Design Analysis and Optimization of Crane Platform Based On Composite Structural Sandwich Plate

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Abstract: A structural sandwich consists of two thin face sheets made from stiff and strong relatively mild steel material welded to a thick light weight material called core made up of same material. This construction has often used in lightweight applications such as aircrafts, marine applications and wind turbine blades. In this paper the structural study of three type of core sandwich panel. Finding out a stress and deformation due to applied to by using ANSYS software, also find out deformation of all structure by using practical method.

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 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 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. In addition to the obtained weight reduction, these solutions can often bring space savings, noise control. Laser-welded metallic sandwich panels offer a number of outstanding properties allowing the designer to develop light and efficient structural configurations for a large variety of applications. These panels have been under active investigations during the last 15 years in the world. Outokumpu has been participating in several collaborative projects in this area. In Finland the research related to all steel sandwich panels was initiated in 1988 in the Ship Laboratory of Helsinki University of Technology. The first study focused on the application of sandwich panels in the shell structures of an icebreaker. Since then in a considerable number of research projects in Finland, such as Shipyard 2000, Weld 2000 and the Kenno – Light Structures Technology Program, manufacturing, design and optimization of steel sandwich panels have been investigated. The work is based on several R&D projects driven jointly with VTT Industrial Systems, technical universities in Finland, stainless steel manufacturer Outokumpu Stainless Oy as well as Finish sandwich panel manufacturers. In this article the results of the earlier mentioned R&D work in steel sandwich structures and applications is summarized from the stainless steel material point of view. The research related to design and design optimization of steel sandwich panels has been summarized by Romanoff and Kujala.[5]

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. The work carried out includes development of design formulations for the ultimate and impact strength, analysis of strength for the joints, and development of solutions to improve the behavior under fire. A number of research projects both at the national and European level have been ongoing. A summary of the applications, main benefits and problem areas of the panels as well as available design tools are given. For weight and cost optimization is also presented proving some of the described benefits of all steel sandwich panels.

III. OBJECTIVE OF PROJECT:

Objective of this project is to increase equivalent stress strength of composite structure and also reduction of weight of composite structure as compare to conventional steel structure. For that various methods available to increase strength and reduction of weight but in this project we considered only two major parameters that have major influence on strength and reduction of weight. The objective is to increase strength by varying parameters and find the best to suit requirement and that have maximum strength and having minimum weight as compare to other conventional structure.
Following are the major objectives of Project.
1. The major objective of the proposed research work is to enhance the equivalent stress at minimum weight.
2. To propose a material which sustain maximum possible strength at minimum weight.
3. Analyze Effect of equivalent stress on composite structure.

4. Analyze Effect of weight on composite structure
5. Compare the numerical, experimental result with FEA analysis result.

IV. SCOPE OF WORK:

Sandwich panels are modeled in CATIA. The top and bottom plates, core parts are modeled by using CATIA. The three parts are assembled by using assembling command. Then the assembled part is saved in STP format and imported to ANSYS workbench. In ANSYS Workbench the STP format is imported and geometry will show three contact pairs. Materials properties are given to the individual part i.e, top and bottom plates are selected and mild steel properties are given to them. Now core is selected and E-glass/Epoxy. Now mesh the geometry as free mapped mesh and structural analysis is done by fixing the plate at bottom and force is applied at top face of the plate. Now by solving the structure the deflection and von misses stress are noted. By changing the corrugated core and same is modeled and analyzed the variation in deflection and von misses and weights are compared.

V. METHODOLOGY:

In this project CATIA is used as CAD software while ANSYS is used for analysis of equivalent stress and total deformation. The value of total deformation and equivalent stress which is getting from ANSYS software and this value is then comparing with manual calculation as well as from experimental Universal Testing Machine. Results are recorded and then compared between Analytical and FEA analysis to conclude result.

VI. ANSYS RESULT:-

1. Circular Steel Structure

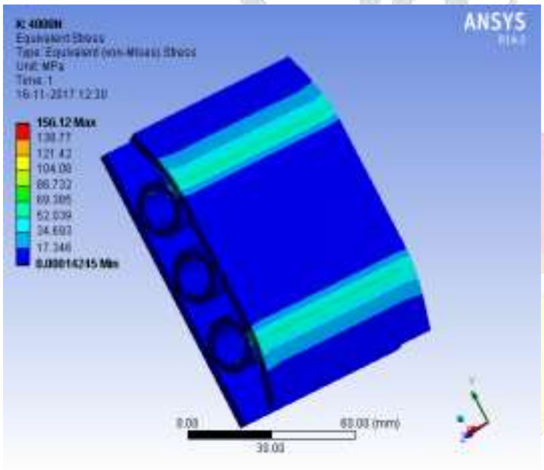

Fig.1. Equivalent stress of Circular steel structure

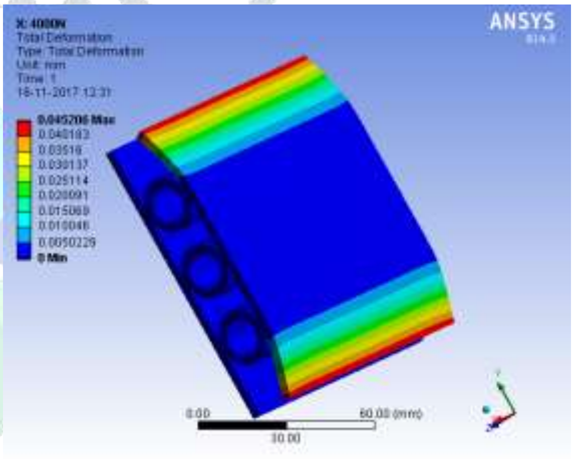

Fig.2. Total deformation of Circular steel structure

2. Triangular Steel Structure

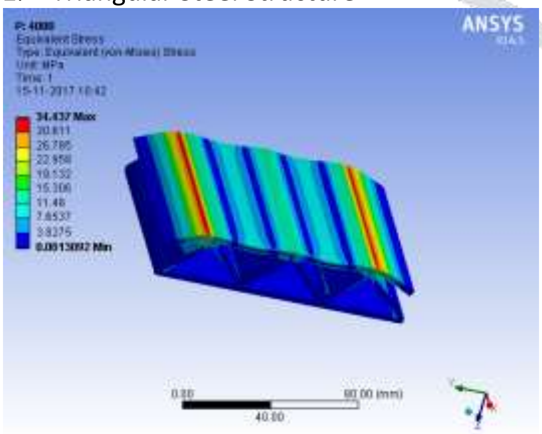

Fig.3. Equivalent stress of Triangular steel structure

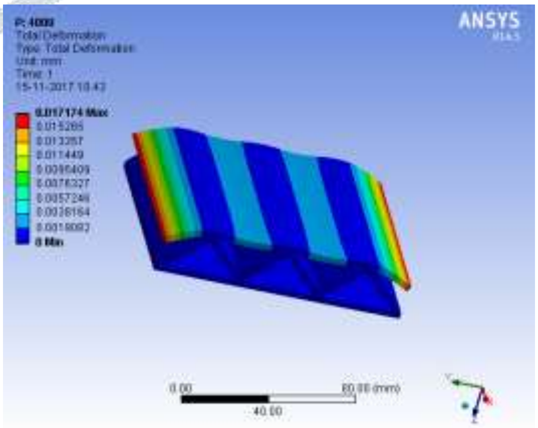

Fig.4. Total deformation of Triangular steel structure

3. Rectangular Steel Structure

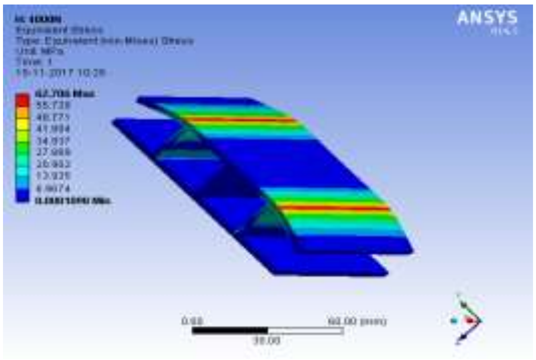

Fig.5. Equivalent stress of Rectangular steel structure

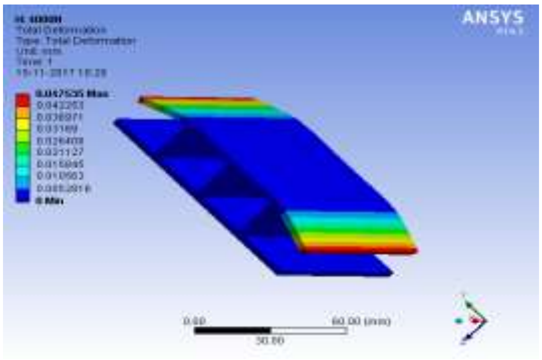

Fig.6. Total deformation of Rectangular steel structure

VII. RESULT TABLE:-

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

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	

Table1. Applied force and obtained value of design characteristics using FEA for Triangular 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	

Table2. Applied force and obtained value of design characteristics using FEA for Circular 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	

Table 3. Applied force and obtained value of design characteristics using FEA for Rectangular Steel 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

Table4. Weight comparisons of all structure

Deformation comparison of all steel structure:

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

Table5. Deformation comparison of all steel structure

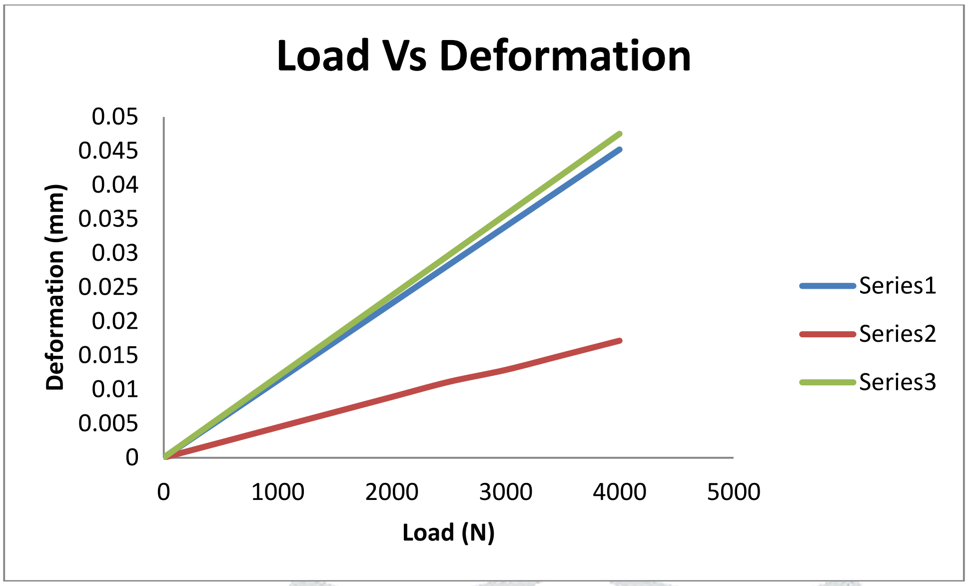

Figure 7 Load vs. Deformation of steel structure

Series 1- Circular Structure

Series 2- Triangular Structure

Series 3- Rectangular Structure

Equivalent Stress comparison of all steel structure:

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

Table 6.Equivalent Stress comparison of all steel structure

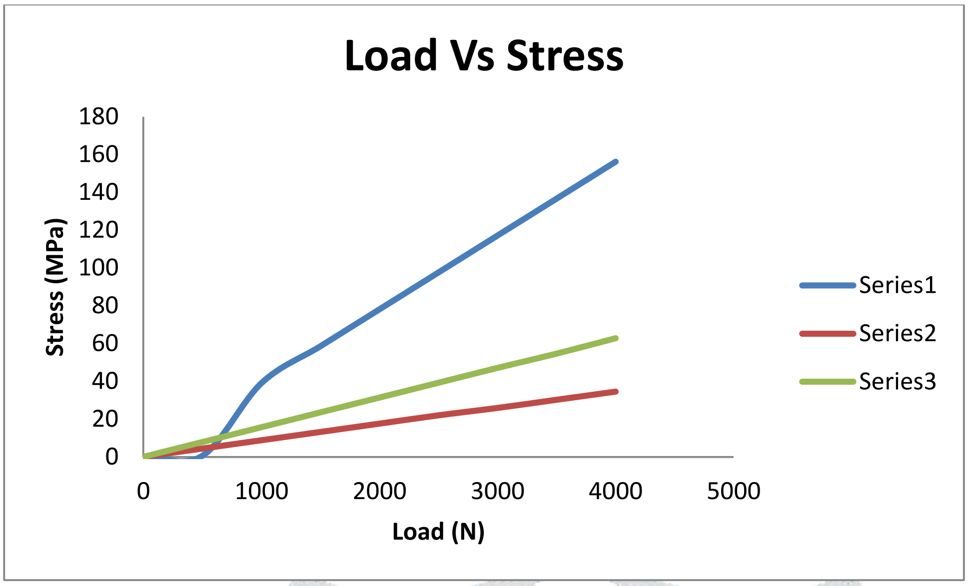

Figure8. Force vs .Equivalent Stress of steel structure

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.

VIII. UTM RESULT

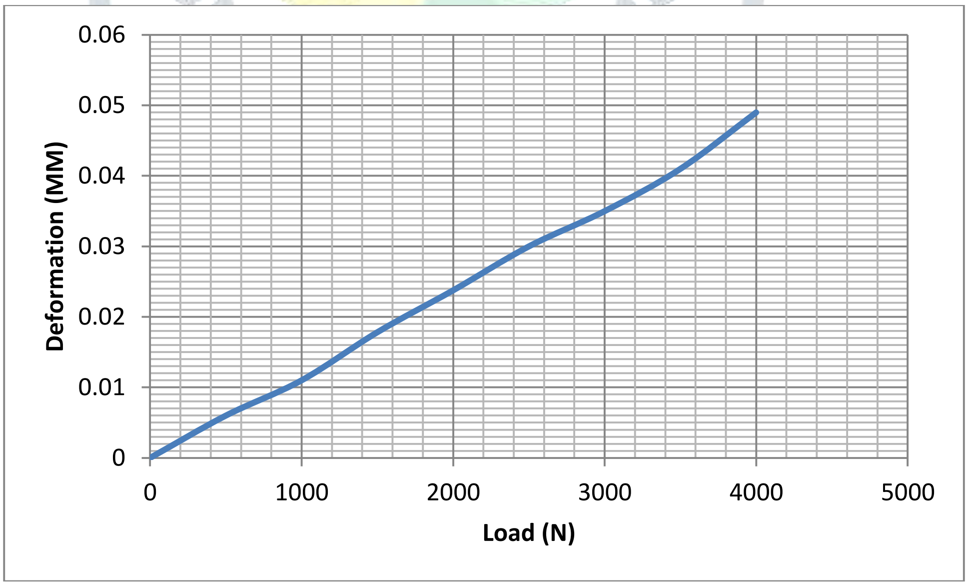

Figure 8. Square Section result of UTM test (Force vs Deformation)

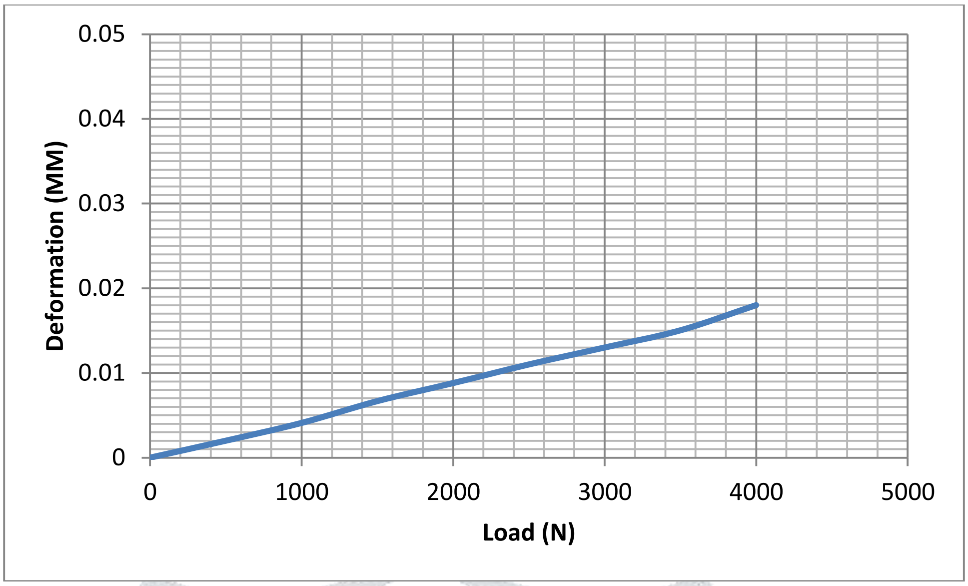

Figure 9 Triangular Section result of UTM test (Force vs Deformation)

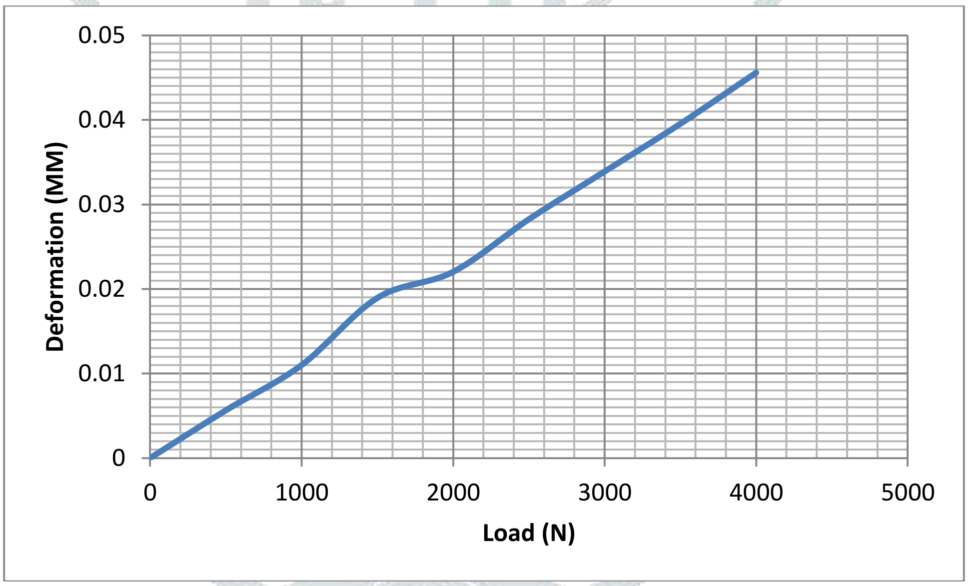

Figure 10. Circular Section result of UTM test Force vs Deformation)

IX. CONCLUSION:

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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