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Design & Analysis of Composite Structure for Industrial Platform

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Abstract - *An The demand for bigger, faster and lighter moving vehicles, such as ships, trains, trucksand 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 underfire. 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*

Key Words: Composite Material, Catia, FEA Analysis etc.

1. INTRODUCTION

Composite structures are often subjected to dynamic impact loads, which often result in progressive damage up to fracture of structures. Research on the damage behaviors of composites under impact loads is an important task to improve the impact resistance and residual lifetime of structures. The impact problems of composites are generally divided into low-velocity impact and high-velocity impact, leading to different damage mechanisms. To promote the lightweight design of composite structures, a transverse low-velocity impact is typically used to evaluate the damage tolerance of composites.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 structure 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. 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.

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. This project work focuses on steel sandwich panels welded by laser. The steel sandwich panels can be constructed with various types of cores as summarized in next figure. The choice of the core depends on the application under consideration.

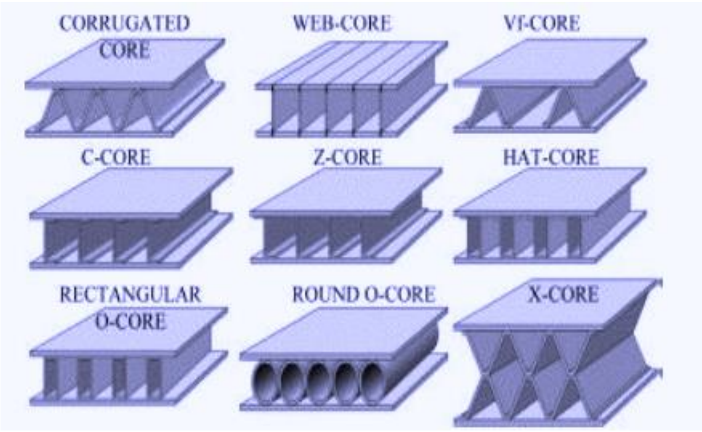

Fig -1: Different Sandwich Structure

1.1 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.

1.2 Importance of Structure

1. High 'strength or stiffness to weight' ratio. As enumerated above, weight savings are significant ranging from 25-45% of the weight of conventional metallic designs.
2. Due to greater reliability, there are fewer inspections and structural repairs.
3. Directional tailoring capabilities to meet the design requirements. The fiber pattern can be laid in a manner that will tailor the structure to efficiently sustain the applied loads.
4. It is easier to achieve smooth aerodynamic profiles for drag reduction.
5. Thermoplastics have rapid process cycles, making them attractive for high volume commercial applications that traditionally have been the domain of sheet metals.
6. Manufacture and assembly are simplified because of part integration (joint/fastener reduction) thereby reducing cost.

1.3 Objectives

- The major objective of the proposed research work is to enhance the equivalent stress at minimum weight
- To propose a material which sustain maximum possible strength at minimum weight
- Analyze Effect of equivalent stress on composite structure.
- Analyze Effect of weight on composite structure.
- Compare the numerical, experimental result with FEA analysis result.

2. 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 were recorded then compared Analytical and FEA analysis to conclude results.

3. EXPERIMENTATION

In our project work we have taken three differnet type of structure, these structure are tested on UTM machine & analytical results are tested on ansys software and result are compared

1. Circular 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
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

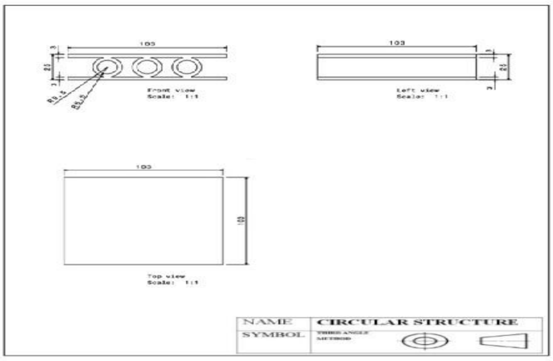

Fig -2: Circular Steel Structure

2. 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): 19mm
Core length (L): 103mm
Core Plate thickness (t): 3mm
Top and Bottom plate, core material: Steel Material

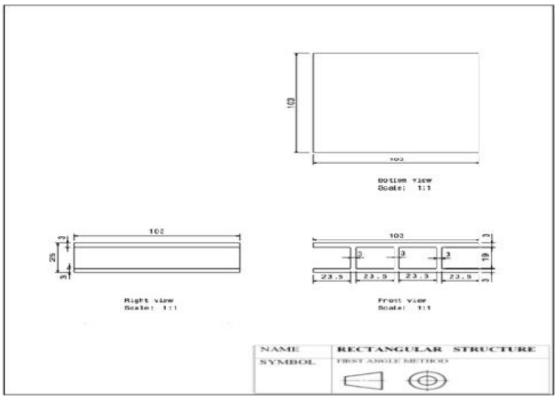

Fig -3: Rectangular Steel Structure

3. Tringaluar 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): 106mm
Bottom Plate thickness (t): 3 mm
Core material size: 25x25x3mm
Top and Bottom plate, core material: Steel Material

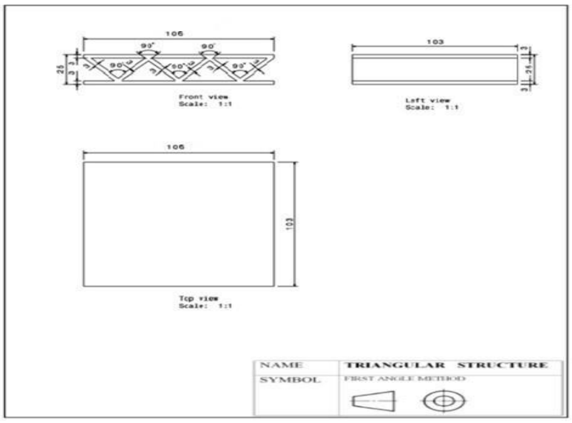

Fig -4: Triangular Steel Structure

4. DESIGN & ANALYSIS OF STRUCTURE

4.1 Catia Modeling

CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites and molded, forged or tooling parts up to the definition of mechanical assemblies.

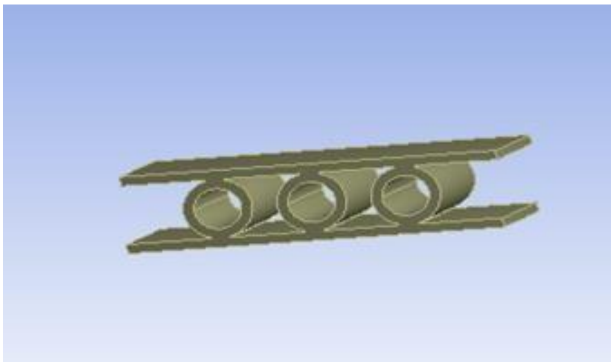

Fig -5: Circular Steel Model

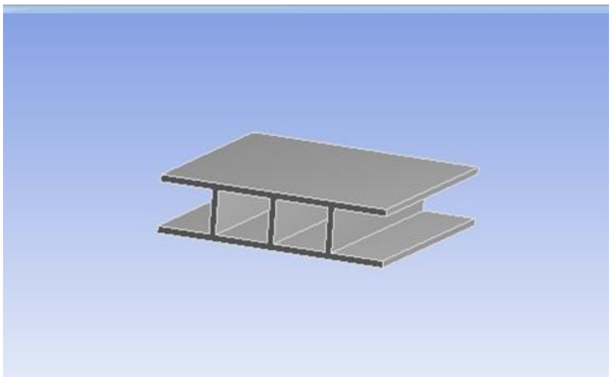

Fig -6: Rectangular Steel Model

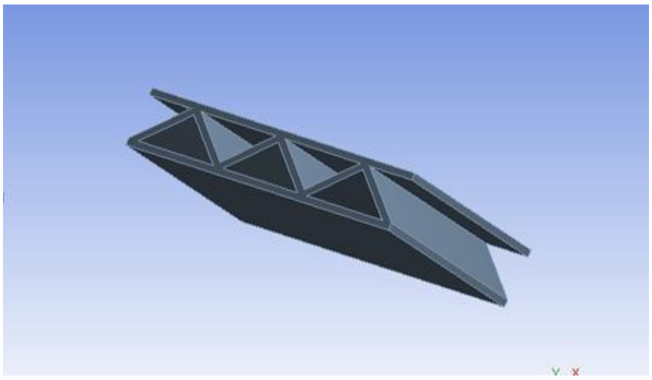

Fig -7: Triangular Steel Model

4.2 Meshing in Ansys

In ANSYS Workbench the STP format is Imported and Materials properties are given to the individual part i.e., All structure are selected and steel properties are given to them. Meshing of all parts done in ANSYS, Mesh generation is one of the most critical aspects of engineeringsimulation.

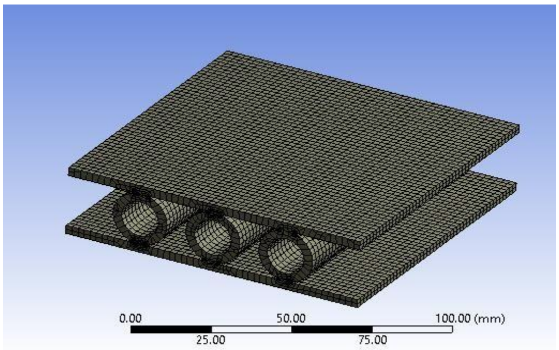

Fig -8: Meshing view of Circular steel structure

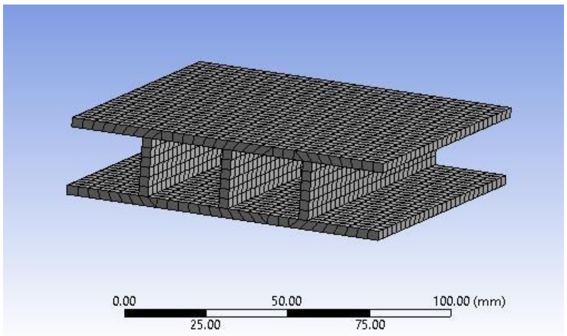

Fig -9: Meshing view of Rectangular steel structure

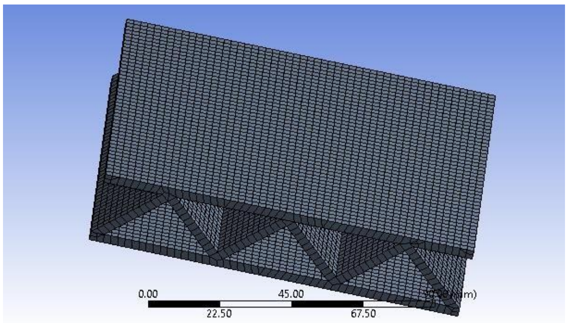

Fig -10: Meshing view of Triangular steel structure

4.3 FEA result:

1. Boundary Condition 500N for Circular cross section

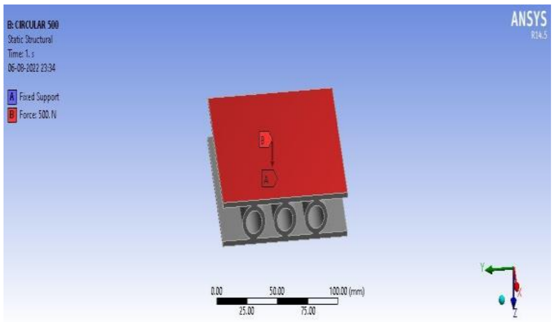

Fig -11: Boundary condition for circular structure

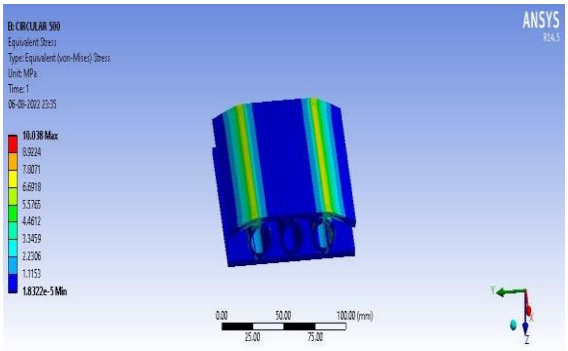

Fig -12: Stress for circular structure

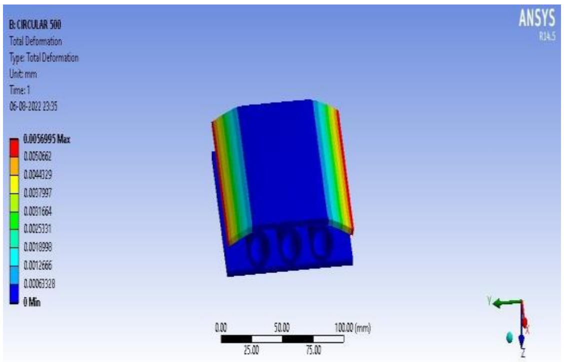

Fig -13: Deformation for circular structure

2. Boundary Condition 500 N for rectangular cross section

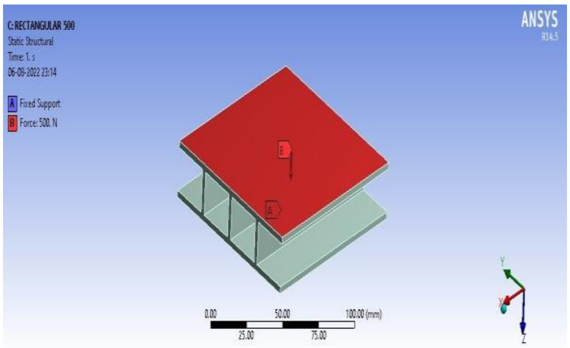

Fig -14: Boundary condition for Rectangular structure

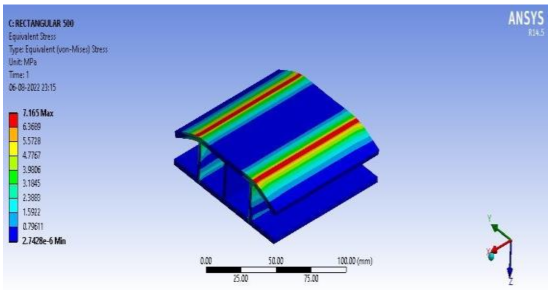

Fig -15: Stress for Rectangular structure

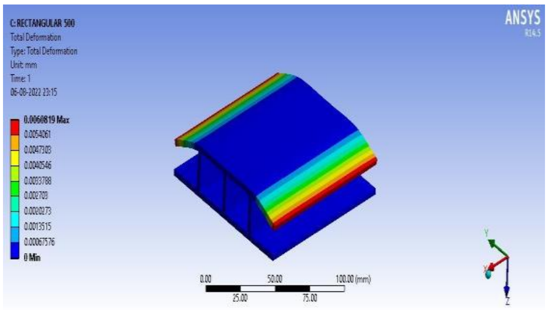

Fig -16: Deformation for Rectangular structure

3. Boundary Condition 500 N for Triangular cross section

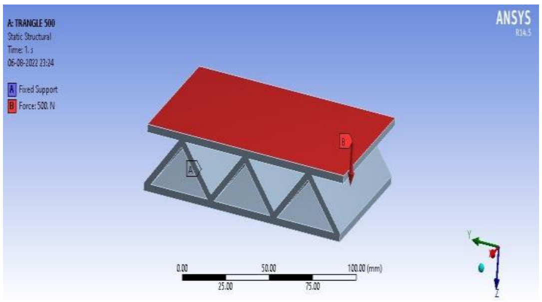

Fig -17: Boundary condition for Triangular structure

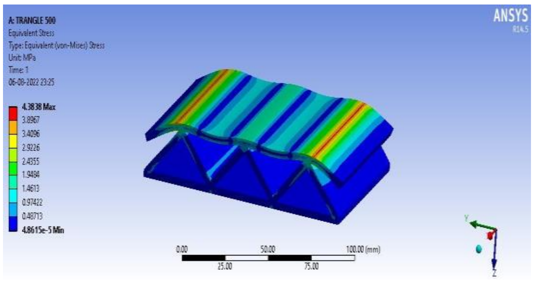

Fig -18: Stress for Triangular structure

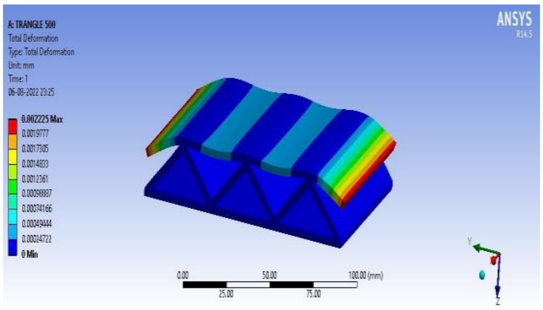

Fig -19: Deformation for Triangular structure

Same result is generated for all three different sections at different loading Condition

5. RESULT AND DISCUSSION

1. Equivalent Stress comparison of all steel structure:

Sr. No.	Force (N)	Circularsteel Structure Equivalent Stress (Mpa)	Triangularsteel Structure Equivalent Stress (Mpa)	Rectangularsteel 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

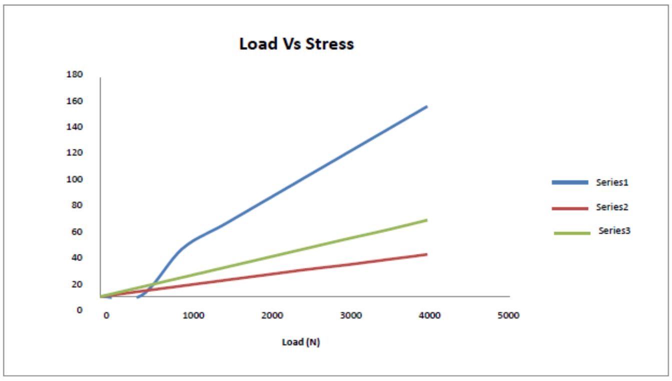

Chart -1: Force vs. Equivalent Stress of steel structure by ANSYS

Series 1-Circular Structure
Series 2-Triangular Structure
Series 3-Rectangular Structure

2. Deformation comparison of all steel structure:

Sr. No.	Force (N)	Circular steel Structure (Deformation)	Triangularsteel Structure (Deformation)	Rectangularsteel 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

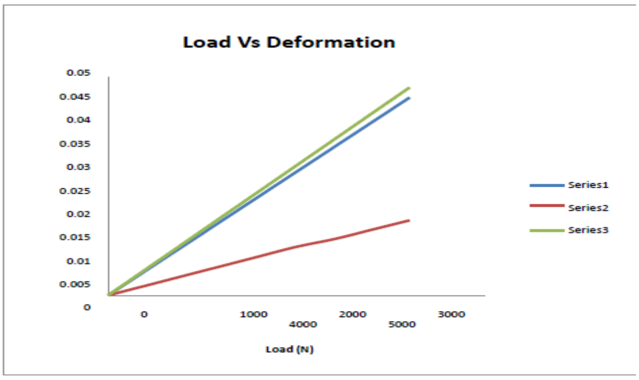

Chart -2: Load vs. Deformation of steel structure by ANSYS

- 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 Equivalent stresses, Total deformation of rectangular steel structure is also small as compare to Triangular and circular steel sturucture.
- 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.

6. 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 increasesand 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.

FUTURE SCOPE

However, the considerable work has been done in this thesis with respect to joint configurations and FEA analysis; the research work may further be extended in the following areas.

1) The core with Composite material is to be developed for the light weight applications

Properties like resistance to heat penetration,

2) Fatigue strength and resistance to impact loads may be considered in developing sandwich panels. Stiffness and strength analysis of curved.
3) The behavior of sandwich panel under the

dynamic loading condition is to be done.

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