IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

FINITE ELEMENT ANALYSIS OF BLACKBOARD DUSTER CLEANING MACHINE

[1]MS. S.M. JAGTAP **[2]MR. S. B. TULJAPURE**

[1]PG Student (Mechanical Department) ,Walchand Institute of Technology, Solapur-413006, India.

[2]Asso. Professor (Mechanical Department),Walchand Institute of Technology, Solapur-413006, India.

ABSTRACT:

These days, teachers are getting affected by respiratory diseases and skin allergies because of using chalk for long duration. Continuous use of chalk-dust also affects vision of a human being. As dust contains tiny particulates of chalk, they tend to accumulate in human respiratory system which can create severe health issues. Traditionally, chalk dusters are being cleaned by beating them on floor, wall or hitting dusters together which triggers above problems and causes environmental pollution. Hence a machine is designed to clean chalkboard dusters. In this paper, transient analysis of the base table has been carried out using ANSYS workbench. Modeling is done using CATIA software. With the help of varying mesh size, the results are plotted and represented graphically. The effect of load is also studied by observing the stresses & deformation. The stresses are found to be within limit & much lesser.

Keywords: *chalkboard duster, ANSYS workbench, finite element analysis, transient analysis.*

1.INTRODUCTION

Teachers and chalk always go together. Chalk particles are tiny enough to get accumulated and form a thin layer within respiratory system which may lead to respiratory and skin allergies. It can disturb throat functioning & also affects vision badly. Many times doctors getting patients with the issues of throat pain, skin allergies or problems with respiratory systems these all are the results of exposure to chalk dust.

Then the only option teacher is to go for change in the teaching method or use a low powder chalks (dustless chalks). Also, using dustless or low powder chalks may cause asthma attacks or allergy for the students who are Casein sensitive because, casein, milk protein is used in a dustless chalk while manufacturing. When these casein particles are inhaled they can cause congestion, coughing, sneezing or severe asthma attacks. The whole scenario results into increase of absenteeism of students in schools, colleges which ultimately leads to degrade their educational performance.

Air containing dust particles affects health of students and teaches as follows:

•Uncomfortable, unhealthy students cannot focus on learning and remain distracted, inactive. The productivity gets suffered due to lack of concentration.

• Students those are already casein sensitive or have issues like asthma gets badly affected due to chalk dust.

• Students tend to fall sick frequently which affects their attendance.

• Teacher's performance gets affected if they are unwell because of over exposure to chalk dust.

Hence a machine is designed to clean the dusters.

2. DUSTER CLEANING MACHINE:

The proposed machine works on the principle of Roller follower and cam. As the supply of 12V DC motor is turned on, the shaft of motor starts to rotate which leads to rotate the cam. Due to the cam, the roller follower gets uniform circular motion. The impacting plate becomes almost vertical due to the motion of the follower. As the follower leaves the impacting plate, due to self-weight the plate does impact on the dusters placed in duster holder. Hence, the dust is removed and whole assembly is enclosed in a casing to avoid spreading of dust to the environment. If required, use of vacuum pump can be done to collect the dust.

Model:

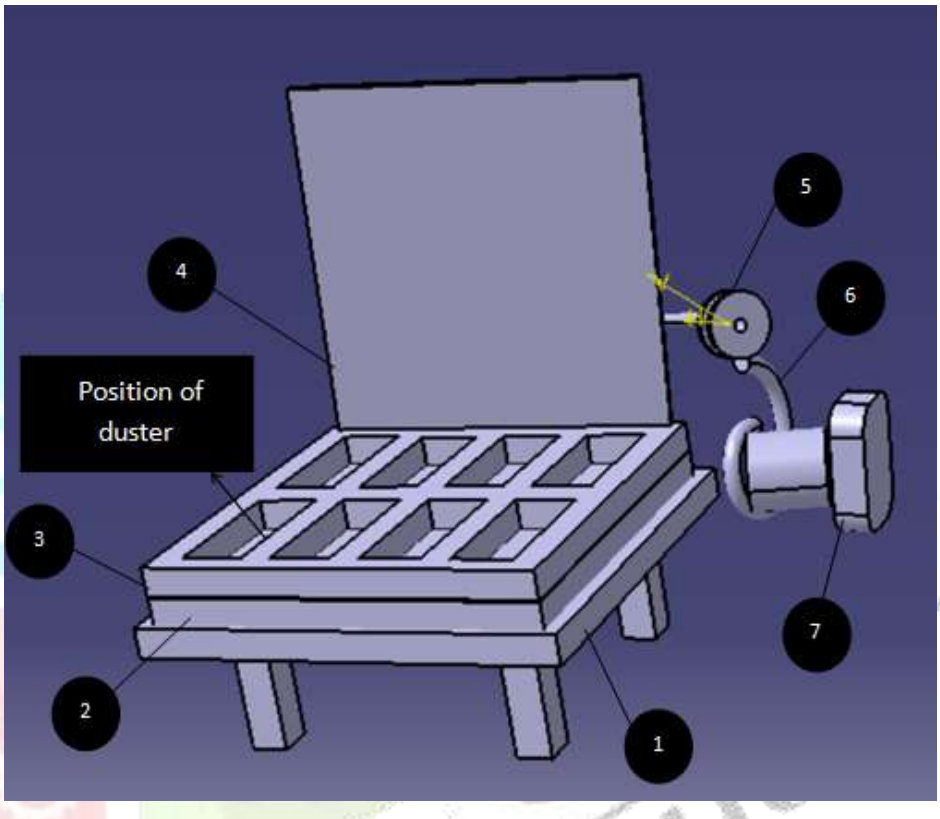

Figure 2.1: Proposed design modelled in CATIA

Table 1: Part List

Part No.	Part Name	Quantity	Material
1	Base Table	1	Mild Steel
2	Isolating Pad	1	Rubber
3	Duster Holder	1	Mild Steel
4	Impacting Plate	1	Mild Steel
5	Roller Follower	1	Mild Steel
6	Cam	1	Mild Steel
7	DC Motor	1	-

- Weight of hammering plate = 3.5 x 9.81 = 34.335 N
- Lift of follower = 50 mm = 0.05 m
  A DC motor of 40 rpm is under consideration.
- Time during which it is lifted once = 60/40 = 1.5 seconds

3. FINITE ELEMENT ANALYSIS:

In this work, the table (with four legs made of square pipes & the top plate), on which dusters are kept & impact is done, is analyzed for stresses & deformation for the impact loads.

Model: The model is generated using the CATIA software. Then it is imported to the ANSYS workbench software.

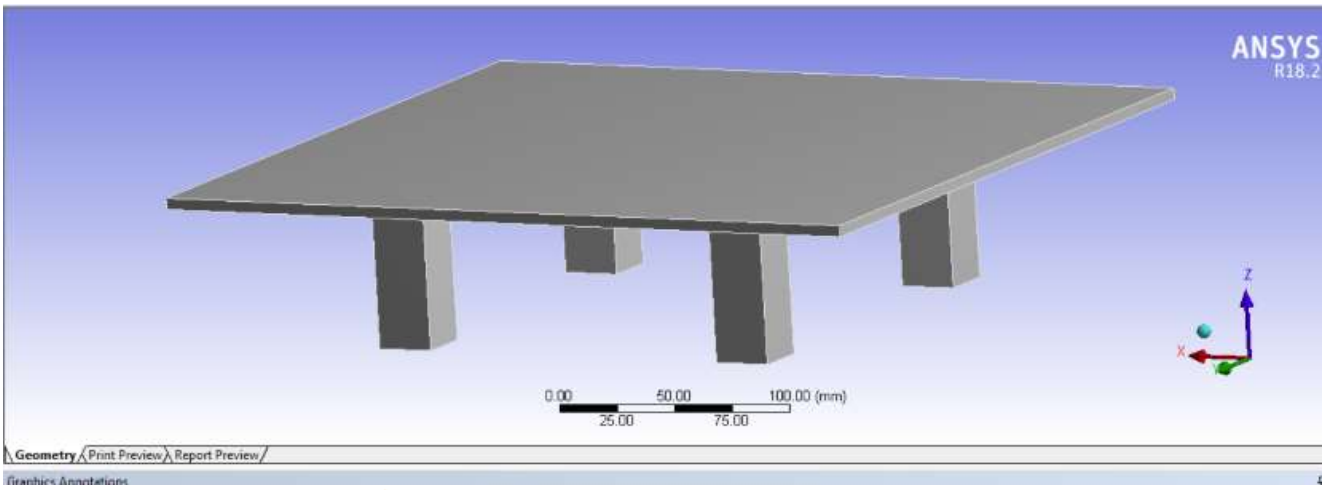

Figure 3.1: Model of Base Plate with legs (Table)

Meshing: The default element in ANSYS Workbench is used for meshing the model.

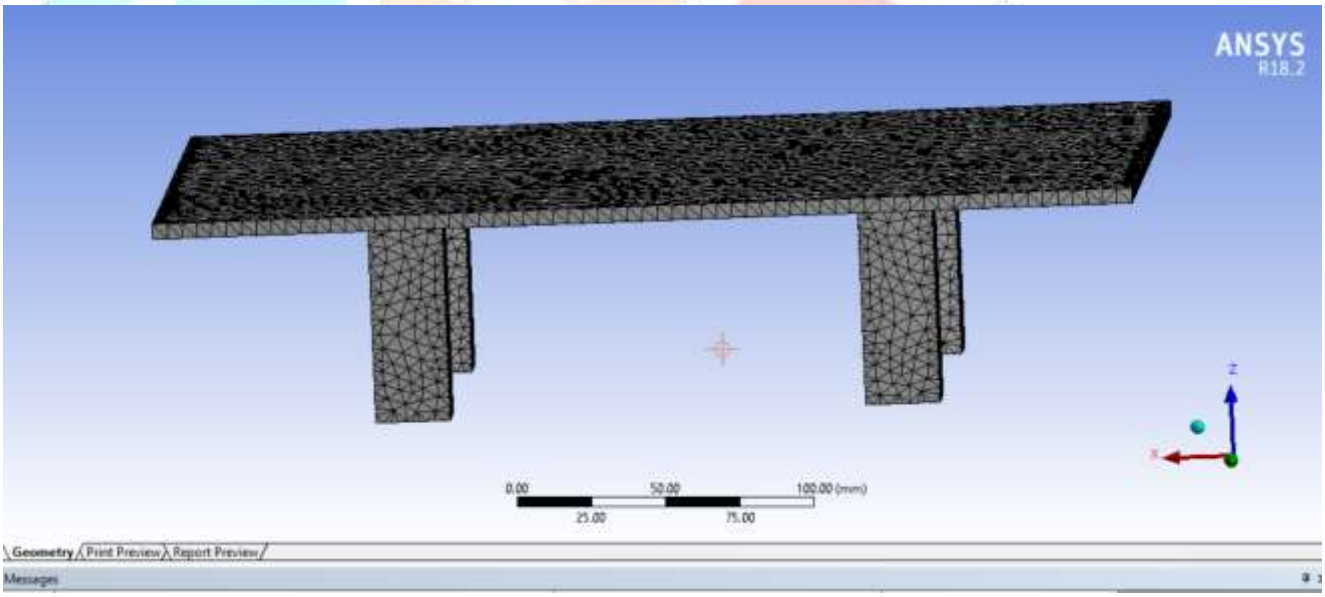

Figure 3.2 Meshed model

Boundary condition: The movement of the bottom of the four legs is restricted in all directions.

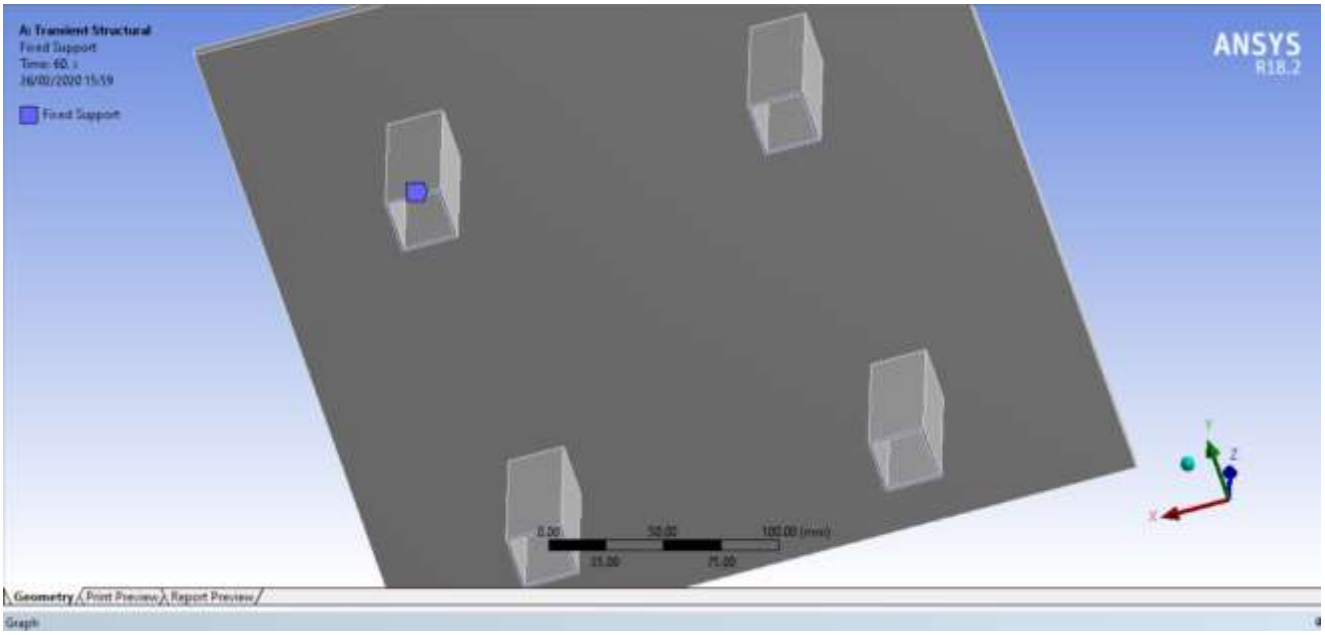

Figure 3.3: Motion of the legs restricted

Load condition:

- As the plate is impacting on the table through dusters, vertical downward impact load is applied to the table. As there are 40 strokes per minute, loads are applied at an interval of 1.5 seconds. Even though the load is lesser, it is of impact type. Hence higher values of loads are applied. Load taken is 3433.5 N

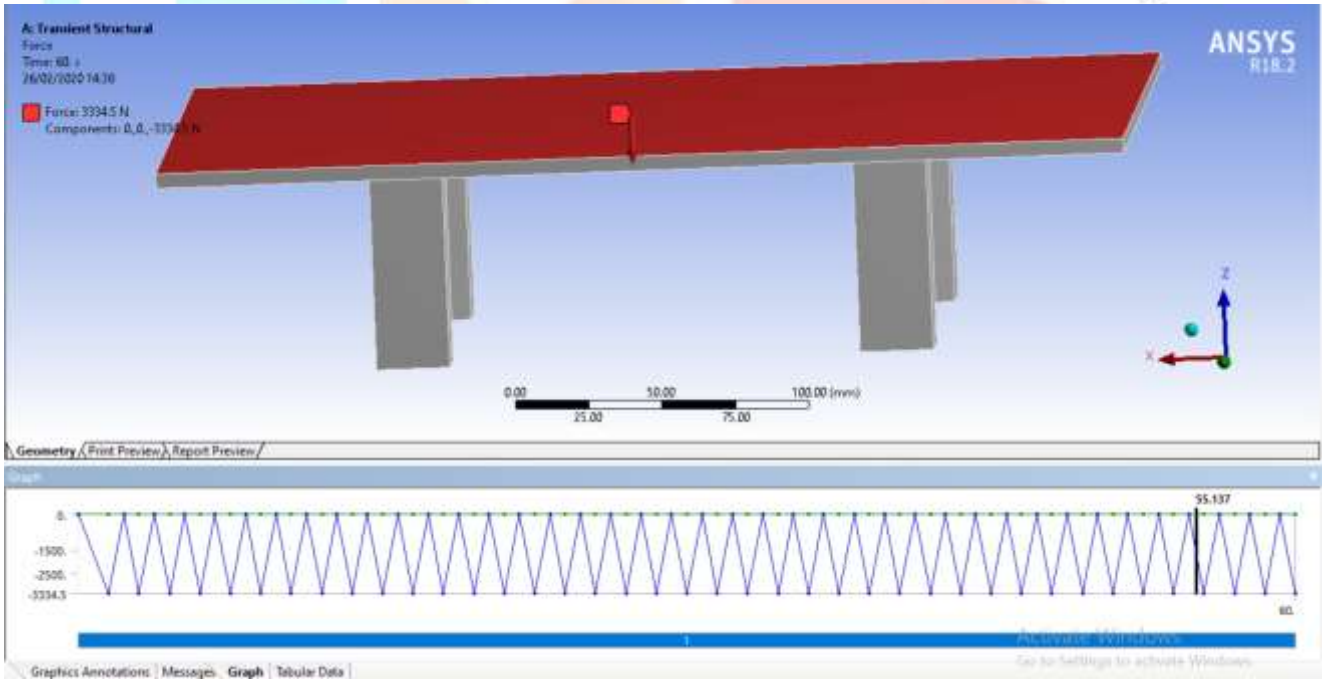

Figure 3.4: Loading conditions of Base Plate

By varying mesh size, the stresses and deformation are shown noted & are as below:

Initially, a random value of load is applied to study the effect of mesh size on the stresses & deformation.

The deformation & stresses for an element size of 5 mm are shown below.

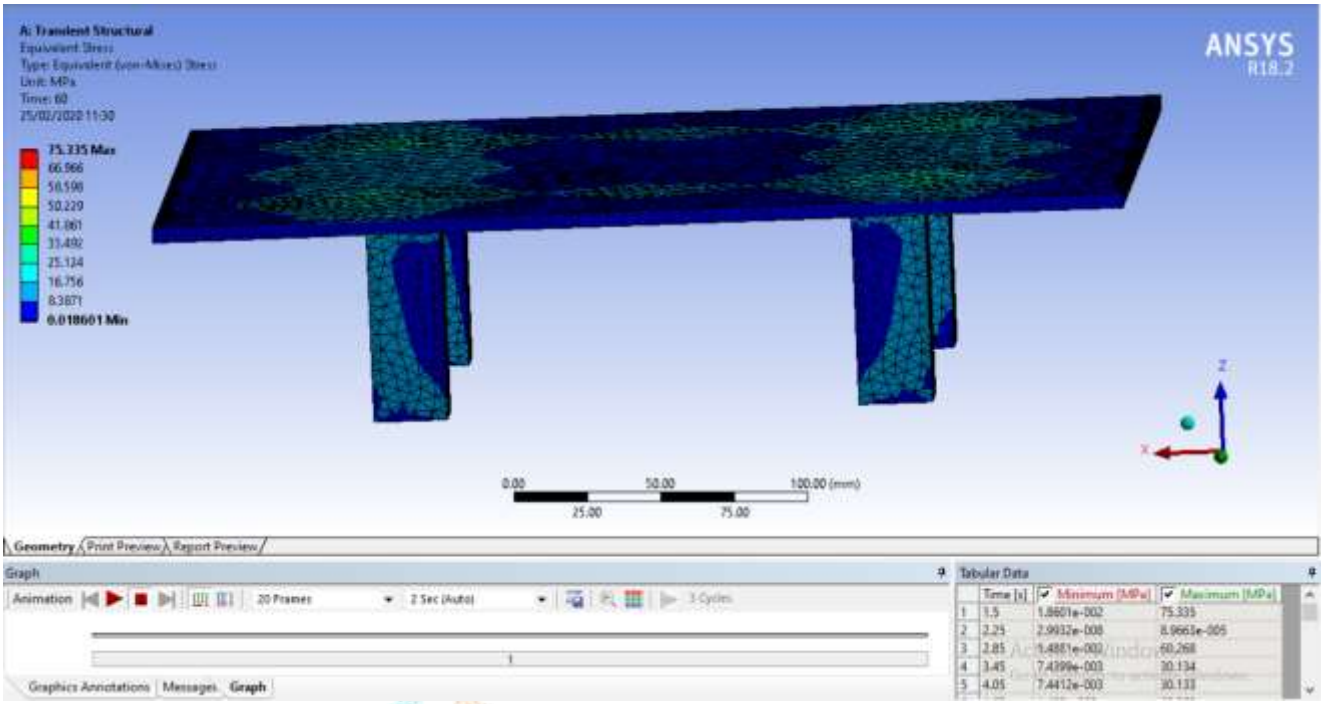

Figure 3.5 Von Misses stresses for 5 mm element size

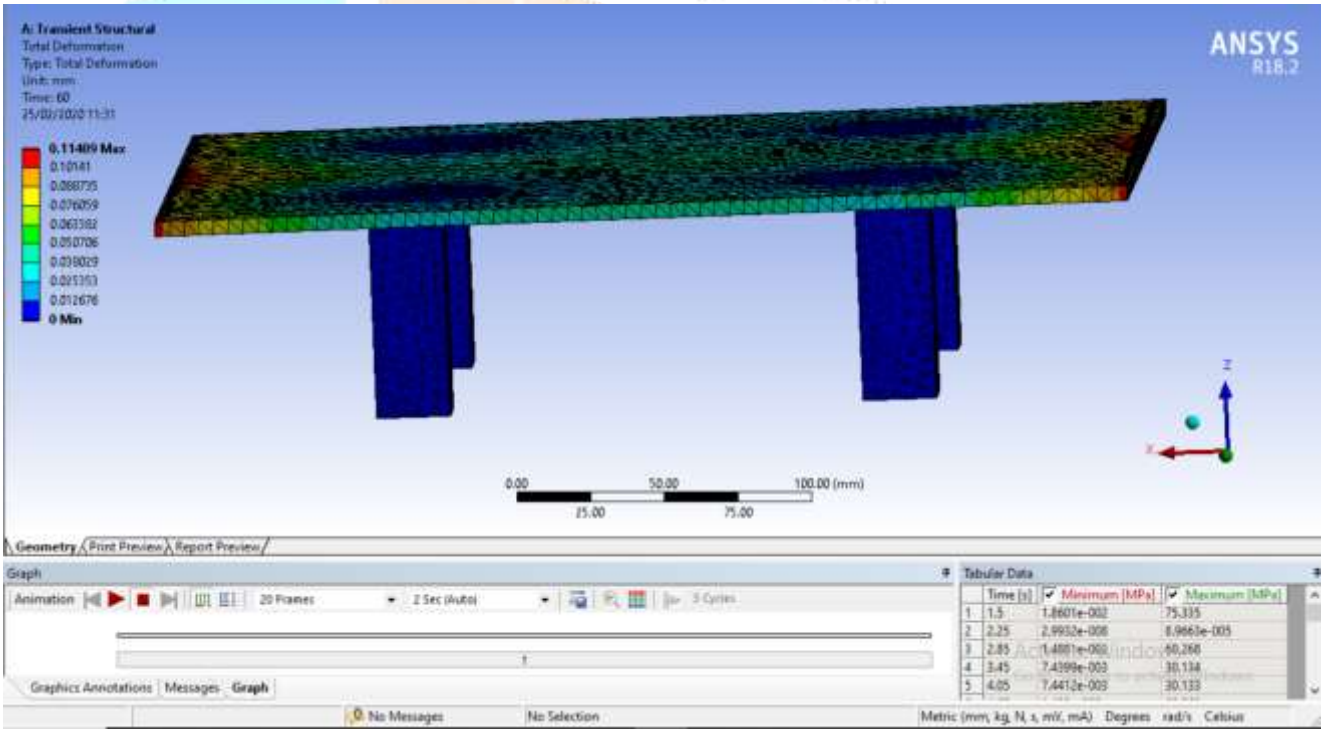

Figure 3.6 Deformation for 5 mm element size

The results are as below.

Table 2. Effect of element size on stresses & deformation

Element size (mm) size	Von Mises Stress (MPa)	Deformation (mm)
3	73.816	0.11417
4	62.878	0.11437
5	75.335	0.11409
6	74.078	0.11363
7	61.767	0.11306
8	59.563	0.11215

Following figure shows effect of element size on Von Mises stresses.

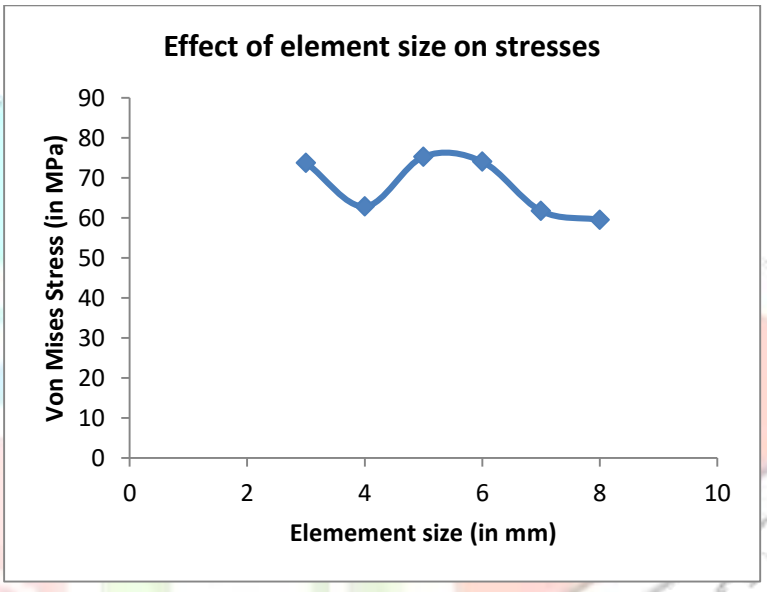

Figure 3.7 Effect of element size on Von Mises stresses

Following figure shows effect of element size on maximum deformation.

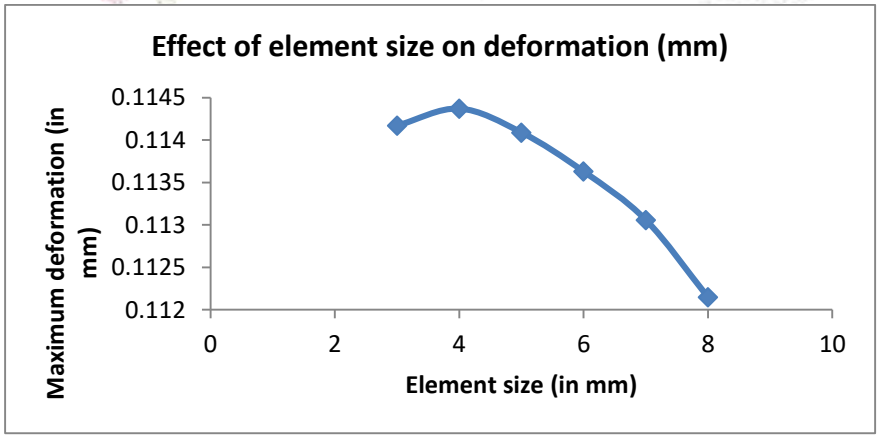

Figure 3.8 Effect of element size on maximum deformation

Effect of load on stress & deformation:

Taking element size 5 mm, the load variation is done & effects are studied.

- Weight of hammering plate = 3.5 x 9.81 = 34.335 N & the distance through which it falls is 50 mm = 0.05 m.
  Considering the factor of safety & impact loads, the forces applied were 1373.4 N , 2060.1 N, 2746.8 N. For these loads also the structure seems to be very much safe. The stresses are very low.

Table 3.Effect of load on stress & deformation

Load (N)	Stress (MPa)	Deformation (mm)
1373.4	30.134	0.045635
2060.1	45.201	0.068453
2746.8	60.268	0.09127
3433.5	75.335	0.11409

The stresses & deformation for a load of 1373.4 N is shown below.

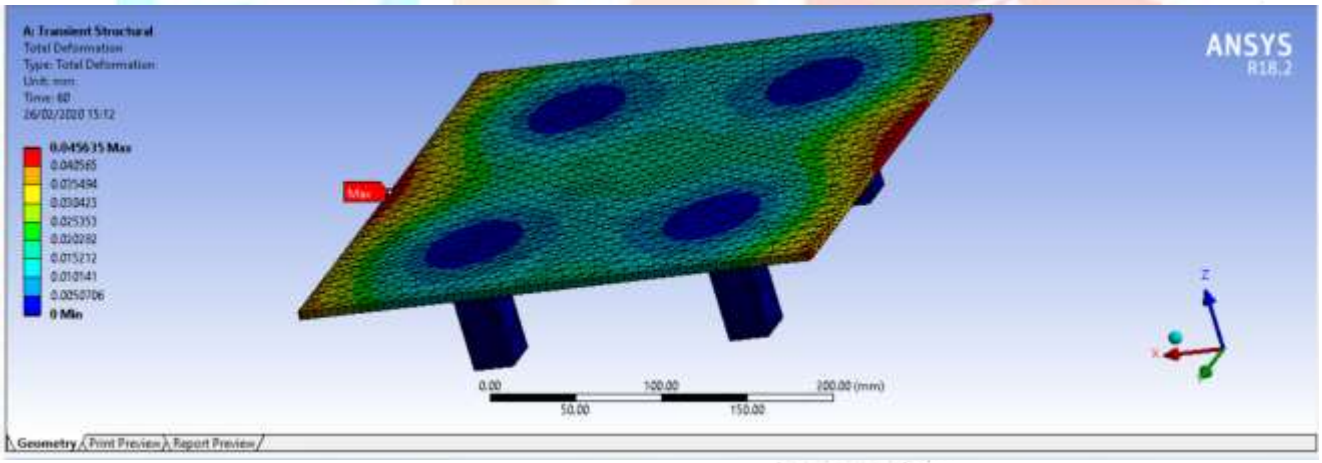

Figure 3.9 Deformation for a load of 1373.4 N

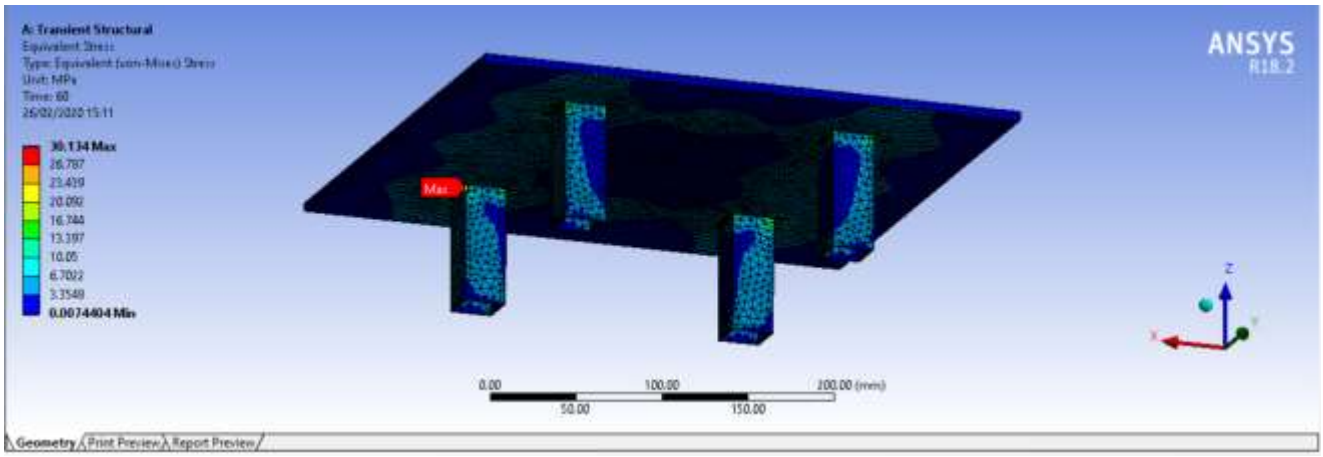

Figure 3.10 on Mises stresses for a load of 1373.4 N

The maximum stress occurs at the connection of leg to the plate.

4.CONCLUSIONS:

Proposed structure gives very less stresses for the actual loading condition. The dimensions of the plate & legs welded to it can be reduced. This will reduce the weight of the whole structure.

5. ACKNOWLEDGEMENT:

We are thankful to Sham Innovative Solutions, Solapur for supporting this work. We are also thankful to Prof. Dr. P.R. Kulkarni, Head-Mechanical Dept., Dr. S. A. Halkude, Principal, Walchand Institute of Technology, Solapur for constant encouragement throughout the work.

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