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Modeling and Analysis of Different Steel Sandwich Structures for Industrial Lift Platform

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***Abstract* – The Steel sandwich structures consists of two thin face sheets welded by a core between them. Core is having different profiles like square, triangular, I section & circular. Face sheets & core are having same material. The steel sandwich structures can be constructed with various types of cores. The choice of the core depends on the application under consideration. These sandwich structures are used in lightweight applications such as aircrafts, marine applications and wind turbine blades. The modeling of steel sandwich structures with square, triangular, I section & circular as a core is carried out in CREO 2.0. Structural analysis of different sandwich structures with stainless steel face sheets and core is done using ANSYS workbench. Compressive strength & bending strength of steel sandwich structures are compared with experimental values. Stress, deformation, Strength and weight ratio is analyzed for each structure. On the basis of this study, a square steel sandwich structure is having less stress, less deformation and more strength as compared to other steel sandwich structure and application of this structure is considered for industrial lift platform to lift 1000 kg weight.**

Keywords - Stainless Steel, CREO 2.0, ANSYS 14.

I. INTRODUCTION

The steel sandwich structures consist of two thin face sheets welded by a core between them. Core is having different profiles like square, I-section, triangular and circular. The steel sandwich structures can be constructed with various types of cores. The choice of the core depends on the application under consideration. Face sheets & core are having same or different material. These sandwich structures are used in lightweight applications such as aircrafts, marine applications and wind turbine blades. For developing efficient structures, there is requirement of new structural design. The steel sandwich structures are well established solution for it. Metallic sandwich structures are basically two types: Structures with metallic face plates and bonded core such as SPS structures and structures with both metallic face plates and core welded together. The metal material can be either regular, high tensile, stainless steel or aluminium alloys.

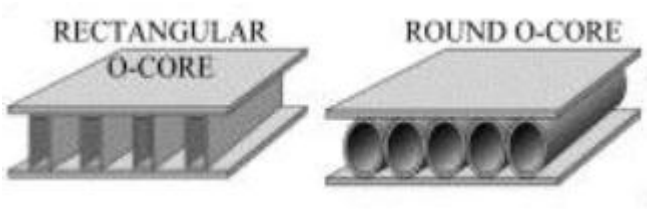

Figure 1: Steel sandwich structure with different cores

Problem Definition and Project Objective

In basic industrial lift, platform of solid plate is used which is having more weight and deformation. So there is requirement of sandwich structure with less weight, less deformation and good mechanical strength. The demand for bigger, faster and lighter moving vehicles, such as ships, trains, trucks and buses has increased the importance of efficient structural arrangements. For developing efficient structures, there is requirement of new structural design. The steel sandwich structures are well established solution for it. By using steel sandwich structures high strength & minimum weight can be obtained. The sandwich structures offer a wide range of attractive design solutions. This solution offer weight reduction, it also saves space & control noise.

The objectives of this project are as follows:

1. To model, analyze and fabricate steel sandwich structures for various profiles i.e. square, I section, circular and triangular for industrial lift platform to lift 1000 kg weight.
2. To compare results of analysis and experimental testing of steel sandwich structures and solid plate.
3. To find the best steel sandwich structure having minimum stress, minimum deformation and maximum strength as compare to other steel sandwich structures for an engineering application i.e. industrial lift platform.

Research Methodology

Modeling of different steel sandwich structures i.e. square, I-section, triangular and circular is carried out in CREO 2.0 & analysis of all structures along with solid plate is done in ANSYS14 for compression and bending test for 1000 kg weight. These structures are fabricated & tested on Universal Testing Machine for compression and bending. Results of ANSYS for deformation & equivalent stress are compared with experimental values. 5 mm Solid plate lift platform and square steel sandwich structure lift platform having length 990

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mm and width 990 mm is fixed at the base of lift structure one by one. Equivalent stress and deformation are compared between them and examined best lift platform having less equivalent stress, deformation and weight.

Material Selection

ASTM A203 Grade B material has been used for both face sheets and core. ASTM A203 Grade B is categorized as Alloy Steel.

Physical Properties:

Density: 7.85 g/cm³

Poisson's Ratio: 0.34-0.37,

Modulus of Elasticity: 200 x 10³ MPa

Melting Range: 1400-1450°C

Mechanical Properties: Ultimate Tensile Strength: 620 MPa, Yield Strength: 275 MPa

Finite Element Analysis

The steel structure models in CREO are efficiently imported into ANSYS workbench in which structural analysis is done on it. In all 5 cases of compression, models are kept horizontal and all edges of models are fixed. Boundary conditions at all edges are, Dx = Dy = Dz = Rx = Ry = Rz =0. There is neither displacement nor rotation at all edges of models. During the analysis load of 10000 N is applied on the top facesheet of steel sandwich structures and solid plate for compression. While in case of bending, models are kept horizontal and opposite side edges of models are fixed. A load of 2000 N is applied at the center of top facesheet of steel sandwich structures and solid plate for bending. Equivalent stress and total deformation are observed.

Sample No 1: Square steel sandwich structure

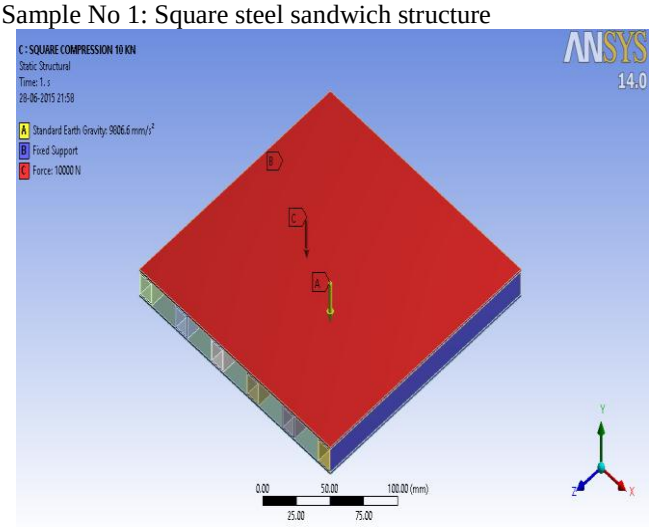

Figure 2: Fixed supports & Load applied on square steel sandwich structure

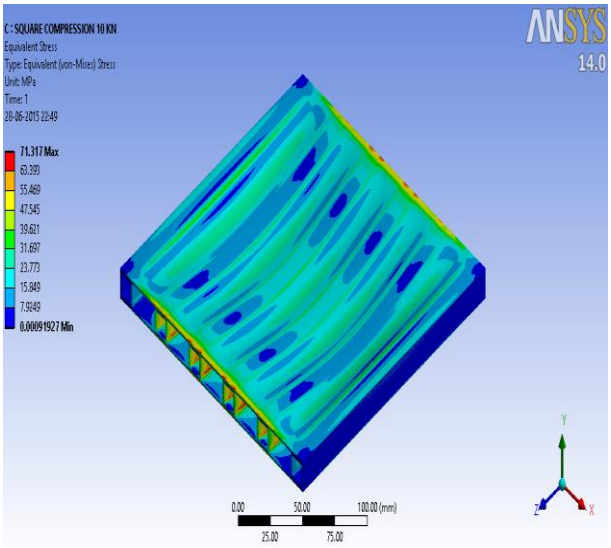

Figure 3: Equivalent stress of square steel sandwich structure

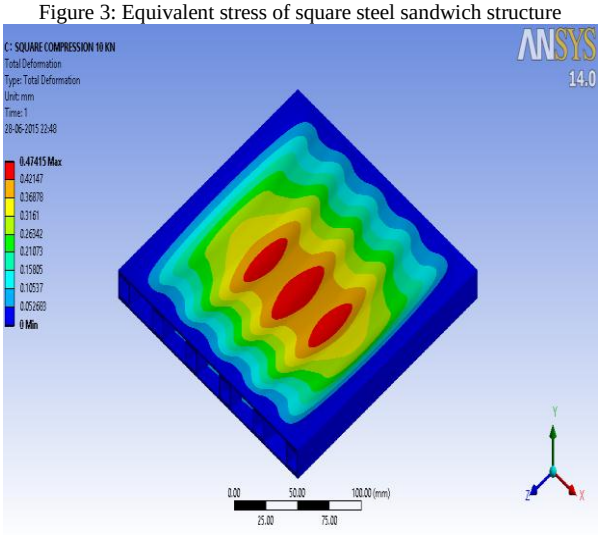

Figure 4: Total deformation of square steel sandwich structure

Sample No 2: 5 mm Steel solid Plate

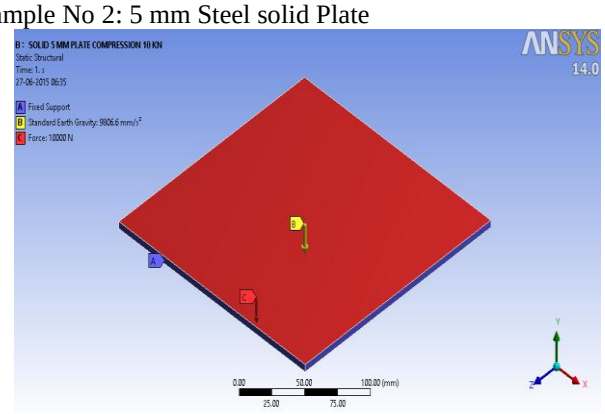

Figure 5: Fixed supports & Load applied on steel solid plate

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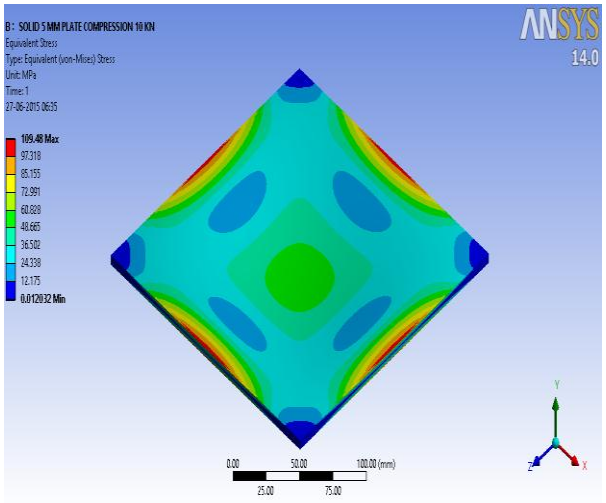

Figure 6: Equivalent stress of steel solid plate

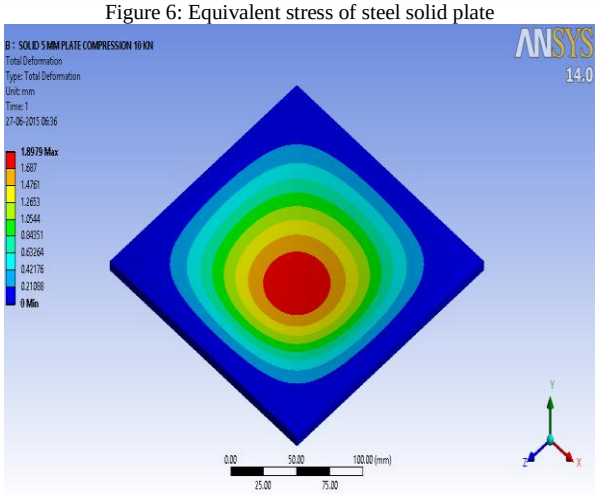

Figure 7: Total deformation of steel solid plate

Finite Element Analysis for Compression of Industrial Lift Platform

1) 5 mm Solid plate lift platform

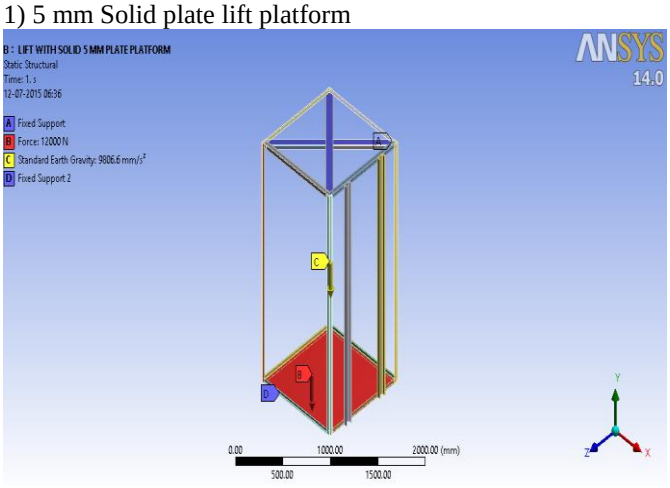

Figure 8: Fixed supports & Load applied on solid plate lift platform

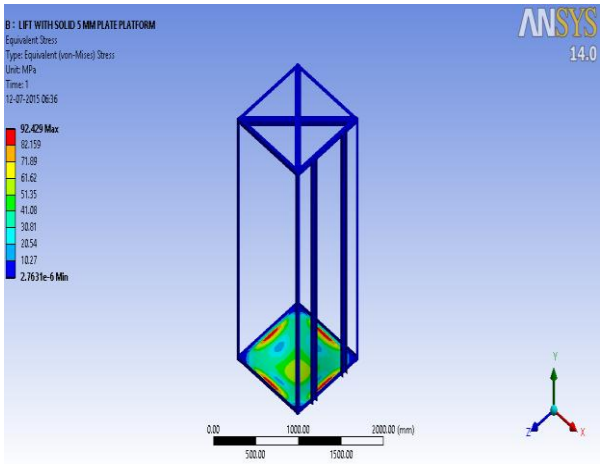

Figure 9: Equivalent stress of solid plate lift platform

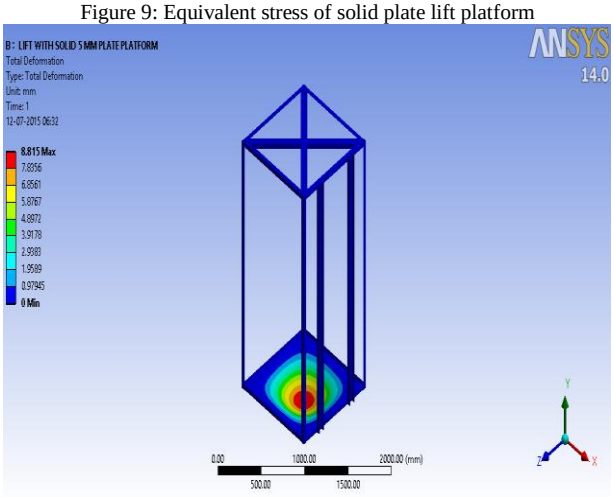

Figure 10: Total deformation of solid plate lift platform

2) Square steel sandwich structure lift platform

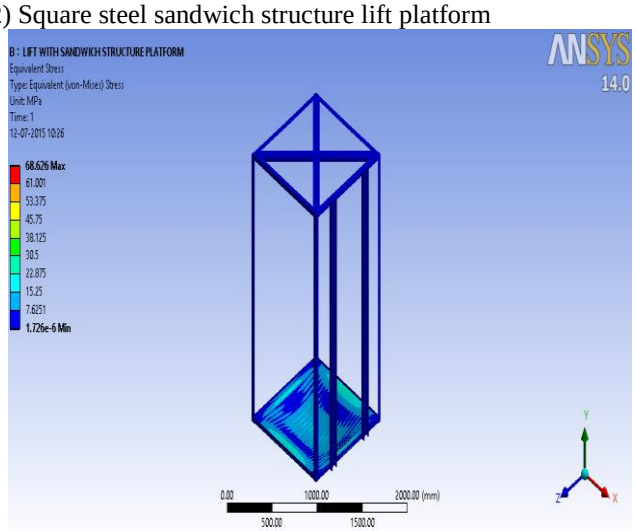

Figure 11: Equivalent stress of square steel sandwich structure lift platform

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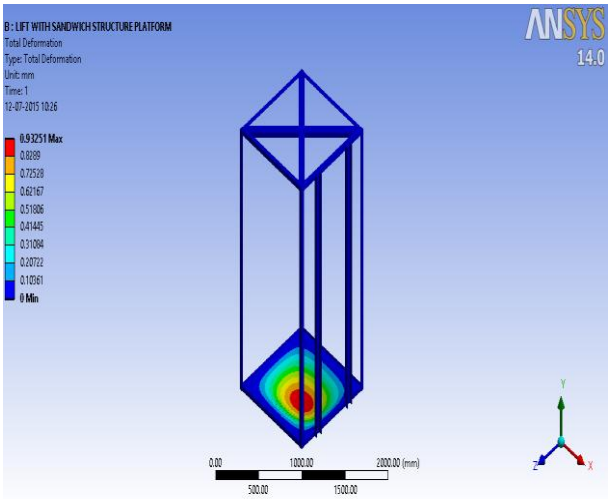

Figure 12: Total deformation of square steel sandwich structure lift platform

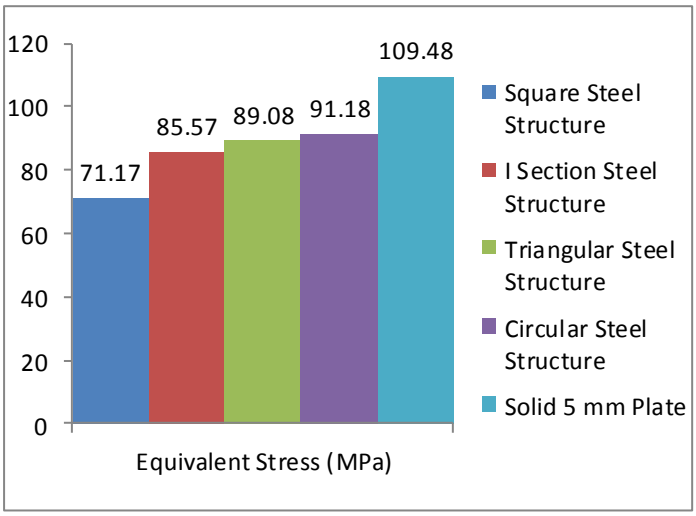

Figure 13: Equivalent stress of all steel structures for compression

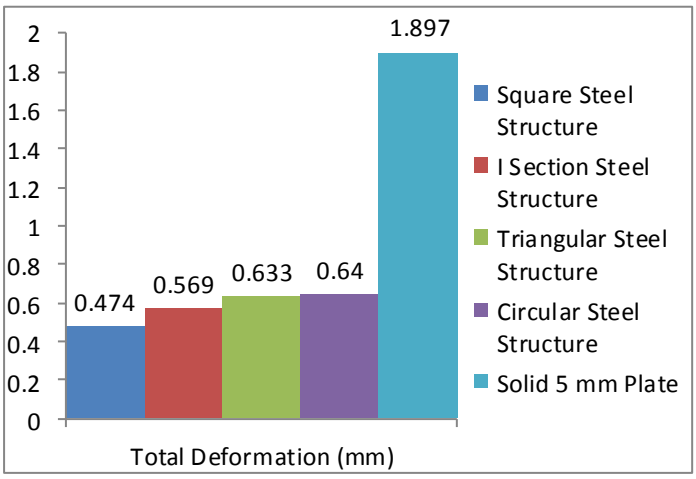

Figure 14: Total Deformation of all steel structures for compression

Results and Discussions

Equivalent stress and total deformation are observed for compression and bending in different steel sandwich structures along with solid plate in ANSYS software and experimentally. It is examined that square steel sandwich structure having less equivalent stress and deformation as compared to I-section, triangular, circular and solid plate. 5 mm Solid plate lift platform and square steel sandwich structure lift platform having length 990 mm and width 990 mm is fixed at the base of lift structure one by one. Equivalent stress and deformation are compared between them. It is examined that square steel sandwich structure lift platform having less equivalent stress and deformation as compared to 5 mm Solid plate platform.

ANSYS Results of Compression & Bending test

Table 1 ANSYS Results of Equivalent stress and Deformation for Compression

Sr No	Steel Sandwich Structure	force applied (N)	equivalent stress (Mpa)	deformation (mm)
1	Square Steel Structure	10000	71.17	0.47415
2	I Section Steel Structure		85.57	0.56997
3	Triangular Steel Structure		89.081	0.63395
4	Circular Steel Structure		91.189	0.64063
5	Solid 5 mm Plate		109.48	1.8979

Table 2 ANSYS Results of Equivalent stress and Deformation for Bending

Sr. No.	Steel Sandwich Structure	Force Applied (N)	Equivalent Stress (Mpa)	Deformation (mm)
1	Square Steel Structure	2000	133.11	0.10171
2	I Section Steel Structure		175.8	0.1859
3	Triangular Steel Structure		285.99	0.2772
4	Circular Steel Structure		234.88	0.23637
5	Solid 5 mm Plate		298.58	0.29103

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Experimental Models

1) Square steel sandwich structure for compression

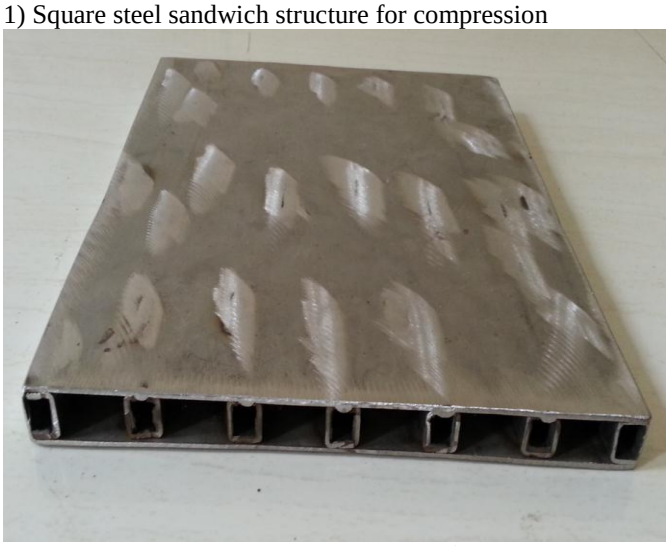

Figure 15: Square steel sandwich structure for compression

2) Solid plate for compression

Figure 16: Solid plate for compression

1) Square steel sandwich structure for bending

Figure 17: Square steel sandwich structure for bending

2) Solid plate for bending

Figure 18: Solid plate for bending

Experimental Results of Compression & Bending Test

Figure 19: Square steel sandwich structure compression test

Figure 20: Square steel sandwich structure bending test

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Table 3 Experimental results of compression test

Sr. No	Steel Sandwich Structure	Force applied (N)	Deformation (mm)	Deformation (mm) in ANSYS
1	Square Steel Structure	10000	0.5	0.47415
2	Solid 5 mm Plate		2	1.8979

Table 4 Experimental results of bending test

Sr. No	Steel Sandwich Structure	Force applied (N)	Deformation (mm)	Deformation (mm) in ANSYS
1	Square Steel Structure	2000	0.11	0.10171
2	Solid 5 mm Plate		0.3	0.29013

ANSYS Results for Compression of Industrial Lift Platform

Table 5 ANSYS Results for Compression of Industrial Lift Platform

Sr. No	Steel Sandwich Structure	Force applied (N)	Equivalent Stress (MPa)	Deformation (mm)
1	5 mm Solid Plate Lift Platform	12000	92.429	8.815
2	Square Steel Sandwich Structure Lift Platform		68.626	0.93251

CONCLUSION

Different steel sandwich structure models i.e. square, I section, circular and triangular in CREO 2.0 are efficiently imported into ANSYS workbench and structural analysis is done on it in ANSYS 14. Equivalent stress and total deformation are observed for compression and bending in different steel sandwich structures along with solid plate in ANSYS software and experimentally. It is observed that equivalent stress in square steel sandwich structure is 71.17 MPa while it is 85.57 MPa in I section structure, 89.081 MPa in triangular steel structure, 91.189 MPa in circular structure and 109.48 MPa in solid plate. Also deformation in square steel sandwich structure is 0.47415 mm while it is 0.56997 mm in I section structure, 0.63395 in triangular steel structure, 0.64063 mm in circular structure and 1.8979 mm in solid plate. In experimental analysis, deformation for square steel sandwich structure is 0.5 mm and that for solid plate is 2 mm. From this observation it is examined that square steel sandwich structure is having less equivalent stress and deformation as compared to I section, circular, triangular & solid plate. Thus the square steel sandwich structure is having more strength than other steel sandwich structures and solid plate considering same weight of all structures. Therefore square steel sandwich structure has used for industrial lift platform. In industrial lift, structural analysis of solid plate platform and square steel sandwich structure platform along with lift structure is done by using ANSYS workbench. Equivalent stress and total deformation are observed for compression in both platforms. It is observed that equivalent stress in 5 mm solid plate lift platform is 92.429 MPa while it is 68.626 MPa in square steel sandwich structure lift platform. Deformation in 5 mm solid plate lift platform is 8.815 mm while it is 0.93251 mm in square steel sandwich structure lift platform. Also weight of 5 mm solid plate lift platform is 38.469 kg and weight of square steel sandwich structure lift platform is 31.219 kg. Therefore using square steel sandwich structure lift platform weight of lift structure is reduced which results in less power consumption for lift.

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