MAE 598 – FINITE ELEMENTS IN ENGINEERING
FINAL PROJECT – CUMULATIVE DESIGN REPORT

Team Members - Antriksh Sharma, Kaushik Lakshmanan, Prashant Gangwani, Varun Agrawal, Vijay Anand Senthilkumar

Professor - Jay Oswald

Team Evaluation –

Antriksh: The design developed is optimum for all possibilities of the hole distance from edges, slot orientation and sizes which resulted in minimal stress and maximum deformation values compared to the group members. But during initial calculations, maximum lateral deformation was used to calculate the plate stiffness and drop height instead of maximum axial deformation. Hence, the results obtained were incorrect.

Kaushik: The design developed is optimum for all possibilities of hole distance from edges, diameter of circular cavity and web thickness which resulted in reduced plate stiffness and maximum stress values. But during optimization, the criteria taken into account didn't consider material removal as a factor. More material could have been removed.

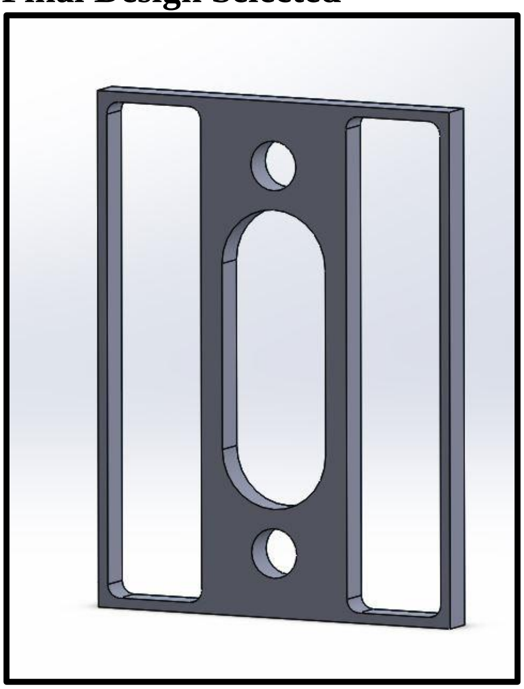
Prashant: The design developed is optimum for all possibilities of hole distance from edges, side length of hexagonal cavity and web thickness which resulted in reduced plate stiffness and maximum stress values. But during optimization, the criteria considered didn't include material removal as a factor. More material could have been removed.

Varun: The design developed was least complex and resulted in most efficient designing parameters. The plate stiffness and stress values were minimal for the slot size and rectangular cavities created. Therefore, selected as final design. For this much material reduction, the plate stiffness could have been further less, but it was not the case.

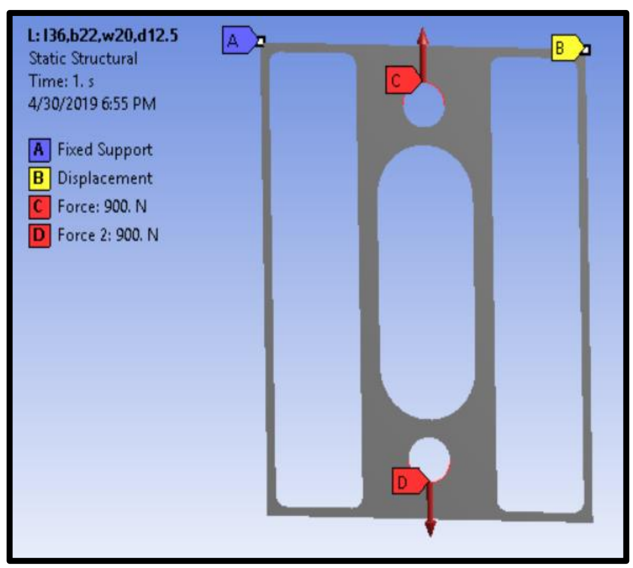
Vijay: The design developed was optimum for the hole distance from edges and slot-width, height, and separation, but the maximum deformation obtained was less compared to other designs. More material could have been removed from appropriate places to reduce the stiffness and increase deformation.

CRITERIA	TEAM MEMBERS AND EVALUATION (Scale – 4)				
	Varun	**Antriksh**	**Vijay**	**Prashant**	**Kaushik**
Report written clearly and professionally	Plot axes are labelled properly. Numerical values have appropriate units				
	4	**4**	**4**	**4**	**4**
Description of Analysis	Material properties used in the analysis are defined and justified. Type of analysis that is performed is clearly elaborated. Element type is specified.				
	4	**4**	**4**	**3.5**	**3.5**
Boundary Conditions	Boundary conditions are specified completely. Boundary conditions are realistic and are explained properly.				
	4	**4**	**4**	**4**	**4**
Mesh Convergence Study	Mesh convergence study is performed. It is verified that the results are not sensitive to element size.				
	3.5	**4**	**3.5**	**4**	**4**
Modification of design geometry	It is explained how FEA was used to optimize design				
	4	**3.5**	**3**	**3.5**	**3.5**
Total	**19.5**	**19.5**	**18.5**	**19**	**19**
Overall Ranking	**1**	**1**	**3**	**2**	**2**

Final Design Selected



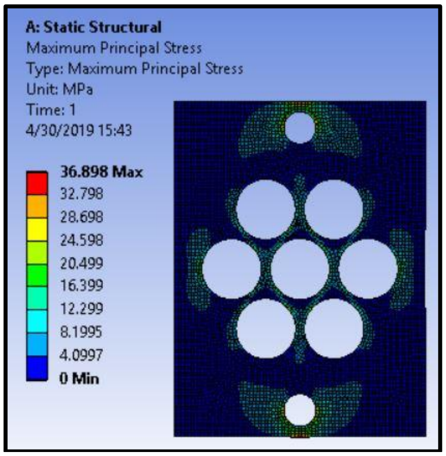
FINAL DESIGN SELECTED



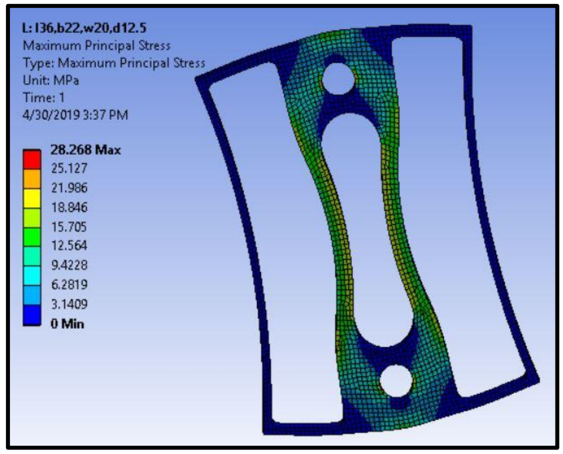
BOUNDARY CONDITION

COMPARISON OF INDIVIDUAL DESIGN

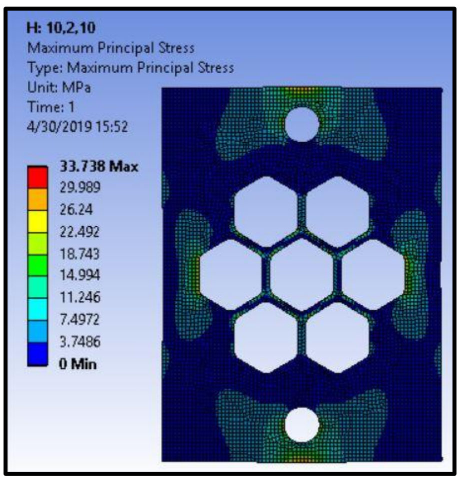
Comparison of Maximum Principal Stress



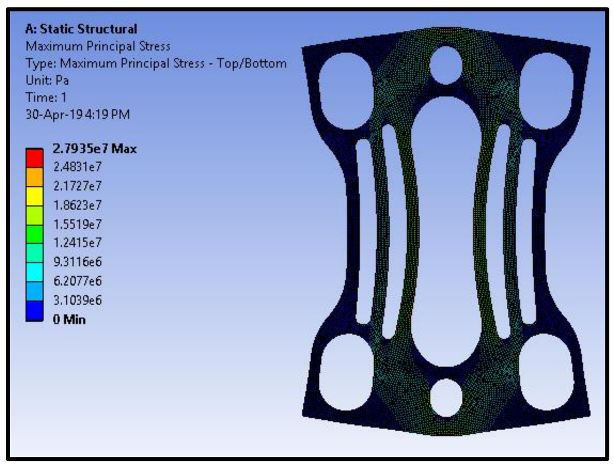
KAUSHIK (1)



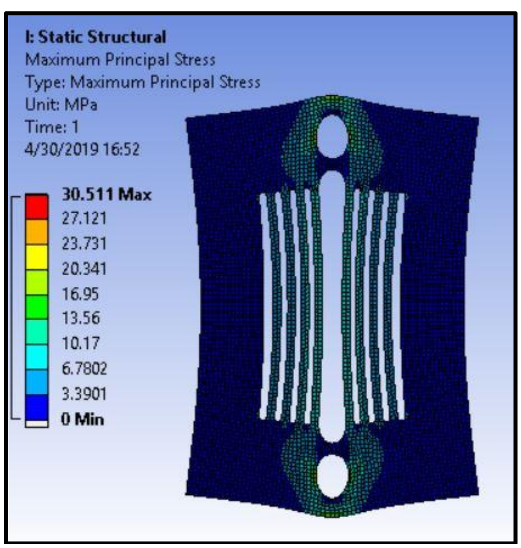
VARUN (2)



PRASHANT (3)

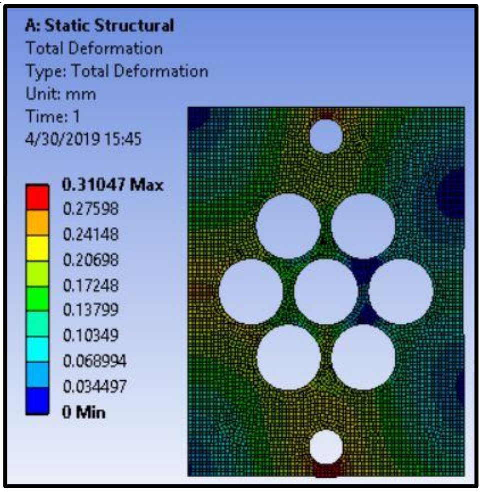


ANTRIKSH (4)

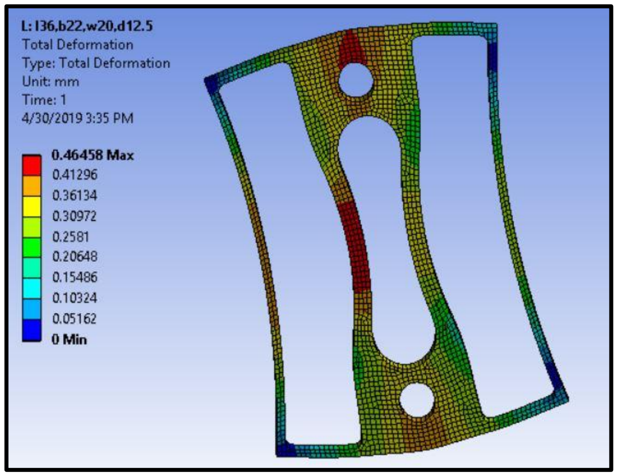


VIJAY (5)

Comparison of Total Deformation



KAUSHIK (1)



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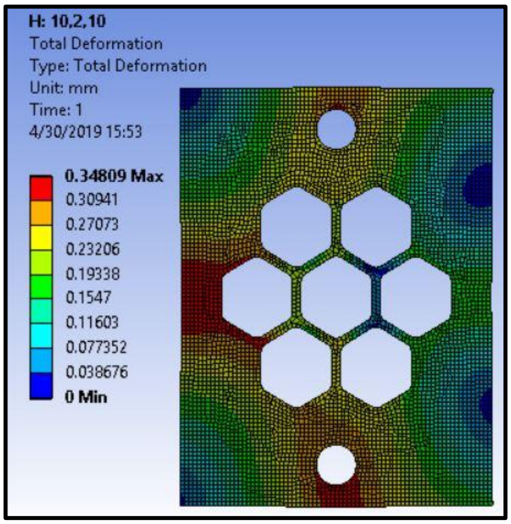
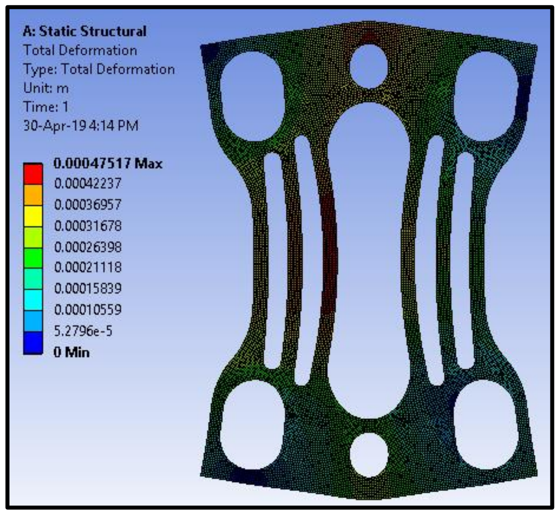
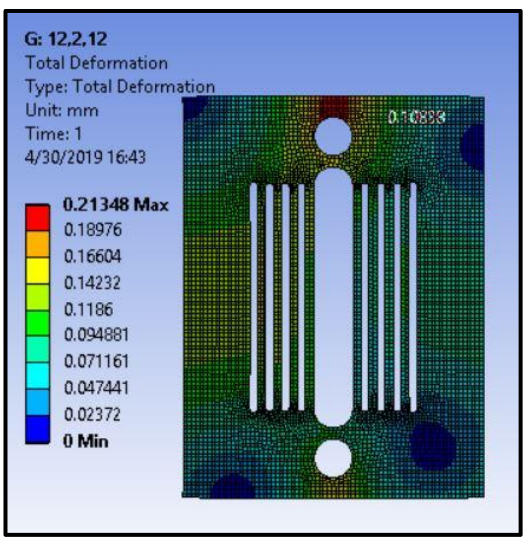


PRASHANT (3)



ANTRIKSH (4)



VIJAY (5)

SELECTION OF DESIGN

The design criterion was to optimize the plate with the minimum stiffness, maximum principal stress, and maximum drop height (for 11.34 kg drop mass).

Design	Maximum Principal Stress (MPa)	Total Axial Deformation (mm)	Stiffness (N/mm)
1	36.898	0.59632	1509.256
2	28.268	0.85171	1056.697
3	33.738	0.65984	1363.967
4	27.935	0.7384	1218.852
5	30.511	0.45134	1994.062

After comparing all the five designs (at the load application of 900N and drop mass of 11.34 kg), the minimum stiffness (1056.6977 N/mm), maximum principal stress (28.268 MPa), and maximum drop height (4.85 mm) was obtained from the chosen optimal plate **design (2).**

COMPARISON WITH THE IN-CLASS TESTING

When the chosen plate was tested in the class then there was no failure in the testing for the 4.54 kg drop weight even from the maximum drop height. But, when the plate was tested with 11.54 kg drop weight and dropped from the maximum height (assumed to be 120 mm), then the cord got ruptured. So, calculating the force in cord analytically in both the cases to validate the results obtained from in-class testing –

Using energy conservation,

$$m\ g\ h = \frac{1}{2}\ Kp\ x_p^2 + \frac{1}{2}\ Kc\ x_c^2$$

$$and\ we\ know,\quad Kp\ x_p = \ Kc\ x_c \ = F\ (say), Force\ in\ cord$$

$$x_p = deformation\ in\ plate, x_c = deformation\ in\ cord$$

After substitution, $m\ g\ h = \frac{F^2}{2}\left(\frac{1}{Kp} + \frac{1}{Kc}\right)$

$Kc = \frac{12566.37}{6*0.120} N/m$ (Stiffness of cord, given)

$Kp = 1056697 N/m$ (Stiffness of plate, from the above table)

$m = 11.34\ kg$ (Drop mass)

$g = 9.81 \frac{m}{s^2}$ (Acceleration due to gravity)

$h = 0.120\ m$ (Assumed drop height)

For the 11.34 kg drop mass,

$$F = 677.06\ N$$

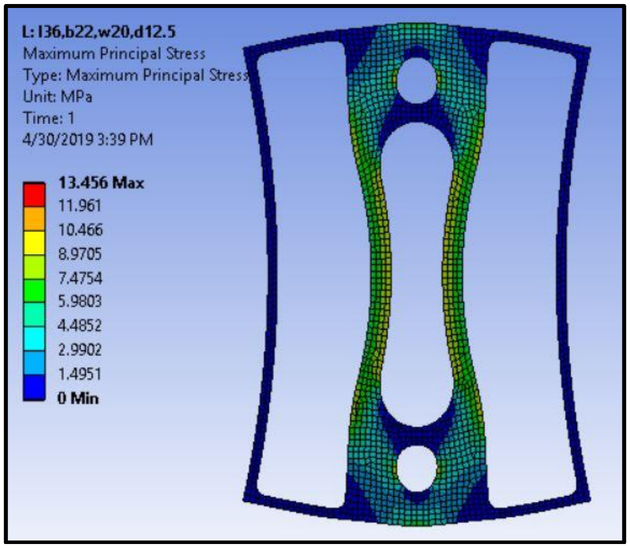
For the 4.54 kg drop mass,

$$F = 428.4\ N$$

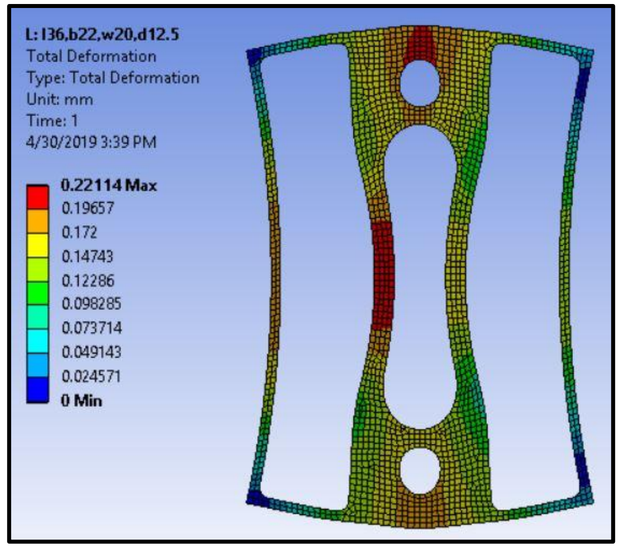
The breaking strength of the cord is considered to be 450 N (after knotting). After analytical calculations, it can be observed that the forces induced in the cord validate with the actual testing performed in the class i.e., it is less than 450 N for 4.54 kg drop mass and more than 450 N for 11.34 kg drop mass.

FEA ANALYSIS ON OPTIMAL DESIGN USING THE ABOVE CALCULATED FORCES

For the force of 428.4 N,



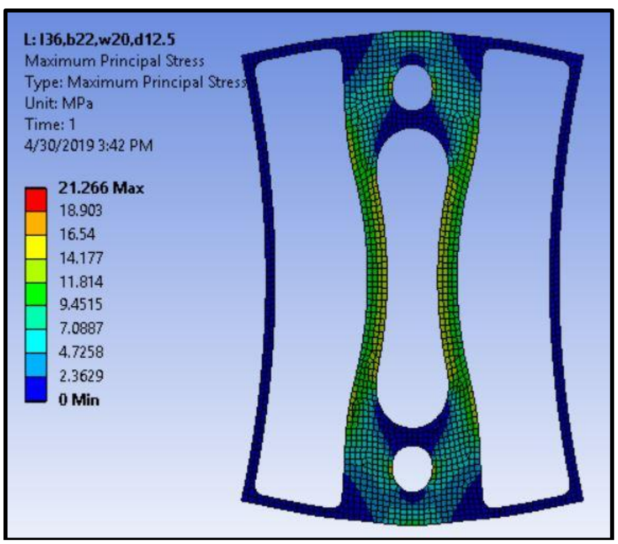
MAXIMUM PRINCIPAL STRESS



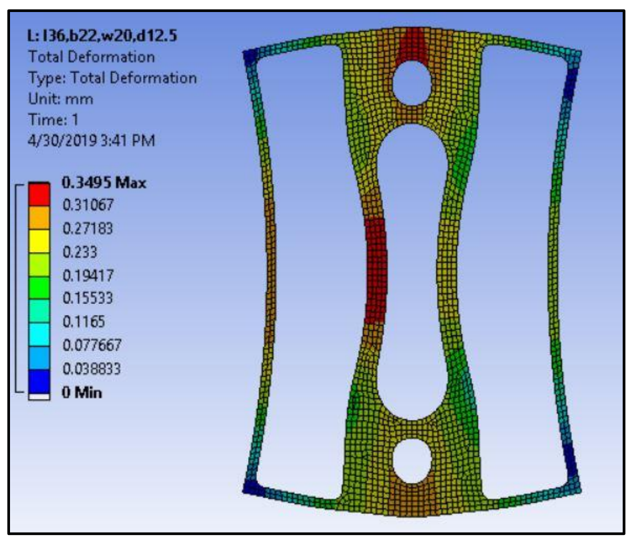
TOTAL DEFORMATION

The maximum principal stress in the plate is very less with the safety factor of 5.945.

For the force of 677.06 N,



MAXIMUM PRINCIPAL STRESS



TOTAL DEFORMATION

CONCLUSION –

On analysis of all the designs received from every group member, the design from Varun Agrawal (design 2) showed optimum results for stress and stiffness which fitted required criteria. So, we conclude (when considered all situations), design 2 is best as compared to all of the other designs.