



MODELLING AND ANALYSIS OF AN AERIAL SCISSOR LIFT BY COMPOSITE MATERIALS FOR DIFFERENT LOADS

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Abstract: Aerial scissor lifts are usually used for provisional, flexible access purposes such as maintenance and construction work or by fire-fighters for emergency access and also commonly used for elevators. These scissor lifts are designed to lift restricted weights, generally less than a ton. The increasing mandate of Aerial Scissor Lifts in companies to advance their manufacturing flexibility and output by providing flexible height access to their work. This leads us to engender an idea of using composite materials to model a scissor lift and perform analysis on Aerial scissor lift for different loads.

Key words: Aerial Scissor Lift, Flexibility, Composite Materials, Loads and Analysis

I. INTRODUCTION

Any vehicle-mounted device, telescoping or articulating, or both, which is used to position personnel is called aerial device. Any aerial device cast-off to elevate personnel to job sites above ground including extensible boom platforms, aerial ladders, articulating boom platforms and vertical towers is called aerial lift. A mobile supported scaffold which can be powered or unpowered is portable and caster or wheel-mounted is called scissor lift. Aerial scissor lifts pose a serious safety hazard if not used properly. Scissor lifts are the elevating platforms that can be raised or lowered to various heights. The platform can be positioned horizontally beyond the base. These lifts are increasingly being used in various industries because they are mobile and provide workers access to elevations to perform required tasks.

A scissor lift is a type of platform which moves in vertical direction. The mechanism incorporated to achieve this function is the use of linked, folding supports in a criss-cross 'x' pattern, known as a pantograph. The upward motion is achieved by the application of pressure to the outside of the lowest set of supports, elongating the crossing pattern, and propelling the work platform vertically upwards. The platform may also have an extending 'bridge' to allow closer access to the work area (because of the inherent limits of only vertical movement).

The name scissor lift originated from the ability of the device to open (expand) and close (contract) just like a scissor. Considering the need for this kind of mechanism, estimating as well the cost of expanding energy more than result gotten as well the maintenance etc. it is better to adopt this design concept to the production of the machine.

The initial idea of design considered was the design of a single hydraulic ram for heavy duty vehicles and putting it underneath, but this has limitations as to the height and stability, and someone will be beneath controlling it. It was rather found out that; there is a possibility of the individual ascending/descending, to be controlling the device himself. Therefore further research was made to see how to achieve this aim.

Before this time scissor lift existing use mechanical or hydraulic system powered by batteries for its operations. Several challenges were encountered in this very design. Some amongst many include; low efficiency, risk of having the batteries discharged during an emergency, extended time of operation, dependent operation, as well as maintenance cost. It is the consideration of these factors that initiated the idea of producing this hydraulically powered scissor lift with independent operator. The idea is geared towards producing a scissor lift using one hydraulic ram placed across flat, in between two cross frames and powered by a pump connected to a motor wheel may be powered by a pump generator. Also, the individual ascending / descending is still the same person controlling it. I.e. the control station will be located on the top frame.

scissor lift is attached to a piece of equipment having a work station known as scissor lift table that houses the pump, the reservoir, the generator, control valves and connections and the motor. A scissor lift does not go as high as a boom lift; it sacrifices heights for a large work station. Where more height is needed, a boom lift can be used. The operation of the scissor action can be obtained by hydraulic, pneumatic or mechanical means (via a lead screw or rack and pinion system).

a) *Statement of the problem:*

A problem remains same until the solution is proffered. ladders, scaffold and mechanical scissor lifts in getting to particular height such as the amount of load to be carried, conformability, time consumption and energy consumed etc. the idea of a hydraulically powered scissor lift which will overcome the above stated limitations is used.

b) *Importance / significance of the study:*

The design and analysis of a hydraulic scissor lift is to lift a worker together with the working equipment comfortably and safely to a required working height not easily accessible. It may be used without a necessary external assistance due to



the concept of the design. This project will be an important engineering tool is used in maintenance. Changing of street lamps, painting of high buildings and walls around the environment.

II. TYPES OF SCISSOR LIFTS

a) Upright's Scissors Lift

Upright introduced an equal innovative family of boom lift in 1990s. Walkce Johnson who created and sold the first platform which was called a "scissors lift" due to the steel cross bricking that supported the platform giving it the product name "magic carpet". This truly innovated company has left their mark with the other products including compact scissors design and modular alloy bridging, as well as expanding the versatility of instant span towers with aircraft docking and faced system, you will find upright products, especially the scissors lift, as standard equipment for a variety of application it is now a visual application in numerous fields and locations.

b) Scaffold :

Scaffold is cross section of pipes, irons or woods which are arranged in such a way that workers or operators can climb on the arranged pipes to get to elevated heights. Scaffolds cannot be adjusted automatically and they only can remain fixed the way it is arranged unless rearranged. The tubes are either steel or aluminum, although composite scaffolding using filament wound tubes of glass fiber in a nylon or polyester matrix. If steel, they are either "black" or galvanized.

c) Mechanical scissors lift:

The mechanical scissors lift is used for lifting materials especially on construction sites. This is one of the most recent advancement on scissors lift. There, the lift utilizes a belt drive system connected to a load screw which constructs the "X" pattern on tightening and expands it on loosening. The lead screw actually does the work, since the applied force from the wheel is converted to linear motion of the lift by help of the lead screw. This can be used to lift the working and equipment to a height.

d) Hydraulic lift:

The hydraulic type, but this time, the load screw is replaced by a hydraulic ram powered by a pump and on electric motor and generator. One outstanding feature about this design however. Is its independent operation and increased efficiency. Fluid power is one of the greater form of power where small input results in a very large output. This scissors lift can be handled by one person to a place of use, and power the generator. The lift does not lifting immediately, the operators' climbs on the platform and switches open the hydraulic circuit thereby leading to an upward extension. When the required height is reached the circuit is closed, and lifting stops the control panel or station is located on the top frame

III. CAD MODELING

CATIA is used in a vast range of industries from manufacturing of rockets to computer peripherals. With more than one lakh seats installed in worldwide many cad users are exposed to CATIA and enjoy using CATIA for its power and capability.

a) Modeling of base plate:

The base plate in a scissor lift only provides proper balance to the structure. Considering the size constraints, the dimensions of the base plate are taken as under. Also it has been found that not much of the stresses are developed in the base plate. It is responsible for the lift to handle the total weight of the lift and the weight to be carried and also acts as carrier for the hydraulic cylinder. The following figure shows the CAD model of a base plate

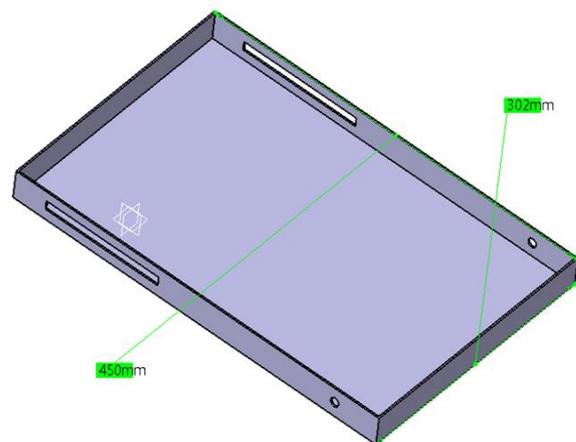


Fig 1: Modeling of a base plate

b) Modeling of top plate:

The upper plate in a scissor lift is used to place the load and transfer it to the links. The designing of the upper plate is undertaken similar as the base plate. The upper plate has the similar requirements as the base plate. Also it has been found that not much of the stresses are developed in the upper plate as well. The following fig shows the Modelling of a Top plate.

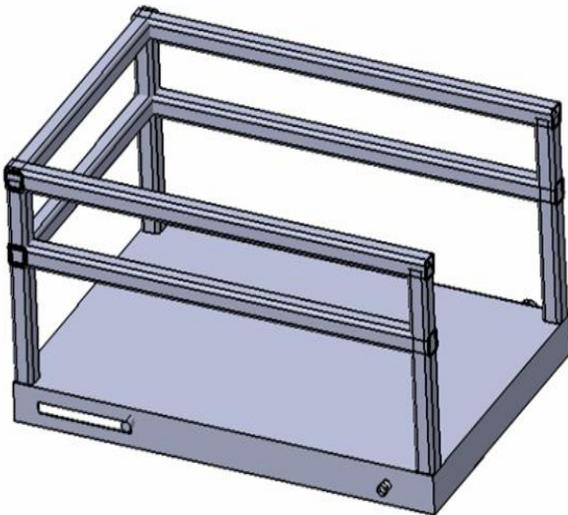


Fig 2: Modelling of the Top plate

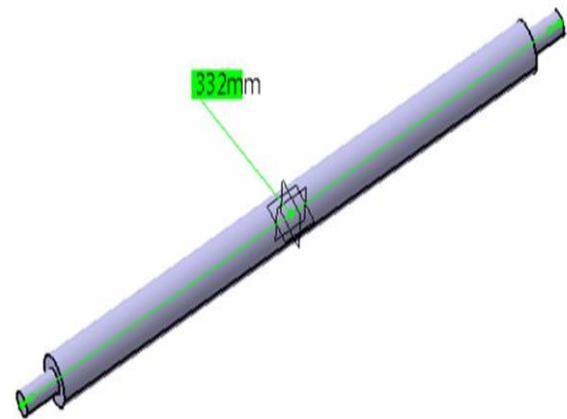
c) Modeling of rod

Fig 3: Modelling of the Rod

d) Modelling of scissors links

The scissor link is responsible for the lift structure to move up and down. The following figure shows the modeling of the scissors links in catia.

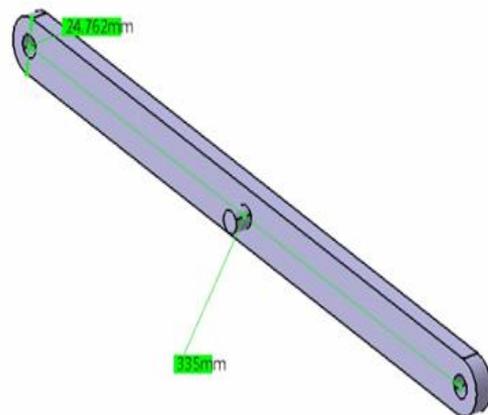


Fig 4: CAD model of scissors connectors

e) Assembly design

The final assembly design is made in catia by checking the proper alignment and keeping the constraints in observance. The following figure shows the assembly design of a scissor lift.

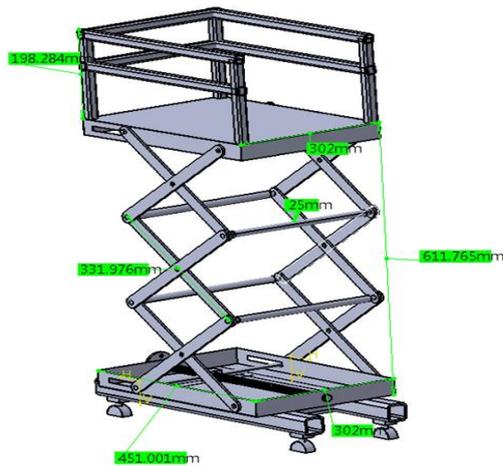


Fig 5: Assembly design of Scissor Lift

f) Drafting of scissor lift

The design constraints for the required scissor lift is illustrated in the Drafting mentioned in the below figure.

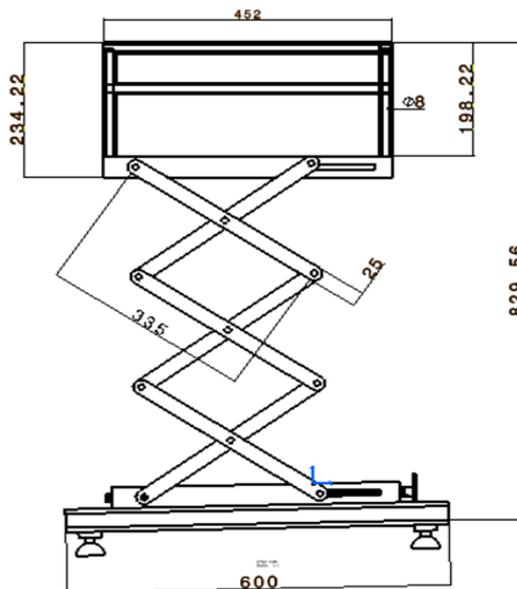


Fig 6: Drafting of the Scissor lift

IV. MATERIAL SELECTION

Material selection plays a very important role in machine design. For example, the cost of materials in any machine is a good determinant of the cost of the machine. More

than the cost is the fact that materials are always a very decisive factor for a good design.

a) Choice of fiber glasses:

1. C-glass

Corrosive resistant glass made with calcium borosilicates. Used in acid corrosive environments.

2. E-glass

Alkali free, highly electrically resistive glass made with alumina-calcium borosilicates. E-glass is known in the industry as a general-purpose fiber for its strength and electrical resistance. It is the most commonly used fiber in the fiber reinforced polymer composite industry.

3. S-glass

High strength glass made with magnesium aluminosilicates. Used where high strength, high stiffness, extreme temperature resistance, and corrosive resistance is needed.

4. Carbon fiber

Carbon fiber or carbon fiber (alternatively CF, graphite fiber or graphite fibre) is a material consisting of fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. To produce carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal alignment gives the fiber high strength-to-volume ratio (making it strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabric. The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion, make them very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports.



V. STRUCTURAL ANALYSIS

a) Material properties

The material which we have chosen is listed below

TABLE
MATERIAL PROPERTIES

	S-Glass Fibre	C-Glass Fibre	E-Glass Fibre	Carbon fibre
Poisson Ratio	0.23	0.23	0.23	0.23
Young's modulus (Mpa)	93000	69000	85000	52500
Ultimate Compression strength (Mpa)	5000	4300	5000	1200
Tensile Yield strength (Mpa)	2200	3310	2000	2457
Density g/cm ³	2.46-2.49	2.56	2.5-2.59	2
	4800	3310	3500	5650

b) ANALYSIS PROCEDURE

- Open the tool.
- Then go for the assembly.
- Then import the components required for the assembly to complete.
- After completing the mates, move to the analysis.
- To perform the analysis on the assembly part you must go for office products, in that select "simulation".
- Then you can find a dialogue box at the top, from that select the study advisor.

d) Mesh

Initial Setup Close the Design Modeller if you haven't already, and open ANSYS Mechanical by double clicking. When ANSYS Mechanical opens, notice that there is a question mark next to Geometry in the Project Outline -

- Now just click the following options in the said order
- I am concerned about excessive loads and deformation.
- Next
- Now apply the material for the components that are to be analysed.

c) Geometry

In Workbench in the Project Schematic window, go to File > Import. In the Import window that opens, change the file type (next to the File Name text box) to Geometry File. Select the geometry file and press Open. The geometry should now be in the project schematic, as shown below.

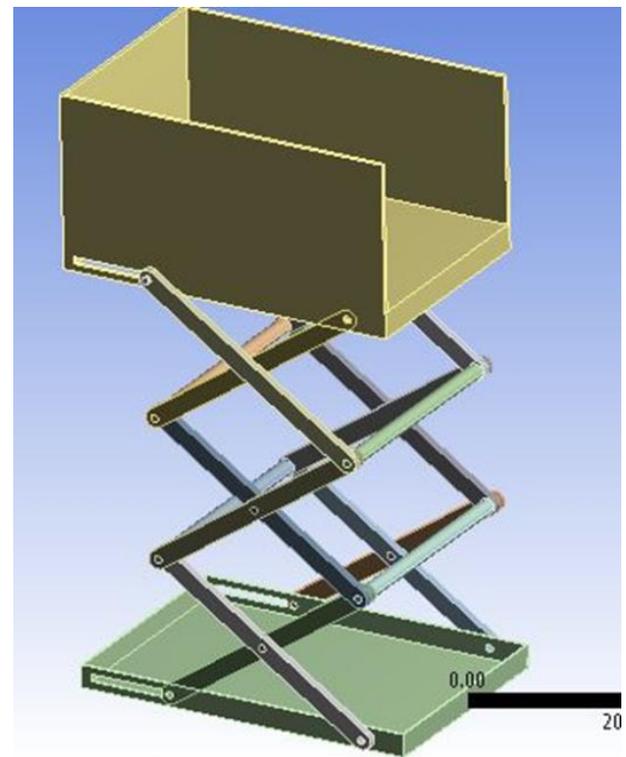


Fig 7: Imported IGS file

this means that there is something missing in this section. Expand Geometry, expand Part and select Outer Surface.

e) Boundary condition

The applied load of 1000 kg in the top of the scissor lift and fixed the Base plate.

ANSYS Mechanical opens, notice that there is a question mark next to Geometry in the Project Outline - this means that there is something missing in this section.

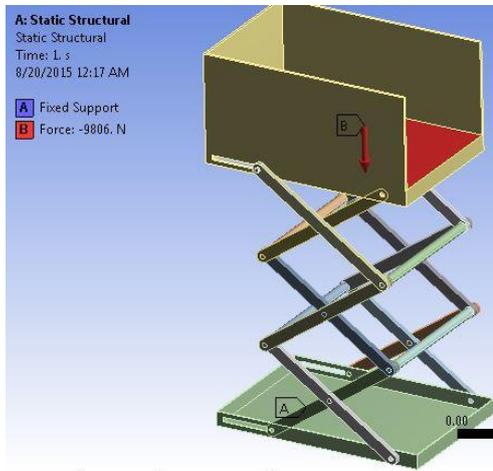


Fig 9: Applied load

f) *Equivalent stress of c glass fibre*

In the solution sub mean, select Stress > Equivalent (von-Mises). In the details pane, ensure Geometry is set to All Bodies.

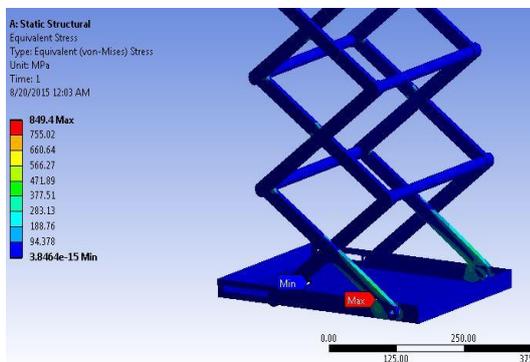


Fig 10: Equivalent vonmises Stress for C glass fibre

g) *Equivalent strain of c glass fibre*

In the solution sub mean, select Result > Equivalent (von-Mises) Strain. In the details pane, ensure Orientations is set to X axis and Geometry is set to All Bodies. Rename the Stress to Stress XX by right clicking Shear Stress in the Outline window and selecting Rename.

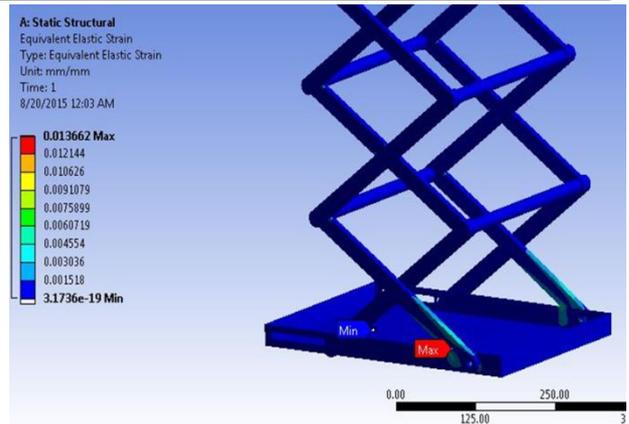


Fig 11: Equivalent vonmises Strain for C glass fibre

h) *Equivalent stress of s glass fibre:*

In the solution sub mean, select Stress > Equivalent (von-Mises). In the details pane, ensure Geometry is set to All Bodies.

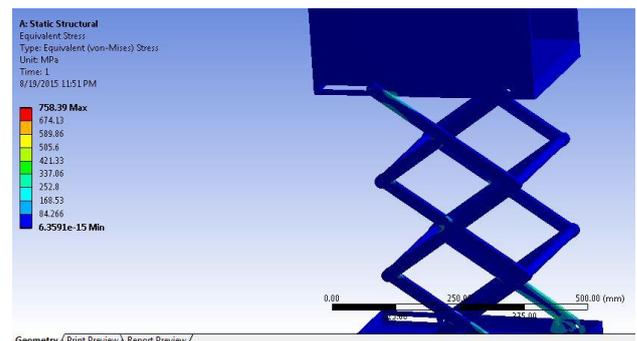


Fig 12: Equivalent vonmises Stress for S glass fibre

i) *Equivalent strain of s- glass fibre*

In the solution sub mean, select Result > Equivalent (von-Mises) Strain. In the details pane, ensure Orientations is set to X axis and Geometry is set to All Bodies. Rename the Stress to Stress XX by right clicking Shear Stress in the Outline window and selecting Rename.

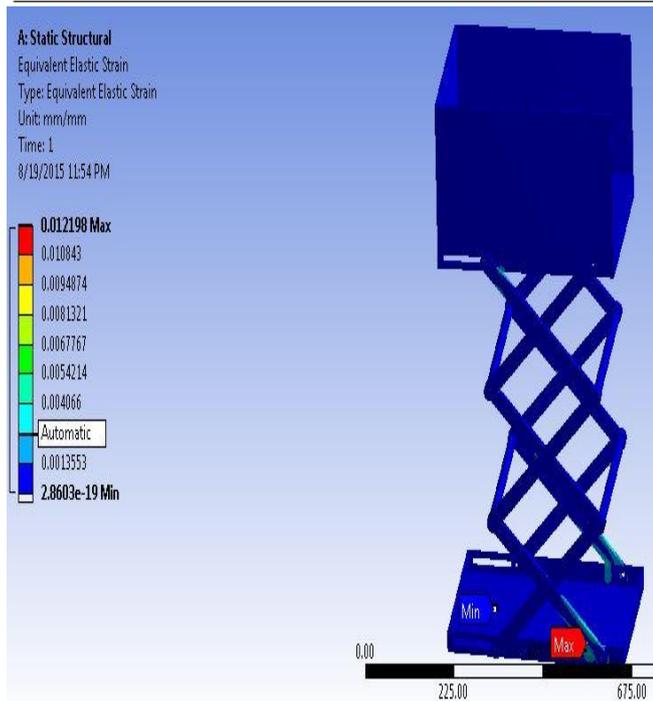


Fig 13: Equivalent vonmises Strain for S glass fibre

j) Equivalent stress of e glass fibre

In the solution sub mean, select Stress > Equivalent (von-Mises). In the details pane, ensure Geometry is set to All Bodies.

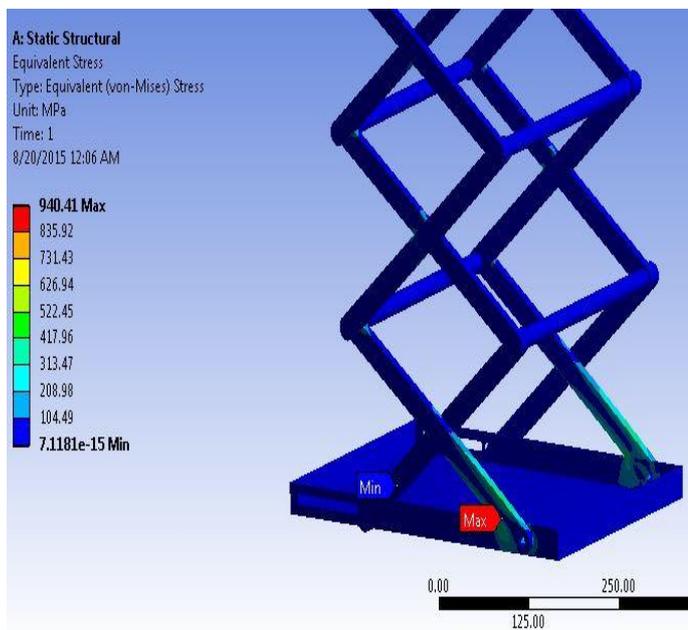


Fig 14: Equivalent vonmises Stress for E glass fibre

k) Equivalent strain of e- glass fibre

In the solution sub mean, select Result > Equivalent (von-Mises) Strain. In the details pane, ensure Orientations is set to X axis and Geometry is set to All Bodies. Rename the Stress to Stress XX by right clicking Shear Stress in the Outline window and selecting Rename.

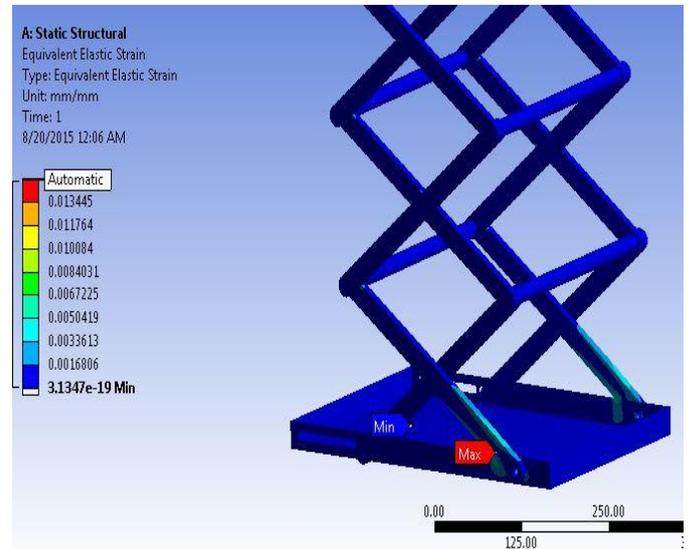


Fig 15: Equivalent vonmises Strain for E glass fibre

n) Comparison chart

TABLE
STRESS AND STRAIN FOR GIVEN MATERIALS

	S- Glass Fibre	C- Glass Fibre	E- Glass Fibre	Carbon fibre
Stress (Mpa)	758.39	849.4	940.41	1137.6
Strain (mm)	0.01219	0.013662	0.015126	0.018297

VI.CONCLUSION

❖ The demand of aerial scissor lifts by companies is increasing, as they are proving efficient in improving their manufacturing flexibility and output by providing variable height access to their work. The main reason that supports companies thinking is that it is much more economical to bring the worker to the work rather than bringing the work to the worker. In the above mentioned condition a good design of the aerial scissor lift is necessary such that the



complexities in the design and the manufacturing time can be reduced so such a design can be used for production in industries.

❖ In our project we designed a model of the aerial scissor lift that can satisfy the mentioned condition, which is later analyzed using the ANSYS software, by applying the constant loads for different materials carbon fiber can have more vonmises stress comparing with other glass fibres, so for our scissor design we can use the carbon fibre material as a engineered material. By the analysis it is clearly evident that the design is safe under certain accepted parameters.

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