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Design and Analysis of Composite Structure for Industrial Platforms

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I. INTRODUCTION

This construction has often used in lightweight applications such as Lift, EOT crane beam, vehicle body, aircrafts, marine applications, wind turbine blades. In principle two approaches exist to develop efficient structures either application of new structural design. A proven and well-established solution is the use of sandwich structures. In this way high strength to weight ratio and minimum weight can be obtained. The sandwich structures have potential to offer a wide range of attractive design solutions. Sandwich panels in general can be classified as composite sandwich and metallic sandwich panels. Composite sandwich panels consist of non-metallic components such as FRP, PU foam etc. and are typically applied as load carrying structures in naval vessels and leisure yachts, and mainly as non-load carrying elements on merchant and large cruise ships. For metallic sandwich panels there are basically two types of panels: panels with metallic face plates and bonded core such as SPS panels and panels with both metallic face plates and core welded together. The metal material can be either regular, high tensile or stainless steel, or aluminum alloys. The choice of the core depends on the application under consideration. The standard cores such as Z-, tube- and hat profiles are easier to get and they are typically accurate enough for the demanding laser welding process. The special cores, such as corrugated core (V-type panel) and I-core, need specific equipment for production, but they usually result with the lightest panels

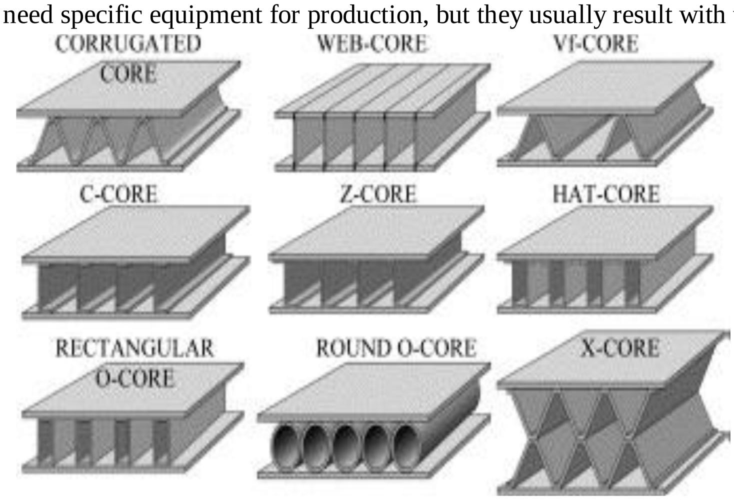

Figure. Different sandwich structure with various cores.

II. PROBLEM STATEMENT

The demand for bigger, faster and lighter moving vehicles, such as ships, trains, trucks and buses has increased the importance of efficient structural arrangements. In principle two approaches exist to develop efficient structures either application of new materials or the use of new structural design. A proven and well-established solution is the use of composite materials and sandwich structures. In this way minimum weight can be obtained. The sandwich structures have potential to offer a wide range of attractive design solutions. In addition to the obtained weight reduction, these solutions can often bring space savings, noise control. Steel sandwich panels can offer 10-25 % weight savings compared to the conventional steel structures.

III. EXPERIMENTATION

For the Experimentation the 3 types of geometry with particular specification are selected, by testing on UTM machine and software analysis the results are carried out. Following case study for experiment, for testing Triangular, Square and Circular geometry get Selected.

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ANSYS Result Of All Structure Compare Between The Total Weight, Total Deformation And Equivalent Stress.

Circular steel structure Case 1: Top Plate width (W): 103mm Top Plate length (L): 103mm Top Plate thickness (t): 3 mm Bottom Plate width (W): 103mm Bottom Plate length (L): 103mm Bottom Plate thickness (t): 3 mm Inner diameter of pipe (core) (di): 13 mm Outer diameter of pipe (core) (do): 19 mm Length of pipe (core) (L): 103mm Top and Bottom plate, Core material: Steel Material	Triangular steel structure Case 2: Top Plate width (W): 103mm Top Plate length (L): 103mm Top Plate thickness (t): 3 mm Bottom Plate width (W): 103mm Bottom Plate length (L): 106mm Bottom Plate thickness (t): 3 mm Core material size: 25x25x3mm Top and Bottom plate, core material: Steel Material	Rectangular steel structure Case 3: Top Plate width (W): 103mm Top Plate length (L): 103mm Top Plate thickness (t): 3 mm Bottom Plate width (W): 103mm Bottom Plate length (L): 103mm Bottom Plate thickness (t): 3 mm Core Plate width (W): 19mm Core length (L): 103mm Core Plate thickness (t): 3mm Top and Bottom plate, core material: Steel Material
Case Study: Rectangular steel structure: Top Plate width (w): 103mm Top Plate length (L): 103mm Top Plate thickness (t): 3 mm Bottom Plate width (w): 103mm Bottom Plate length (L): 103mm Bottom Plate thickness (t): 3 mm Core Plate width (w): 19 mm Core length (L): 103mm Core Plate thickness (t): 3 mm	Modulus of Elasticity (E): 2.1 * 10^3 kg/mm^2 (For steel) Force (F) = 10000N Top and Bottom plate material: Steel Material: Fe 410 having UTS = 410 Mpa & Syt = 235 Mpa	Finding the stress of Rectangular Steel structure by using following formula Stress = force/ Area 6 = F/A =10000/1246 = 8.02 N/mm^2 Finding Total deformation Rectangular Steel structure by using following formula. Total Deformation (δl) = FL/AE =10000x100/1245x210x10^3 =0.04mm

Applied force and obtained value of design characteristics using FEA for Triangular Steel Structure

Triangular Steel Structure				
Sr. No.	Force (N)	Equivalent Stress (Mpa)	Deformation (mm)	Weight (Kg)
1	500	4.3838	0.002225	0.94672
2	1000	8.7676	0.0044499	
3	1500	13.151	0.0066749	
4	2000	17.535	0.0088999	
5	2500	21.919	0.011125	
6	3000	25.828	0.01288	
7	3500	30.132	0.015027	
8	4000	34.437	0.017174	

Applied force and obtained value of design characteristics using FEA for Circular Steel Structure

Circular Steel Structure				
Sr. No.	Force (N)	Equivalent Stress (Mpa)	Deformation (mm)	Weight (Kg)
1	500	0.59117	0.0056488	0.86869
2	1000	39.029	0.011301	
3	1500	58.544	0.016952	
4	2000	78.058	0.022603	
5	2500	97.573	0.028254	
6	3000	117.09	0.033904	
7	3500	136.6	0.039555	
8	4000	156.12	0.045206	

Applied force and obtained value of design characteristics using FEA for Rectangular Steel Structure

Rectangular Steel Structure				
Sr. No.	Force (N)	Equivalent Stress (Mpa)	Deformation (mm)	Weight (Kg)
1	500	7.8382	0.0059418	0.63795
2	1000	15.676	0.011884	
3	1500	23.515	0.017826	
4	2000	31.353	0.023767	
5	2500	39.191	0.029701	
6	3000	47.029	0.035651	
7	3500	54.565	0.041593	
8	4000	62.706	0.047535	

IV. WEIGHT COMPARISONS OF ALL STRUCTURE

Weight comparisons of all structure

Sr. No.	Name of Structure	Weight (Kg)
1	Circular Steel Structure	0.86869
2	Triangular Steel Structure	0.94672
3	Rectangular Steel Structure	0.63795

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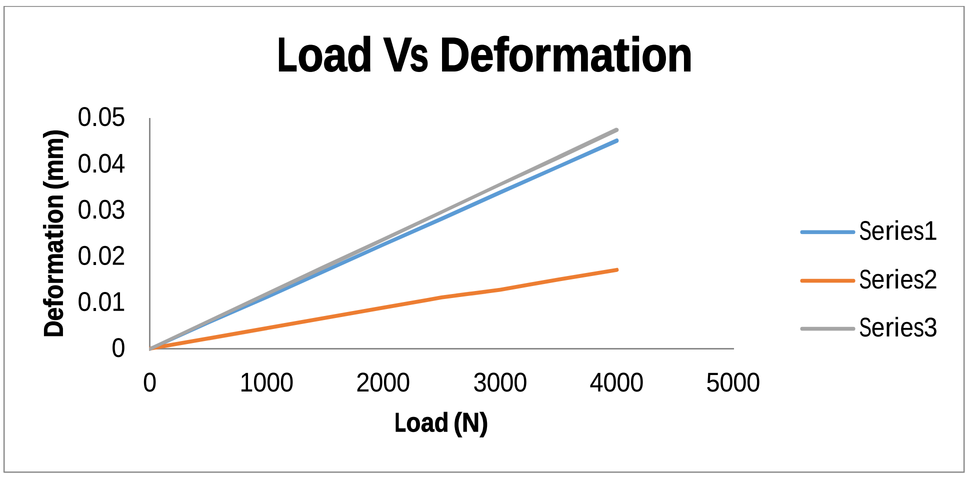
V. DEFORMATION COMPARISON OF ALL STEEL STRUCTURE

Deformation comparison of all steel structure in ANSYS

Sr. No.	Force (N)	Circular steel Structure (Deformation)	Triangular steel Structure (Deformation)	Rectangular steel Structure (Deformation)
1	500	0.0056488	0.002225	0.0059418
2	1000	0.011301	0.0044499	0.011884
3	1500	0.016952	0.0066749	0.017826
4	2000	0.022603	0.0088999	0.023767
5	2500	0.028254	0.011125	0.029701
6	3000	0.033904	0.01288	0.035651
7	3500	0.039555	0.015027	0.041593
8	4000	0.045206	0.017174	0.047535



Load vs. Deformation of steel structure by ANSYS
Series 1- Circular Structure
Series 2- Triangular Structure
Series 3- Rectangular Structure

VI. EQUIVALENT STRESS COMPARISON OF ALL STEEL STRUCTURE

Equivalent Stress comparison of all steel structure in ANSYS

Sr. No.	Force (N)	Circular steel Structure Equivalent Stress (Mpa)	Triangular steel Structure Equivalent Stress (Mpa)	Rectangular steel Structure Equivalent Stress (Mpa)
1	500	0.59117	4.3838	7.8382
2	1000	39.029	8.7676	15.676
3	1500	58.544	13.151	23.515
4	2000	78.058	17.535	31.353
5	2500	97.573	21.919	39.191
6	3000	117.09	25.828	47.029
7	3500	136.6	30.132	54.565
8	4000	156.12	34.437	62.706

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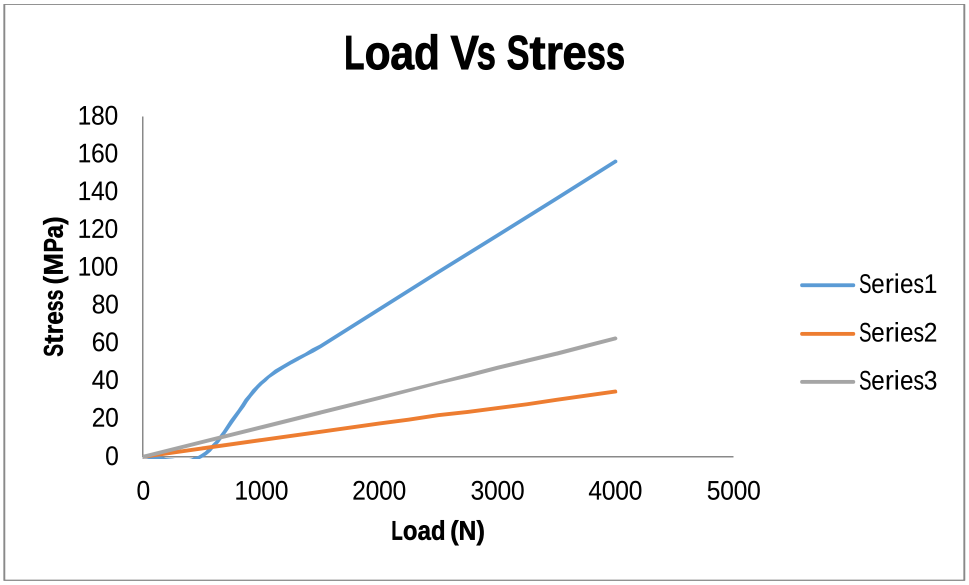
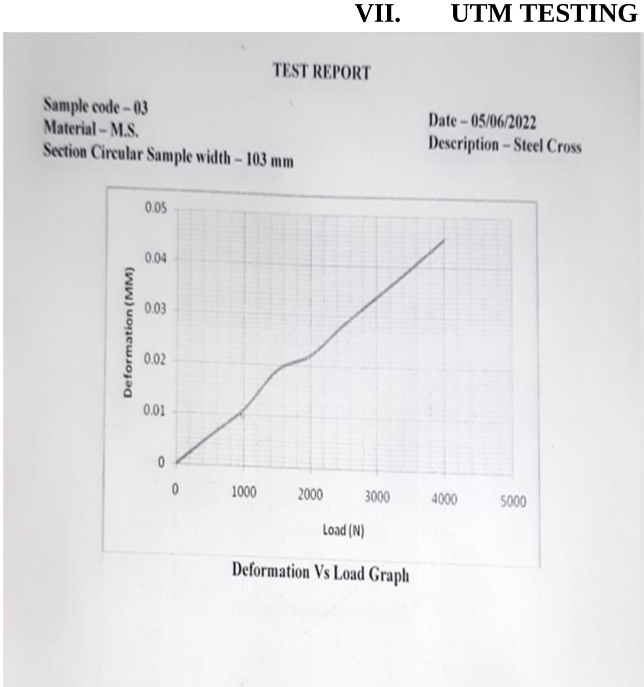


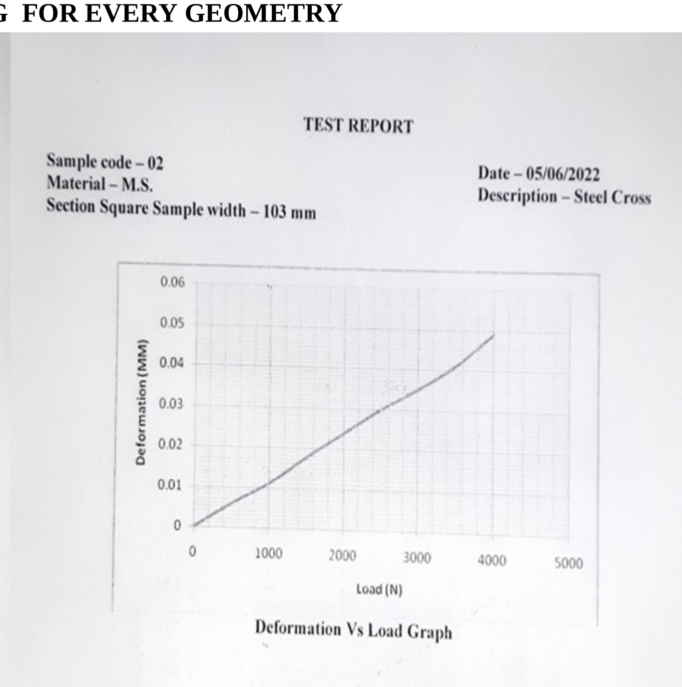
Force vs. Equivalent Stress of steel structure by ANSYS
Series 1- Circular Structure
Series 2- Triangular Structure
Series 3- Rectangular Structure

In above table shows the deflection, equivalent stress and self-weight of investigated Triangular, Rectangular and Circular composite structure and Triangular, Rectangular and Circular steel structure. The weight of composite structure is 0.785 kg is small as compare to the steel structure (weight of Mild steel plate of same thickness is 2.08 kg.) The Equivalent Stresses, Total deformation of Rectangular steel structure is also small as compare to Triangular, circular steel structure. From above table it is observed that the minimum stress and minimum deformation is observed in rectangular composite structure when it is compare with Triangular, Circular composite structure.

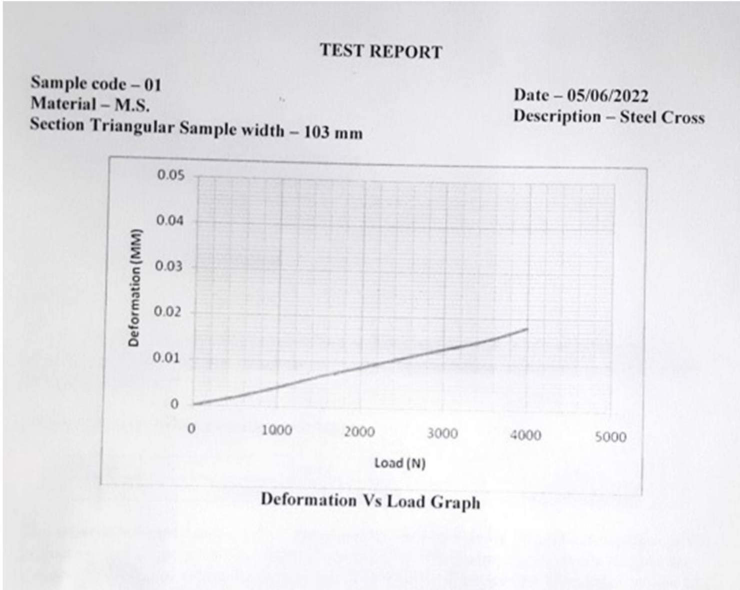
VII. UTM TESTING FOR EVERY GEOMETRY



For Circular Shape



Foe Square Shape



For Triangular Shape

VIII. CONCLUSION

The composite structure models in CATIA are efficiently imported into ANSYS workbench structural analysis is done and max stress and total deflection is observed.

For given span of the structure, decreasing the weight of composite structure also the strength increases and weight is reduced. The weight of composite structure is decrease of19-40%as compares to steel structure. And also increases the strength of composite structure as compare to steel structure.

By comparing Triangular composite structure with Rectangular and circular composite structure it is observed that Triangular composite structure have minimum stresses and also have minimum deflection. As per maximum principal stress theory we get that all structure we select having within the limit of allow able stress so we take a structure with minimum weight is rectangular. So, rectangular structure is the perfect replacement for the traditional industrial crane base platform.

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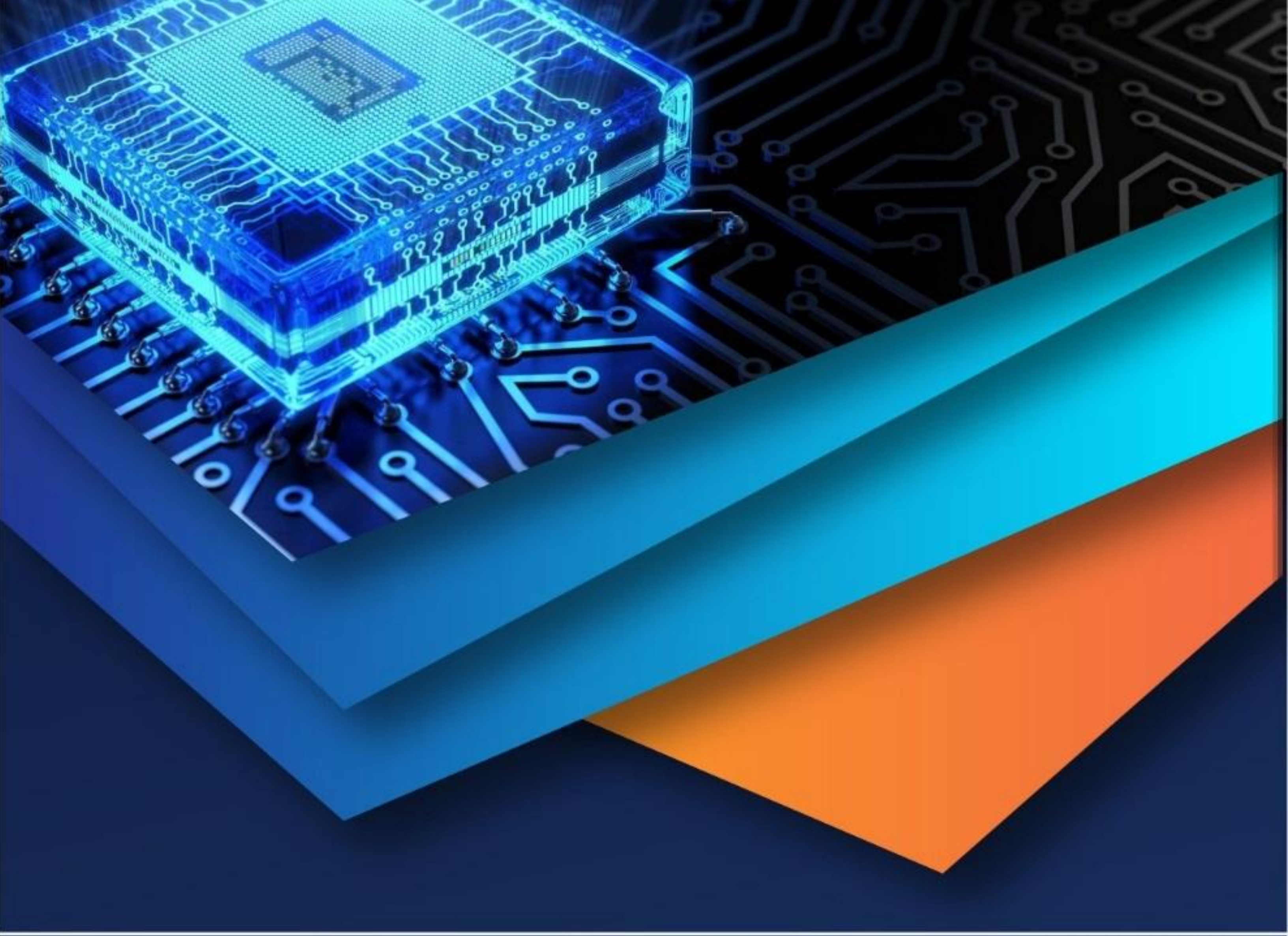

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