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# FEM ANALYSIS OF SMART MOVING LADDER.

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***Abstract:*** - Today our world is no stranger to progress in terms of development facilities. Studies have been conducted to identify and also improve the design of ladder according to the passage of time. The ladder is the best innovation for the people in the entire world. Ladders are needful tools for reaching heights safely in various settings, such as from construction sites, home maintenance tasks etc. Ladders come in different materials like aluminum, fiberglass, and wood, each with its own benefits. Consider a factors like height, weight capacity, and portability when choosing the right ladder for our day-to-day needs. Safety precautions, such as maintaining three points of contact while climbing and using proper ladder positioning, are crucial to prevent accidents occurs for doing work.

***Keywords—Safety, Forces, Smart, Ladder, Climbing***

## I. INTRODUCTION

The construction industries contributed 87 of the 146 fatal falls. A ladder is a vertical or inclined set of rungs or steps commonly used for climbing or mounting to the up side and down side. There are two types of ladders: rigid ladders and self-supporting or that may be leaned against a vertical surface such as a wall and rollable ladders, such as made of iron, aluminum, that may be hung from the top. The vertical members of a rigid ladder are called stringers or rails (US) or stiles (UK). Rigid ladders are usually portable, but some types are permanently fixed to a structure, building, or equipment's, may be done. They are commonly made of metal, wood, fiberglass but they have been known to be made of tough plastic. If we are making a huge ladder, we required the though material even they can sustain the work load and human comfort to the uneven surface during the working with the ladder. A ladder is featured in a Mesolithic rock painting that is at least 11,000 years old, depicted in the Spider Caves in Valencia, Spain. The painting depicts two humans using a ladder to reach a wild honeybee nest to harvest honey.to bring the ladder are the best innovation for the people in the entire world. Gripping the rungs provides much greater holding power than gripping the siderails when the ladder is in working in condition may be also done.

## II. CONSTRUCTION AND WORKING OF SMART MOVING LADDER.

- The working principle of a ladder is based on stability, weight distribution, and maintaining a secure angle of inclination. When used correctly and on stable surfaces, ladders provide a safe and efficient way to access elevated areas. Safety precautions and adherence to weight limits are essential to prevent accidents while using ladders. Or to make a ladder that can be moved by the one person on the ladder just by using the leg without having them to climb down the ladder

Fig. CAD Model of Smart moving ladder.

**Phase I (Forword Direction)**

When we push the ladder base in downward direction and maintain the proper angle in positive direction of ladder inner leg, then the ladder will move forward in direction.

**Fig. Forword in Direction**

**Phase II (Backward Direction)**

When we push the ladder base in downward direction and maintain the proper angle in negative direction of ladder inner leg, then the ladder will move backward in direction.

**Fig. Backward in Direction**

- **COMPONENTS USED IN SMART LADDER**

**1. MAIN FRAME (CHASSIS)**

MAIN FRAME A chassis consists of an mild steel robust frame that supports a manmade object in its construction and use, consisting of the frame (on which the components are mount). A ladder frame is a vertical or inclined set of rungs or steps commonly used for climbing or descending. There are two types: rigid ladders that are self-supporting or that may be leaned against a vertical surface such as a wall, and rollable ladders, such as those made of rope or aluminum that may be hung from the top. The vertical members of a rigid ladder are called stringers or rails (US) or stiles (UK). Rigid ladders are usually portable, but some types are permanently fixed to a structure, building, or equipment. They are commonly made of metal, wood, or fiberglass but they have been known to be made of tough plastic

**Fig. 1.2 Main Frame**

**2. SPRING**

A coil spring is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded. A spring is a device consisting of an elastic but largely rigid material (typically metal) bent or molded into a form (especially a coil) that can return into shape after being compressed or extended. Springs can store energy when compressed. In everyday use, the term most often refers to coil spring, but there are many different spring designs. Modern springs are typically manufactured from springs steel.

**Fig. 1.3 Spring**

**3. WHEEL**

A caster (or castor) is an undriven wheel that is designed to be attached to the bottom of a larger object (the "vehicle") to enable that object to be moved. Casters are used in numerous applications, including shopping carts, office chairs, toy wagons, hospital beds, and material handling equipment. High capacity, heavy duty casters are used in many industrial applications, such as platform trucks, carts, assemblies, and two lines in plants. Trolley wheels are an essential component for many types of trolleys, carts, and other material handling equipment. They allow for smooth and efficient transportation of goods, making the job of moving heavy loads much easier. However, not all trolley wheels are created equal, and there are several factors to consider when choosing the right set of wheels for your trolley.They are commonly used with small removable plate and are perfect casters for small equipment, coffee tables, ottomans, plant stands and bookshelves. Trolleys are used in airports and some large railway stations for passengers to carry their luggage

**Fig. 1.4 Wheels**

**4. HINGE**

a jointed device or flexible piece on which a door, gate, shutter, lid, or other attached part turns, swings, or moves. a piece of metal that fastens the edge of a door, window, lid, etc. to something else and allows it to open or close A hinge is a mechanical bearing that connects two solid objects, typically allowing only a limited angle of rotation between them. Two objects connected by an ideal hinge rotate relative to each other about a fixed axis of rotation, with all other translations or rotations prevented; thus a hinge has one degree of freedom. Hinges may be made of flexible material or moving components. In biology, many joints function as hinges, such as the elbow joint.

The primary reason for using a hinge, rather than a simpler device such as a slide, is to prevent the separation of adjacent components. When no bending stresses are transmitted across the hinge, it is called a zero-moment hinge.

**Fig. 1.5 Hinge**

## III. FABRICATED SMART MOVING LADDER

**Fig. Fabricated smart Ladder**

## IV. FEM ANALYSIS

Finite elements analysis of structural analysis of smart moving ladder depends on the conditions such as follows

1. Material
2. Load
3. Boundary Conditions
4. Meshing of the components

Steel has strong strength, low weight, durability, ductility, and corrosion resistance as physical qualities. Steel, despite its small weight, has a lot of strength. Steel, in fact, has the lowest strength-to-weight ratio of any building material.
Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section. Mild steel is a type of carbon steel that has low carbon content, typically around 0.05% to 0.25% by weight. Contrast this with high-carbon steel containing up to 2.5% carbon by weight. It is prized for being weldable, machinable, and ductile. It is utilized in many applications, including fences, signs, and the automotive and construction industries

Factor of safety = Maximum stress/ Working stress (in case Ductile Material) Factor of safety = Yield point stress/ Working stress

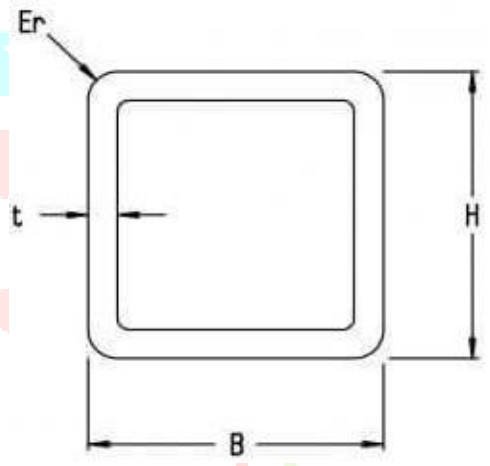
(in case Ductile Material Factor of safety = Ultimate stress/ Working stress (in case Ductile Material

When we calculate the capacity of ladder to how many loads can be sustained.

Calculation for the capacity of ladder it may be consider as some following factors such as Load, Material, Boundary condition and meshing of the components

When we consider as a load 100 kg when the factor of safety as be consider as on the safety of the human need Material of ladder is structural steel square pipe

The dimension of the ladder pipe is 25 mm x 25 mm Square hallow pipe Thickness of square pipe is 5mm




| Parameters | Specifications |
|---|---|
| Density | 7850 kg/ $m^3$ |
| Youngs Modulus | 2.e+005 |
| Poisson's Ratio | 0.3 |
| Bulk Modulus | 1.6667e+011 pa |
| Shear Modulus | 76923e+006 Pa |
| Yield Strength | 250e+006 Pa |
| Ultimate strength | 460+006 Pa |

In analysis of ladder is when we load acting on the platform of the ladder up to 100 kg

on the ladder is resting on floor which may be the degree of freedom is zero because when it is fixed due this condition the load is acting on the platform it minorly collapsed when the load are increased gradually stresses are developed in the platform it will goes the deformation of the bar.

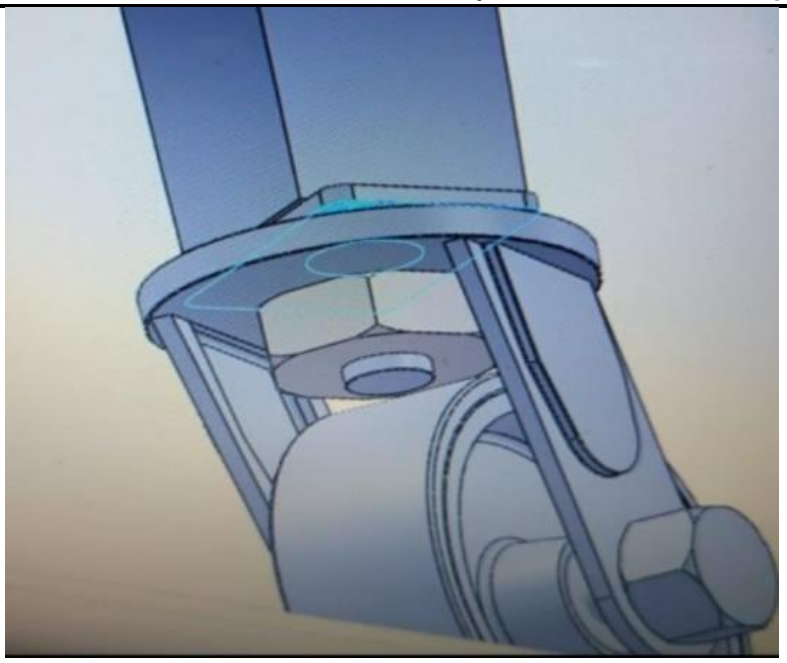


Figure shows the one end is fixed and other is free.

Boundary condition of the ladder is the one end is fixed and other is free The all data stored in the analysis Software it gives the detail report.

Cart EnSite Co-ordinate 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. ] |

When we analysis the stresses of ladder the ladder will deform in the platform it will be collapsed due the sustainability of load The maximum capacity of ladder can carry the load of up to 100 kg. it can hold up to 150 kg after that the material can be collapsed due to the stresses developed in the ladder.

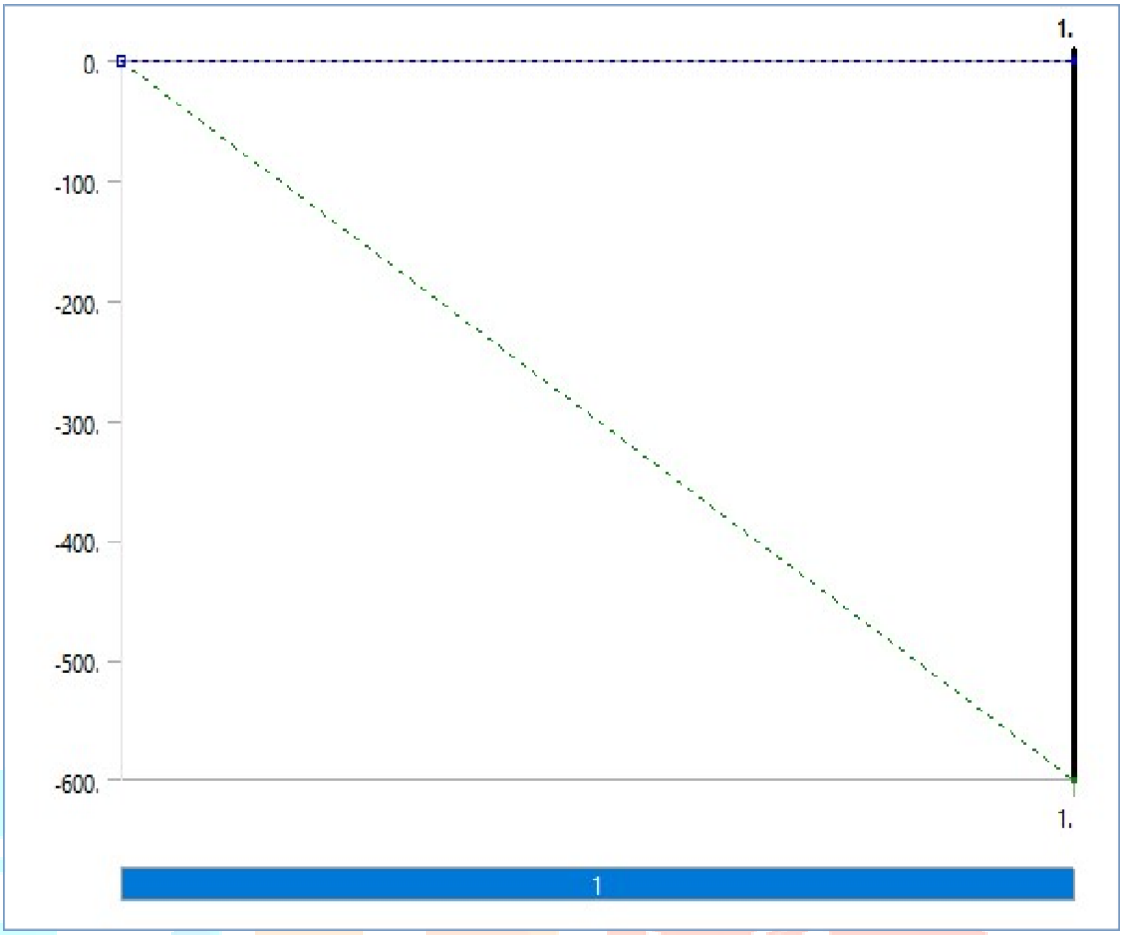



Fig. Graph Static Structural Analysis of Ladder.

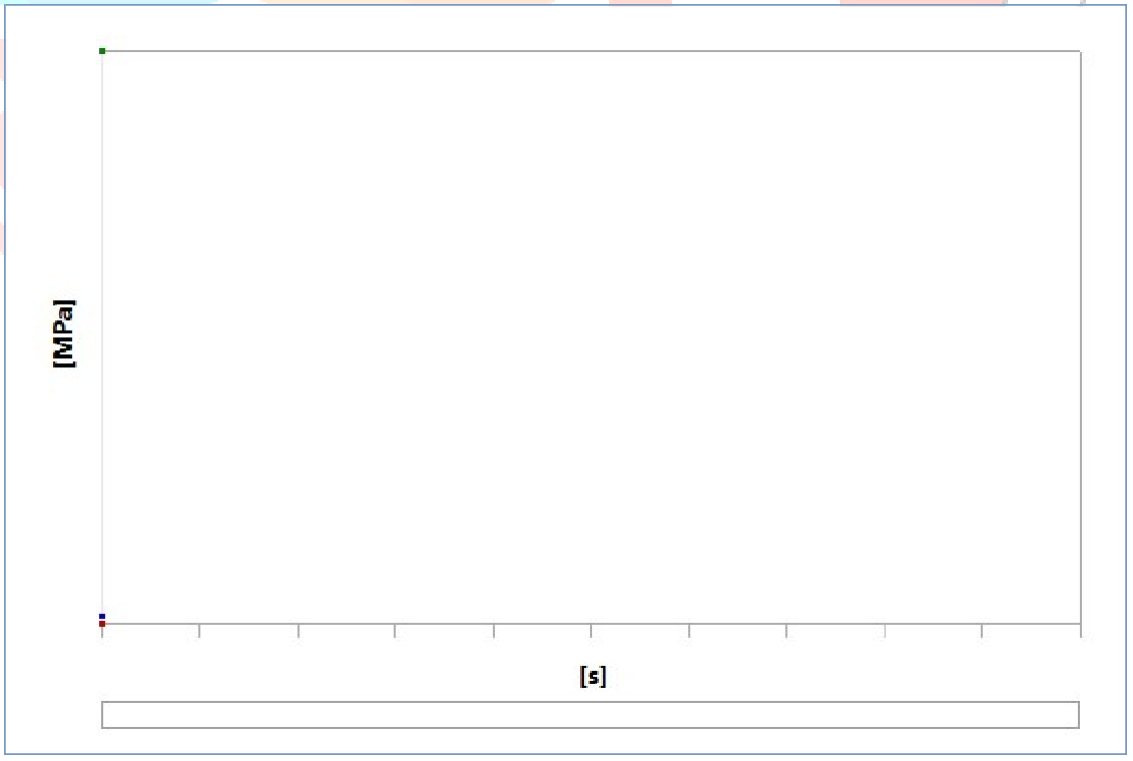



Fig. Deformation Graph

**1.Equivalent Stress.**

Equivalent stress is actually a scalar derivative of shear strain energy per unit volume measured at different points in a stressed material and helps in determining the likelihood of the failure of the said material according to the Von Mises failure criteria. It is commonly used for ductile materials.

Equivalent stress = maximum allowable stress / equivalent stress.

Equivalent stress as shown in table1.1

Static Structural > Equivalent Stress

| Time [s] | Minimum [MPa] | Maximum [MPa] | Average [MPa] |
|---|---|---|---|
| 1. | 1.8385e-005 | 182.73 | 2.2323 |

Table 1.1

2.**Total Deformation as shown in table**

Static Structural > Total Deformation

| Time [s] | Minimum [mm] | Maximum [mm] | Average [mm] |
|---|---|---|---|
| 1. | 0. | 0.67364 | 0.2417 |

Table 1.2

Total Deformation found in Ansys software is 0.67364

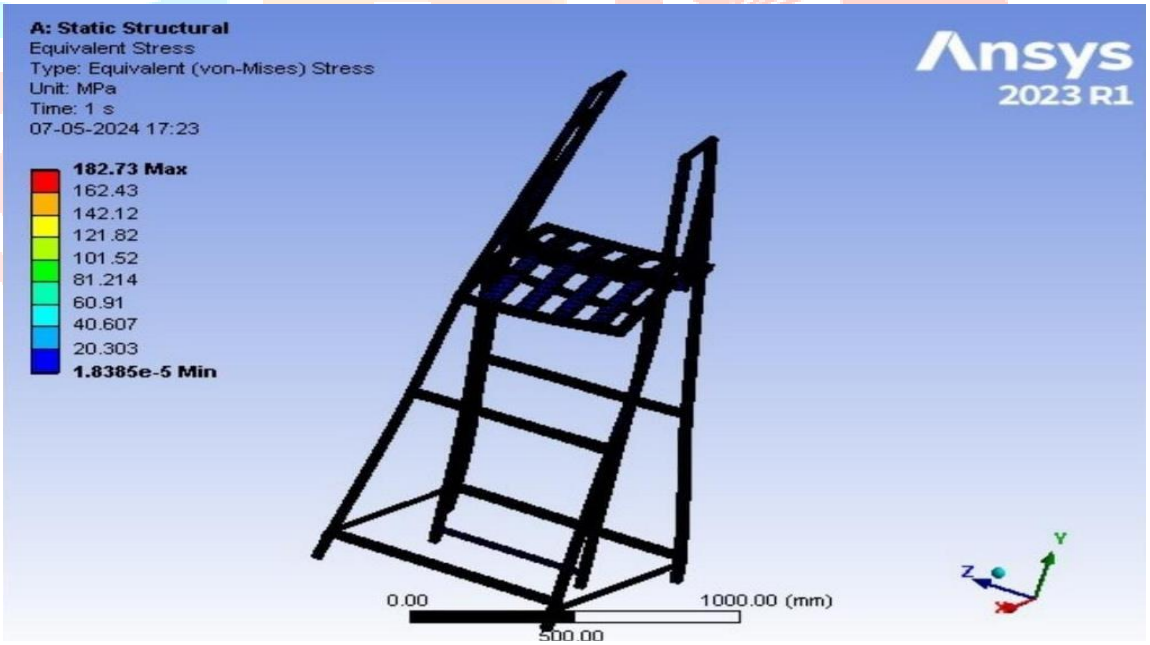



Fig. Structural Analysis of smart Ladder.

Figure shows the when applied the load and the platform is deformed due to stresses developed in the ladder.
Result shows by Ansys software is

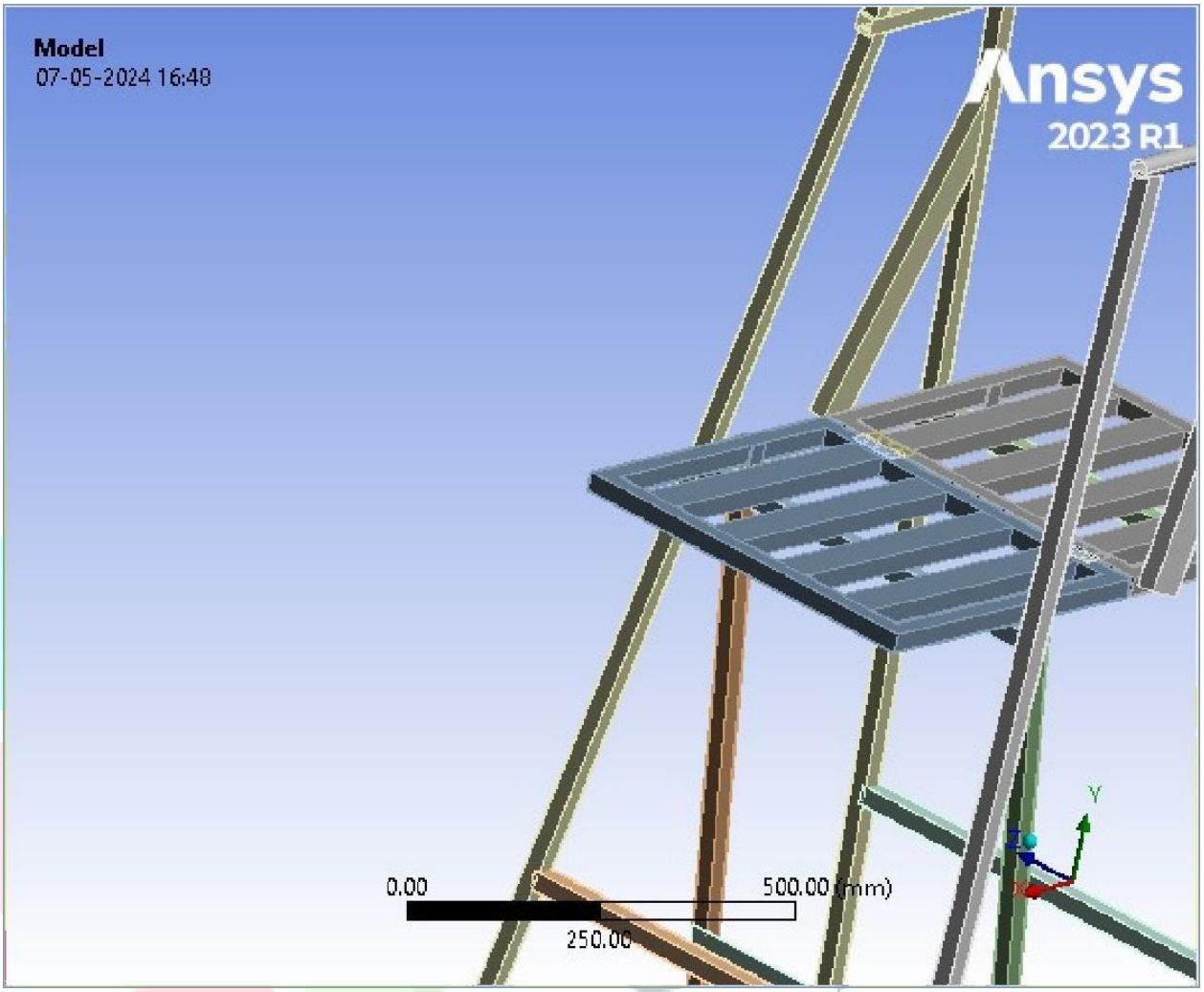
**STATIC STRUCTURAL ANALYSIS**

1)Total deformation: 0.67364
2)Equivalent stress: 1.8385e-005

Total Deformation found in Ansys software is 0.67364

## V. RESULT

The project titled "Design fabrication and Analysis of Smart moving Ladder" has been successfully completed, yielding satisfactory results. These findings hold significant value for future endeavors, particularly for individuals seeking to undertake modifications or advancements in similar projects. Moreover, the ladder boasts a design with fewer moving components, resulting in reduced wear and tear and enhanced durability. Smart ladder effectively useful for normal people that can avail to save the time and energy. The successful implementation of the "Design fabrication and Analysis of Smart moving ladder" project underscores its potential to revolutionize for the painters, electrician, fire safety officers and also house hold services.




**STATIC STRUCTURAL ANALYSIS**

3)Total deformation: 0.67364
4)Equivalent stress: 1.8385e-005

Total Deformation found in Ansys software is 0.6736

## VI. CONCLUSION:

Our project, titled "Design, Fabrication and Analysis of Smart Moving Ladder," has been successfully completed with satisfactory results. The outcomes obtained will greatly facilitate individuals undertaking the project for further modifications. This project is particularly well-suited for the house hold services such as paintings also common man uses, offering numerous advantages such as no pollution, and noiseless ladder. Its efficiency is enhanced by the presence of fewer moving components, resulting in less wear and tear.

- This system encourages physical exercise for individuals and is designed for easy handling.
- As it reduces overall handling time therefore it can be used for various mounting purpose.
- During operation it does not leave any trace on load means doesn’t affect the surface finish of product.
- Because of more reliability it can be used for heavy load lifting.
- Since no pollution take place during operation therefore it also helps to maintain pollution free environment.
- As in future it works on DC motor which use to run as drive.

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