Bodies	formed hex screw_am_B18.2.3.2M - Formed hex screw, M8 x 1.25 x 50 --50WC		Part5		Part6-1	Part4-2	Part4-1	Part4	Part1-2	Part1-1
Target	Part1-2	Part1-1	Part4-2		Part6	Part4-	Part4	Part3	Part1	

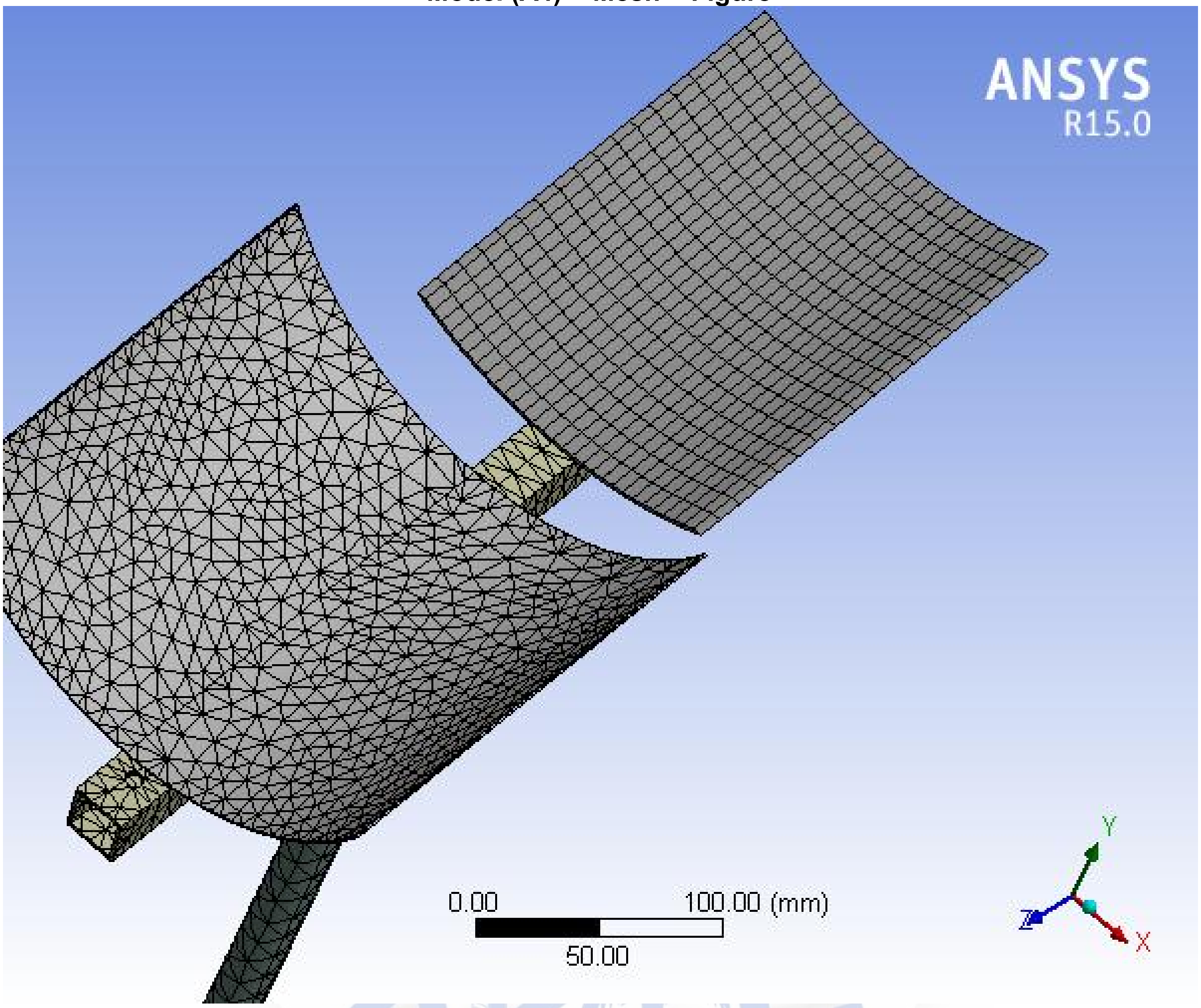
Bodies					1			
Definition								
Type	Bonded						No Separation	Bonded
Scope Mode	Automatic							
Behavior	Program Controlled							
Trim Contact	Program Controlled							
Trim Tolerance	2.0319 mm							
Suppressed	No							
Advanced								
Formulation	Program Controlled							
Detection Method	Program Controlled							
Penetration Tolerance	Program Controlled							
Elastic Slip Tolerance	Program Controlled							Program Controlled
Normal Stiffness	Program Controlled							
Update Stiffness	Program Controlled							
Pinball Region	Program Controlled							
Geometric Modification								
Contact Geometry Correction	None							

Mesh

TABLE 4.10
Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Fine
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	0.60 mm
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	
Topology Checking	Yes
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
Statistics	
Nodes	35578
Elements	15156
Mesh Metric	None

FIGURE 4.2
Model (A4) > Mesh > Figure



Static Structural (A5)

TABLE 4.11
Model (A4) > Analysis

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 4.12
Model (A4) > Static Structural (A5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Program Controlled
Large Deflection	Off
Inertia Relief	Off
Restart Controls	
Generate Restart Points	Program Controlled
Retain Files After Full Solve	No
Nonlinear Controls	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Off
Output Controls	
Stress	Yes
Strain	Yes
Nodal	No

Forces	
Contact Miscellaneous	No
General Miscellaneous	No
Store Results At	All Time Points
Analysis Data Management	
Solver Files Directory	C:\Users\24shakil\AppData\Local\Temp\WB_SHAKIL_24shakil_4960_2\unsaved_project_files\dp0\SYS\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Nonlinear Solution	No
Solver Units	Active System
Solver Unit System	nmm

TABLE 4.13
Model (A4) > Static Structural (A5) > Loads

Object Name	*Fixed Support*	*Pressure*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	2 Faces	
Definition		
Type	Fixed Support	Pressure
Suppressed	No	
Define By		Normal To
Magnitude		0.3105 MPa (ramped)

FIGURE 3
Model (A4) > Static Structural (A5) > Fixed Support > Figure

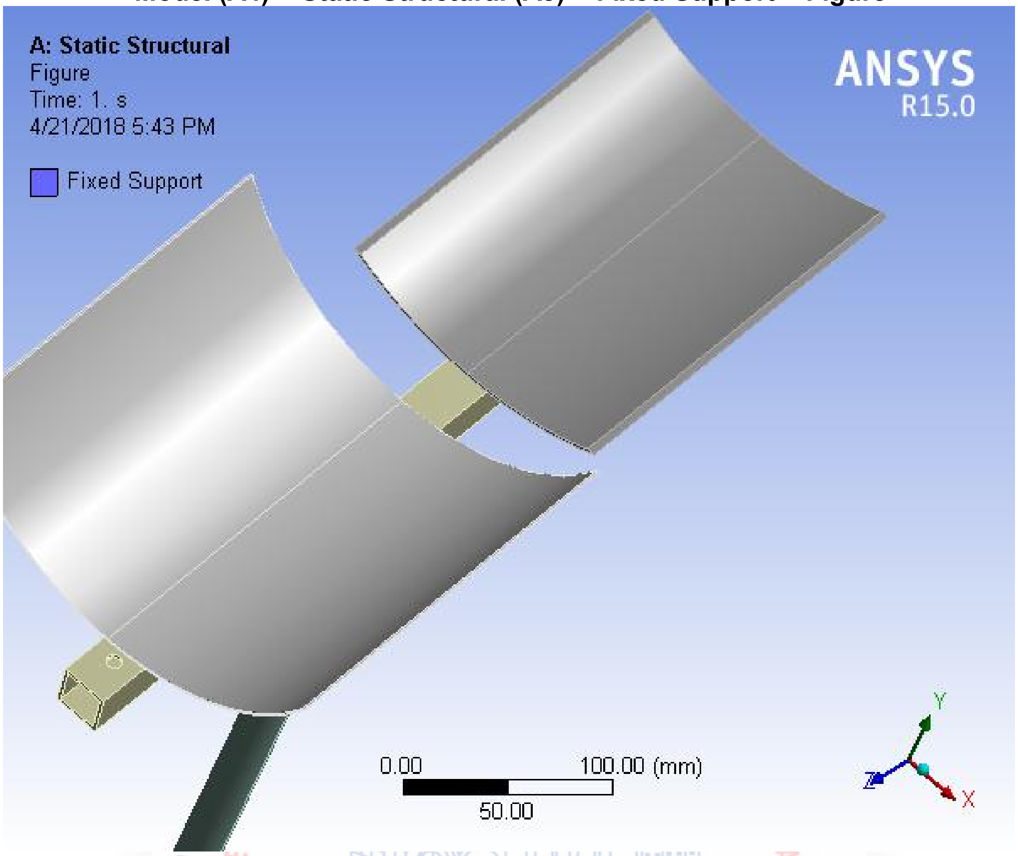


FIGURE 4.4
Model (A4) > Static Structural (A5) > Pressure

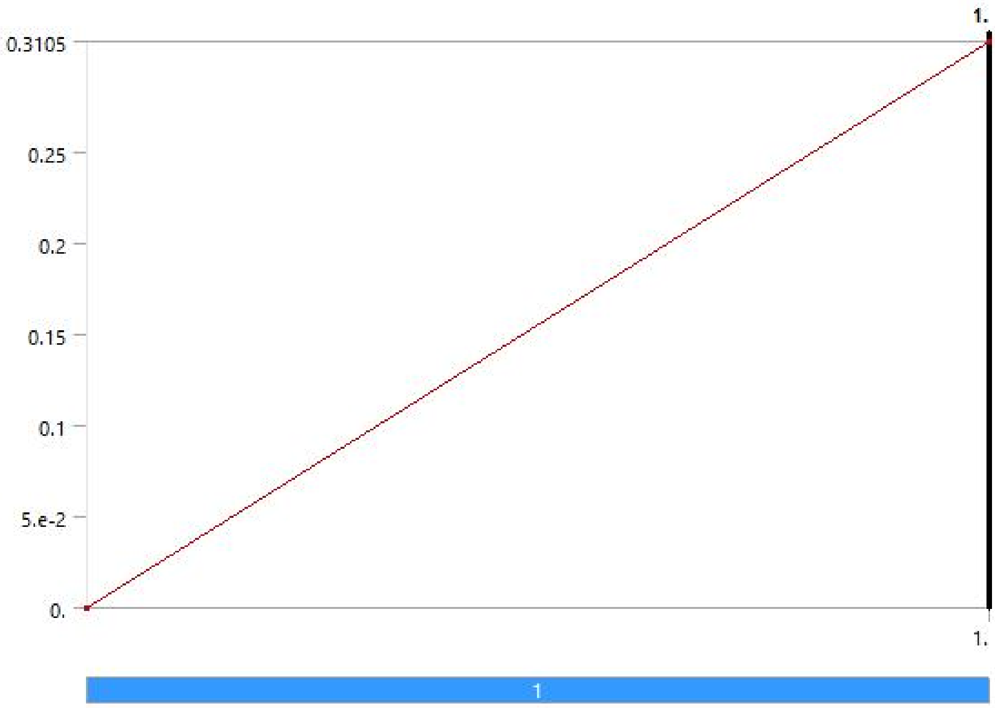
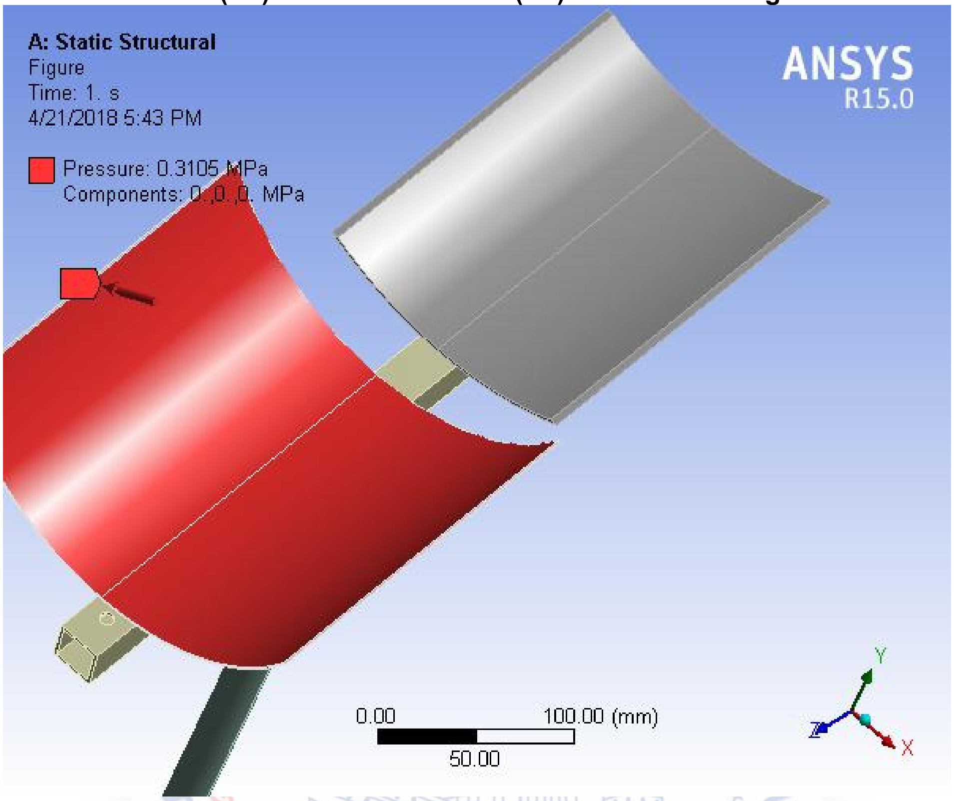


FIGURE 4.5
Model (A4) > Static Structural (A5) > Pressure > Figure



Solution (A6)

TABLE 4.14
Model (A4) > Static Structural (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done

TABLE 4.15
Model (A4) > Static Structural (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type

TABLE 4.16
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Equivalent Stress*	*Total Deformation*	*Equivalent Stress 2*	*Equivalent Stress 3*	*Equivalent Stress 4*	*Equivalent Stress 5*
State	Solved					
Scope						
Scoping Method	Geometry Selection					
Geometry	All Bodies		1 Body	3 Bodies		1 Body
Definition						
Type	Equivalent (von-Mises) Stress	Total Deformation	Equivalent (von-Mises) Stress			
By	Time					
Display Time	Last					
Calculate Time History	Yes					
Identifier						
Suppressed	No					
Integration Point Results						
Display Option	Averaged		Averaged			
Average Across Bodies	No		No			
Results						
Minimum	5.4901e-006 MPa	0. mm	66.815 MPa	2.0233e-002 MPa	2.3629e-003 MPa	25.582 MPa
Maximum	86437 MPa	603.19 mm	86437 MPa	5457.6 MPa	13499 MPa	6500. MPa
Minimum Occurs On	Part5			Part6-1	Part4	
Maximum Occurs On	Part3	Part1		Part1-1	Part4	
Minimum Value Over Time						
Minimum	5.4901e-006 MPa	0. mm	66.815 MPa	2.0233e-002 MPa	2.3629e-003 MPa	25.582 MPa
Maximum	5.4901e-006 MPa	0. mm	66.815 MPa	2.0233e-002 MPa	2.3629e-003 MPa	25.582 MPa
Maximum Value Over Time						
Minimum	86437 MPa	603.19 mm	86437 MPa	5457.6 MPa	13499 MPa	6500. MPa
Maximum	86437 MPa	603.19 mm	86437 MPa	5457.6 MPa	13499 MPa	6500. MPa
Information						
Time	1. s					
Load Step	1					
Substep	1					
Iteration Number	1					

FIGURE 4.6
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Figure

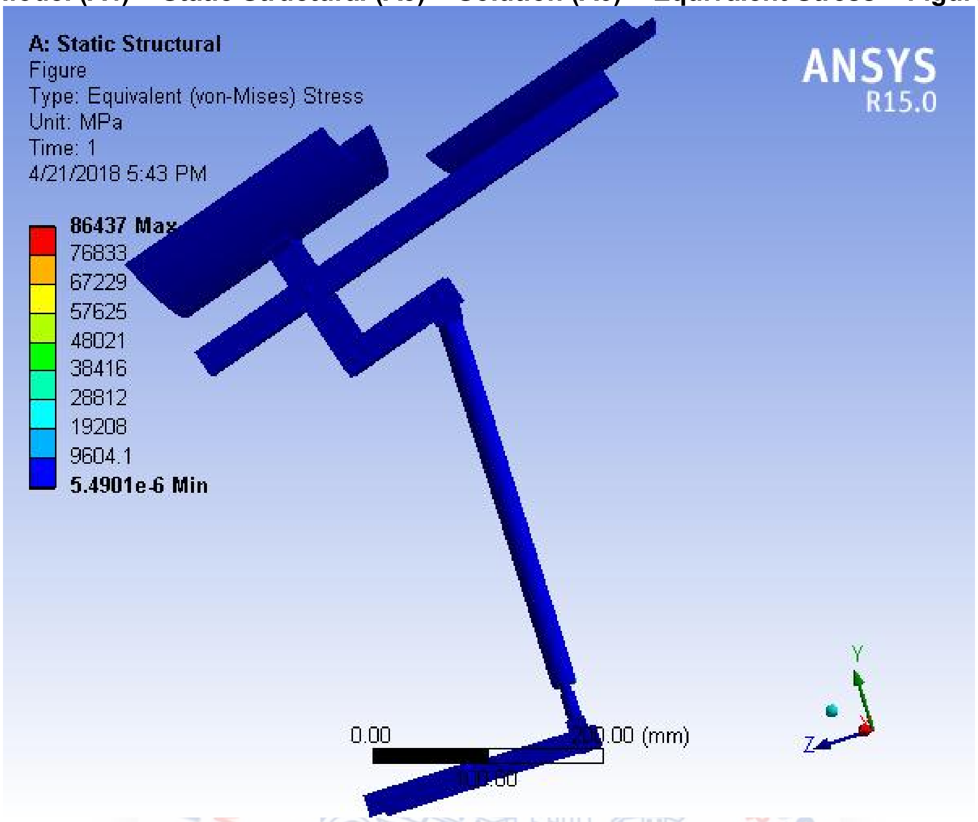
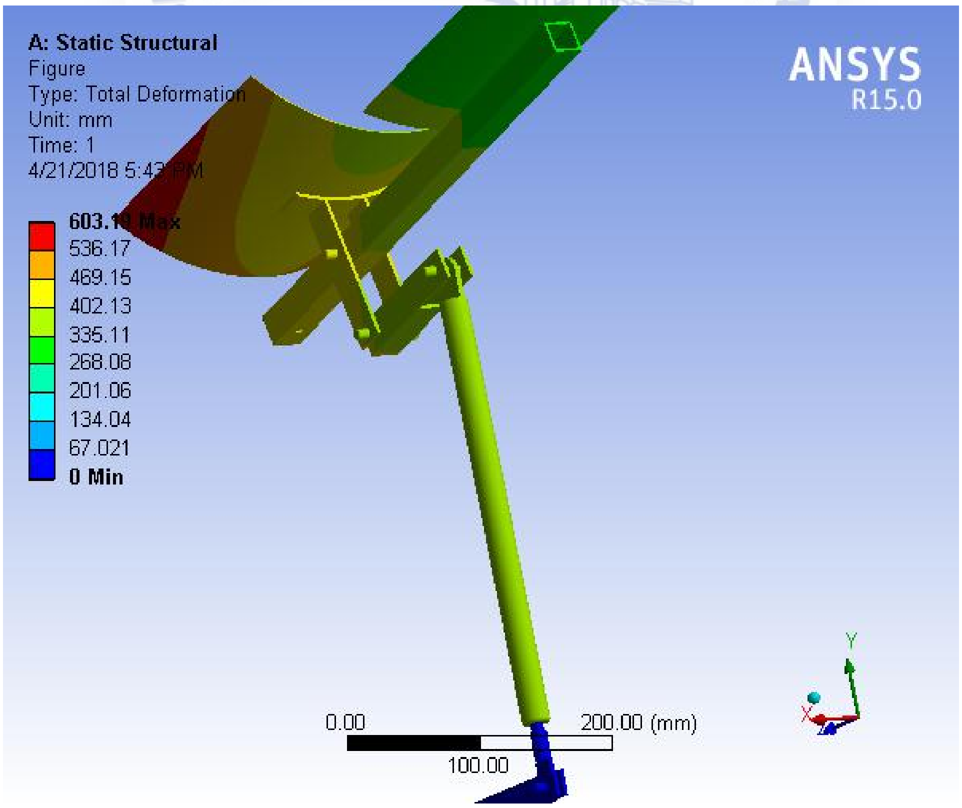


FIGURE 4.7
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Figure



Material Data

Structural Steel

TABLE 4.17
Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

TABLE 4.18
Structural Steel > Compressive Ultimate Strength

Compressive Ultimate Strength MPa
0

TABLE 4.19
Structural Steel > Compressive Yield Strength

Compressive Yield Strength MPa
250

TABLE 4.20
Structural Steel > Tensile Yield Strength

Tensile Yield Strength MPa
250

TABLE 4.21
Structural Steel > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
460

TABLE 4.22
Structural Steel > Isotropic Secant Coefficient of Thermal Expansion

Reference Temperature C
22

TABLE 4.23
Structural Steel > Alternating Stress Mean Stress

Alternating Stress MPa	Cycles	Mean Stress MPa
3999	10	0
2827	20	0
1896	50	0
1413	100	0
1069	200	0
441	2000	0
262	10000	0
214	20000	0
138	1.e+005	0
114	2.e+005	0
86.2	1.e+006	0

TABLE 4.24
Structural Steel > Strain-Life Parameters

Strength Coefficient MPa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient MPa	Cyclic Strain Hardening Exponent
920	-0.106	0.213	-0.47	1000	0.2

TABLE 4.25
Structural Steel > Isotropic Elasticity

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	2.e+005	0.3	1.6667e+005	76923

TABLE 4.26
Structural Steel > Isotropic Relative Permeability

Relative Permeability
10000

CHAPTER 5

CONCLUSION

Hence our design is affordable and specially designed for the people at different assembly line work Due to this arrangement peoples felt relaxed who were suffering from the back pain and spinal cord diseases. The design project is a success based on tilting device. It reduced body fatigue and increased the workability of the person in the office hours as well as in the commercial places. When in full-scale production, the Chairless chair will be available in three sizes, From 5ft to 5"5": Regular Size From 5"5" to 6ft: Large Size From 6ft to 6"5": Extra Large Size

FUTURE SCOPE

The basic operation of this machine to reduce fatigue by sustaining the weight of the wearer in a similar fashion as that by a regular chair . As your leg weakness progresses due to increasing in your age, your health care team may recommend equipment known as ambulation aids and bracing to help you with walking. Other devices can help give you needed support as the muscles in your neck and arms weaken.

There may be a use of such exoskeletons which can give more effect than braces and ambulation aids. The specific aid or device that's best for you depends on the extent of the weakness and your willingness to use such a device. Using such instruments for walking climbing, doing work is safe and you're confident that you won't fall. For some, this means having an attendant or using an assistive device when walking short distances.

Such instruments are going to bring more flexibility, mobility and most importantly the confidence Apart from in medical therapy and military sector, active or hoses or exoskeletons offer other applications, for example as a power booster during assembly work in production. They act here as a strength support device to prevent signs of fatigue that occur especially when performing repetitive actions.

REFERENCE

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APPENDIX

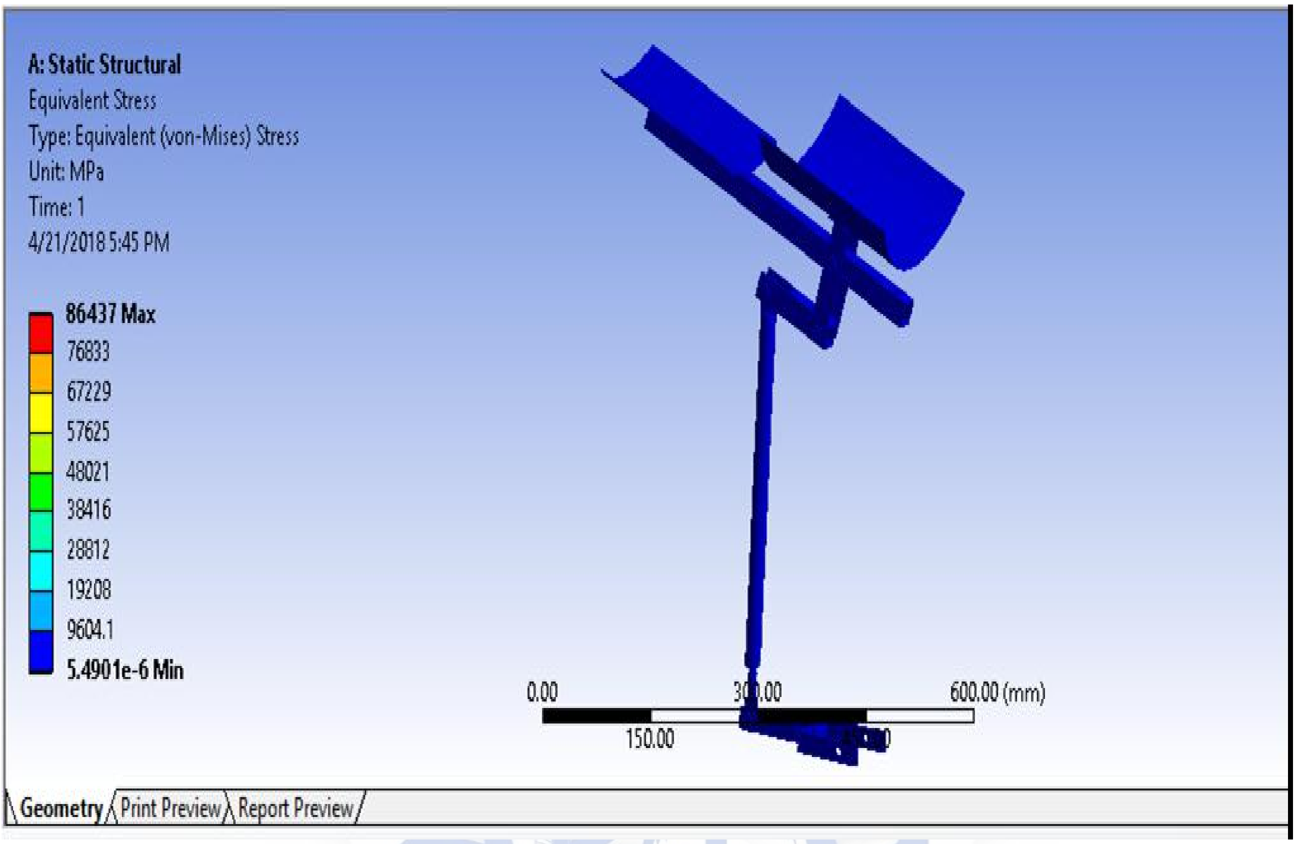

Fig. Static structural analysis (Full Body)

Fig shows that at static condition when no load is applied, there is minimum stress induced inside the structure. The analysis is done on ANSYS and theory applied is Von-missess criteria

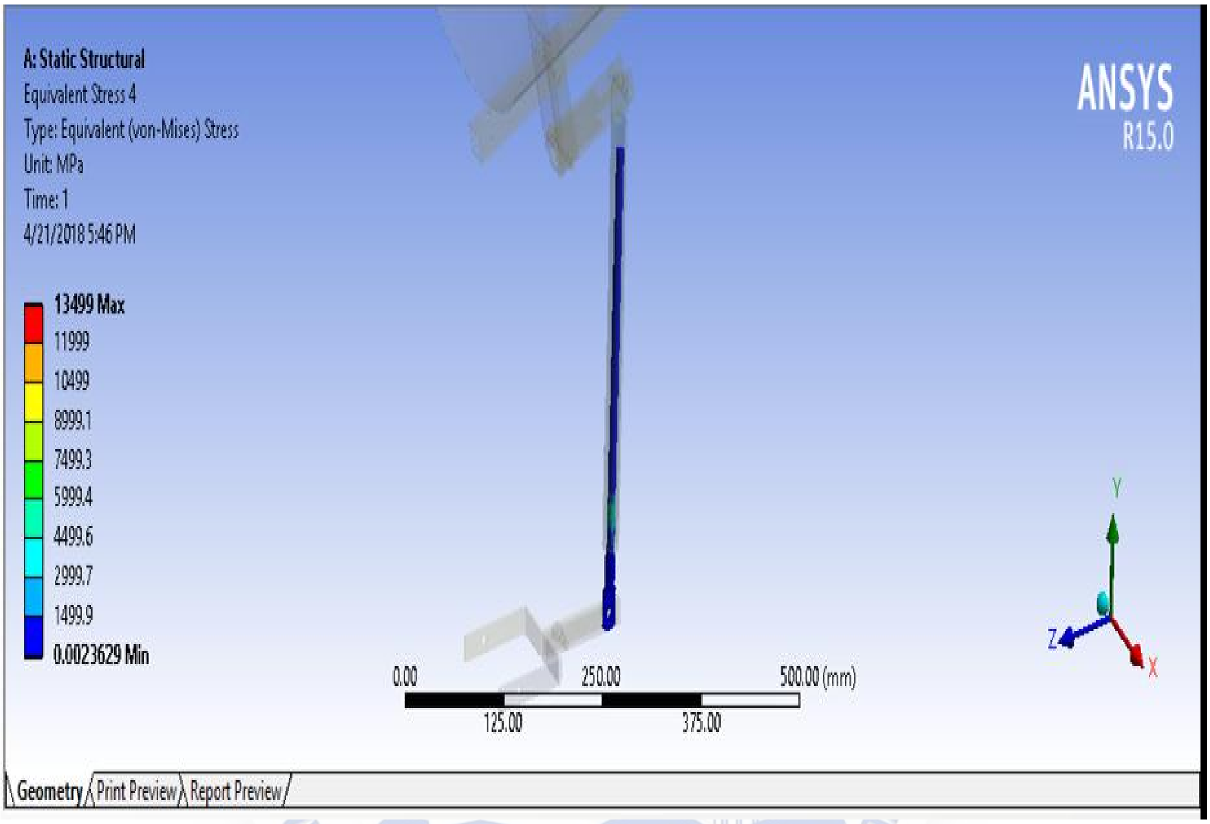

Fig. Static structural analysis (elongated pneumatic cylinder)

Fig shows that when we apply a pressure of 3105 N/m2 the minimum stress is 0.0023629 Mpa and the max stress is 13499Mpa

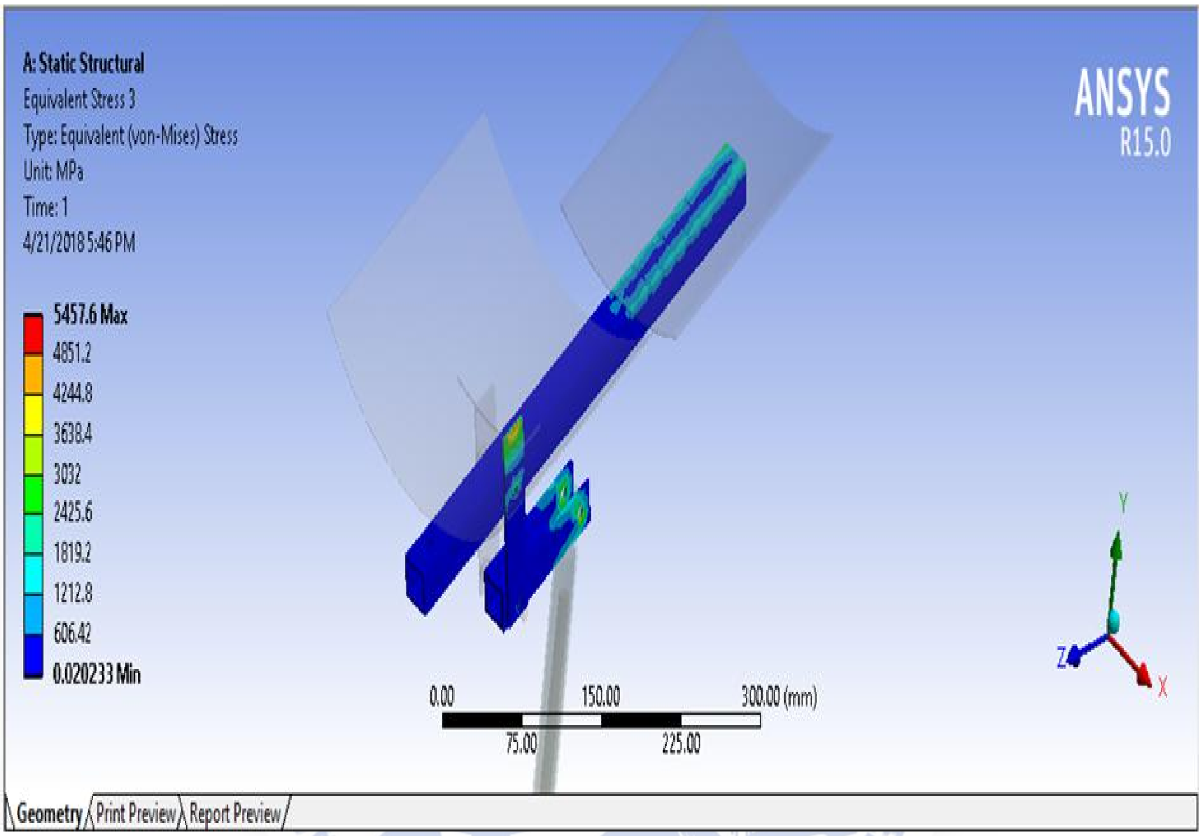

Fig Stresses on links

At loading position the max stress goes to the pivot point which is 5457.6Mpa and minimum stress is0.02023Mpa

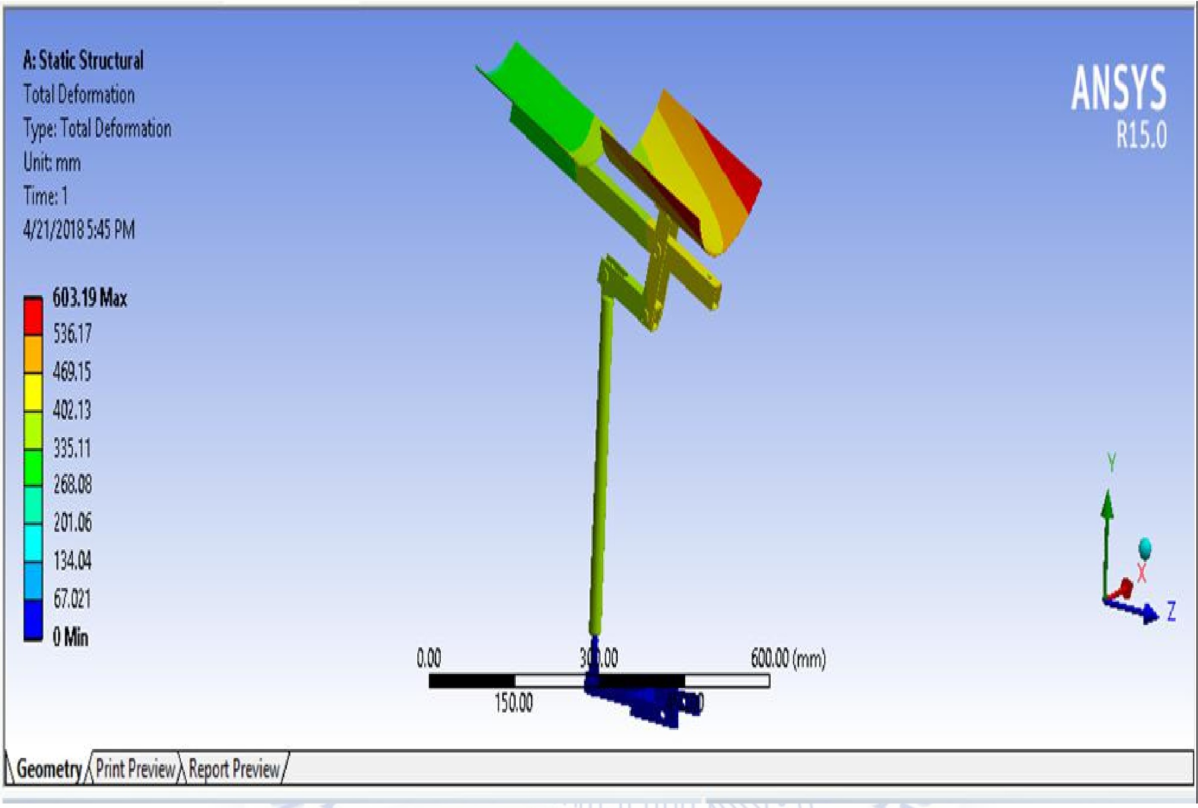

Fig shows the Total deformation results of the structure.

At full load the max deformation or stress concentration occurs on the thigh rest part.