Analytical Study on Seismic Performance of Aluminium Sandwich Shear Wall with Different Core Shapes

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ABSTRACT

Shear walls are efficient monotonic load resisting systems in high rise or super high rise framed structures and hence are the most critical elements in seismic design. This paper focus on application of Aluminium sandwich shear walls (ASSW) consist of aluminium panels as top and bottom plates and aluminium core to serve as seismic protection system. ASSW have the advantage that these are light weight systems with high stiffness to weight ratio and bending strength. These could well replace steel shear walls which are having more structural weight. This paper presents analytical analysis of performance of ASSW under monotonic and seismic loading using ANSYS software. Sandwich shear wall models were first simulated, verified and analysis was carried out. The response of aluminum sandwich shear wall with two different core shapes or configurations are studied to obtain optimum core shape or configuration for maximum load bearing capacity. Then full scale monotonic and cyclic tests were conducted on aluminium sandwich shear wall with optimum core shapes or configurations. The obtained results allow useful information for the selection of aluminium sandwich shear wall in the seismic design of framed structures.

Keywords: Aluminium sandwich shear walls, Seismic Performance.

1 Introduction

Compared to other lateral force resistance structures, Steel Plate Shear Walls (SPSWs) are built-in buildings due to high stiffness, energy absorption potential and attractive ductility. The Steel Plate Shear Wall (SPSW) is known to be one of the effective monotonic load resistance systems used in severe earthquake areas [1]. The SPSW gains the benefits of good ductility, superior seismic stability, light weight and high construction quality, quick repair, fast demolition and reusability relative to the standard reinforced concrete shear wall [2]. A variety of experiments have been conducted in the area on the theory and testing of the thin SPSW (steel plate height-to-thickness ratio (λ) >150).

Many research findings shows that certain shortcomings in thin SPSW's performance characteristics, such as the out-of-plane buckling deformation of the steel plate wall under cyclic monotonic loads, the excessive noise of the phase change, affect the structure's usefulness productivity and the tension field's appearance will carry the vertical edge portion with additional bending moment [3]. In order to improve the inadequate seismic behavior induced by the extreme out-of-plane deflection of the steel plate, a practical technological solution to avoid SPSW from bending out-of-plane must be established.

As structural engineers discovered the advantages of this choice, the selection of Steel Plate Shear Walls (SPSWs) as the predominant monotonic force resistance device in structures has risen dramatically. Since the original prototypes, its use has evolved, and did not cause the post-buckling capacity to be used, but rather the elastic and shear yield plate behavior. Typically, this construction strategy has prompted the improvement of a

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comparatively thick panel for the infill. A large plate thickness will also cause comparatively large forces on the surrounding frame members while creating a stiff structure that would minimize displacement demand during a cataclysmic activity, which must be described appropriately to ensure sufficient efficiency.

2 Methodology

The methodology of the study includes preparing a model of the steel plate shear wall, data validation, preparing model of aluminium sandwich shear wall with two different core shapes. Analysis of models is carried out under axial, monotonic and cyclic loading conditions and the results of deformation produced are compared.

3 Results and Discussion

3.1 Validation of model

The model of a SPSW is prepared with LYP shear web, flange plate, connection plate, vertical stiffeners, and horizontal stiffeners. The SPSW is designed with a width of 2110 mm and a height of 1500 mm. the width to height ratio of the SPSW is taken as 1.4, which is a moderate value in case of SPSW [1].
The size of flange plate chosen is 450 mm and 30 mm. Low yield point steel (LY225) was chosen as material for SPSW and normal structural steel (Q345B) was chosen for connection plates, stiffeners and flange plates. Table 1 shows the mechanical properties of steel for different structural components.

Table 1. Mechanical properties of steel for different structural components

Components	Yield strength (MPa)	Ultimate strength (MPa)	Elongation corresponding to the fracture (%)
Shear web plate (LY225)	240	316	56.5
Connection plates, flange plates and stiffeners (Q345B)	379	524	29.5
High-strength bolts	1018	1243	12.6

Figure 1 and Figure 2 shows the model and meshed structure of steel plate shear wall with above mentioned dimensions and properties. Once the meshed structure is generated for the prepared model, proper specific loading and boundary conditions are applied and the model is run to get the deformations. Table 2 shows the deformation values from present study and as per study conducted by Jia Chun Cui et. al. (2020).

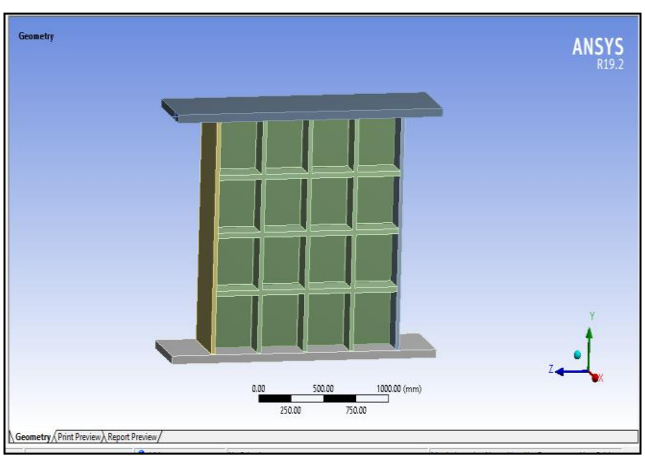

Figure 1. Model of SPSW

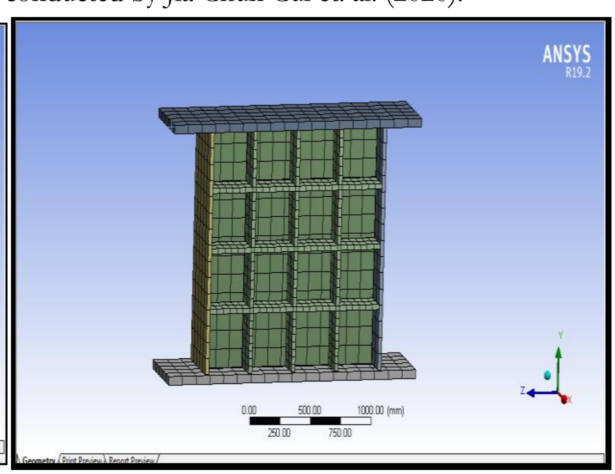

Figure 2. Meshed structure of SPSW

Table 2. Validation data of model

Characteristics	Present study	As per reference	Error
Deformation at yield (mm)	5.19	4.98	4.04%
Deformation at peak (mm)	100.56	101	0.4%

Deformation at yield and peak obtained from the analysis of SPSW using ANSYS is 5.19 mm and 100.56 mm. It is in accordance with work done by Jia Chun Cui et. al (2020). The average error percentage is only 2.22%, hence the model is validated.

3.2 Analysis

Aluminium sandwich shear wall is made with same dimensions used for modeling of steel plate shear wall. ASSW is provided with two different core shapes, which are corrugated and honeycomb. Once these models are prepared, they were analysed under axial, monotonic and cyclic loading conditions and the results are found out. The analysis is performed using static structural tool in ANSYS. Following are the various analysis results with their diagrams.

3.2.1 ASSW with Corrugated Core

ASSW is provided with corrugated core shape and was subjected to axial, monotonic and cyclic loading. Figure 3 and Figure 4 shows the model and loading condition provided for ASSW with corrugated core shape. Figure 5 shows the deformation of ASSW subjected to axial loading.

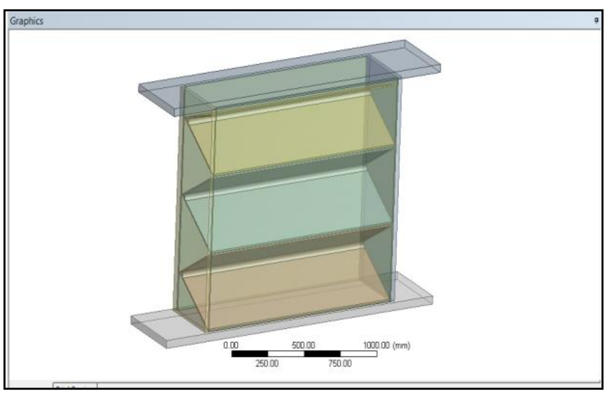

Figure 3. ASSW with corrugated core

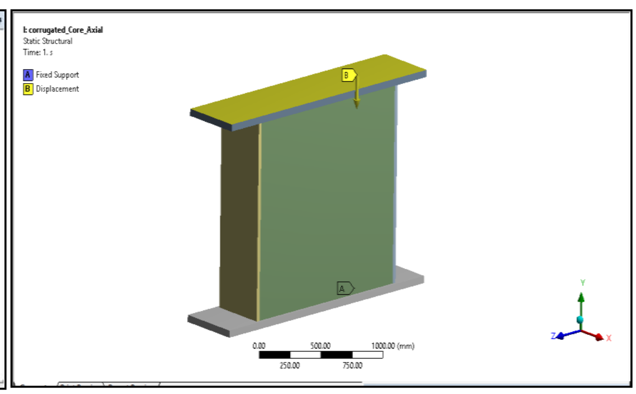

Figure 4. loading and support conditions

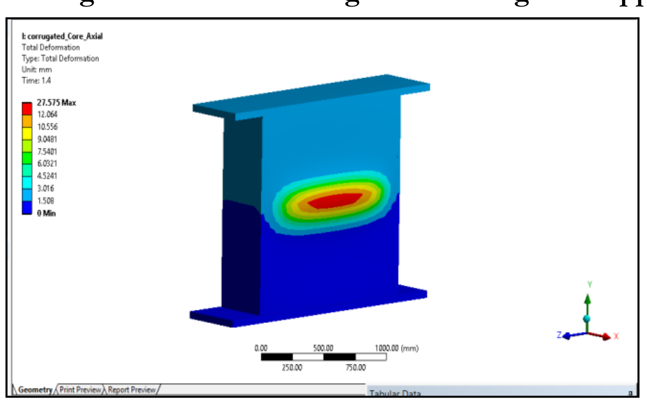

Figure 5. Deformation of ASSW with corrugated core under axial load

Figure 6 and 7 shows the loading condition provided and the deformation occured for ASSW with corrugated core when it is subjected to monotonic load.

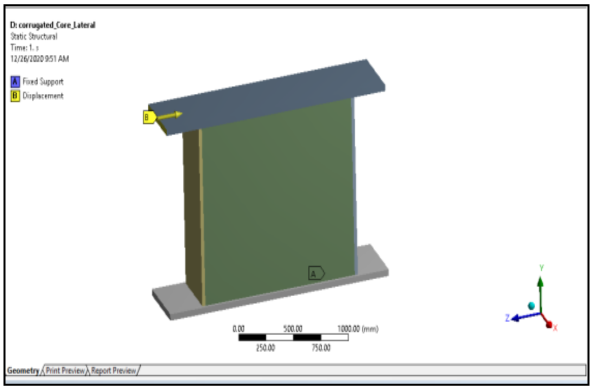

Figure 6. Loading conditions

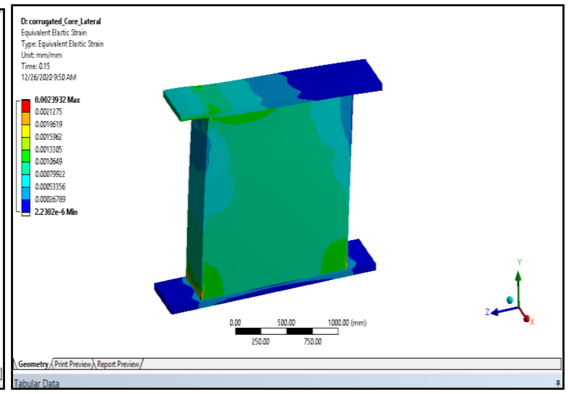

Figure 7. Deformation occurred

Figure 8 and 9 shows the loading condition given for analysis of ASSW with corrugated core shape under cyclic load, and it's load-deformation curve.

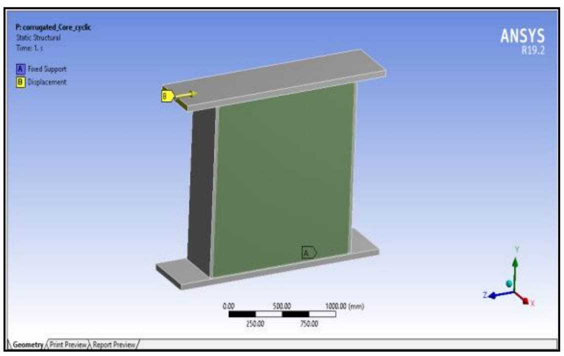

Figure 8. Loading and support conditions

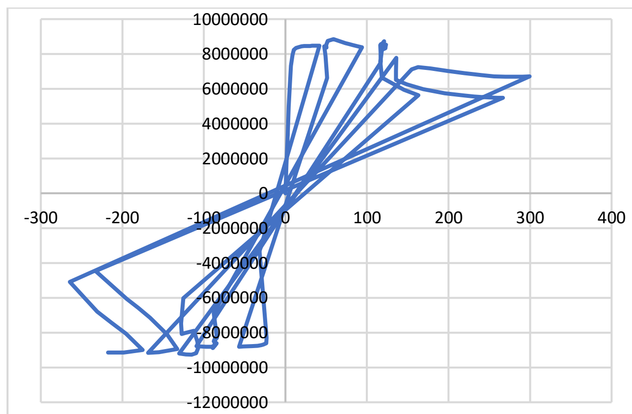

Figure 9. Load- Displacement curve

3.2.2 ASSW with Honeycomb Core

ASSW is provided with honeycomb core shape and was subjected to axial, monotonic and cyclic loading. Figure 10 and 11 shows the model and meshed structure provided for ASSW with honeycomb core shape. Same loading and support conditions as in the case of corrugated core shape is given for all models of ASSW under three different loadings.

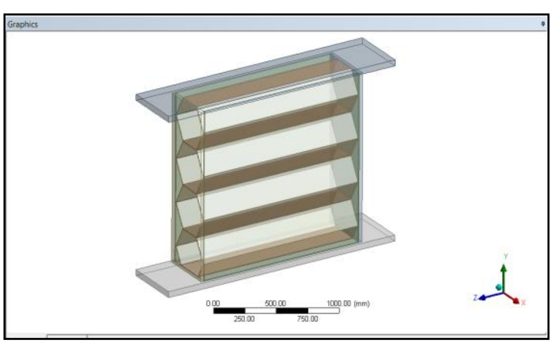

Figure 10. ASSW with honeycomb core

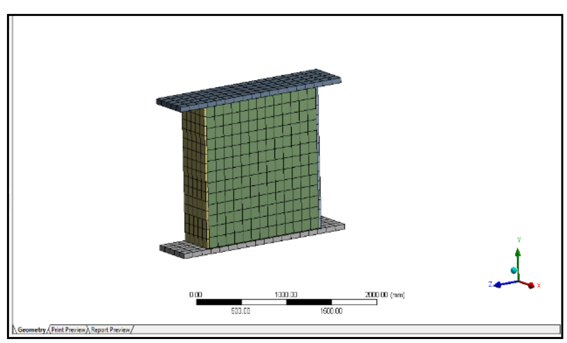

Figure 11. Meshed structure of ASSW

Figure 12 and 13 shows the deformation caused in ASSW with honeycomb core shape when subjected to axial and monotonic load.

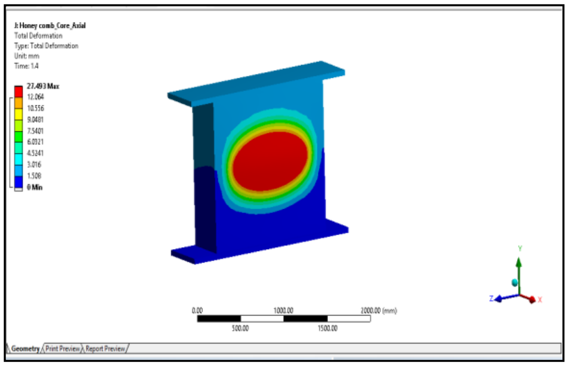

Figure 12. Deformation under axial load

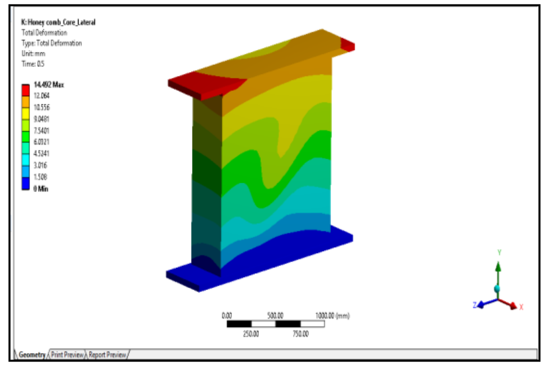

Figure 13. Deformation under monotonic load

Figure 14 and 15 shows deformation caused in ASSW with honeycomb shear wall under cyclic load and it's load-displacement curve. Table 3 shows the deformation of aluminium sandwich shear wall with corrugated and honeycomb core under axial, monotonic and cyclic loading.

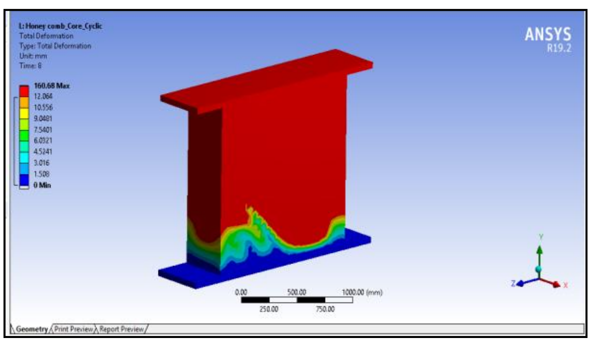

Figure 14. Deformation occurred

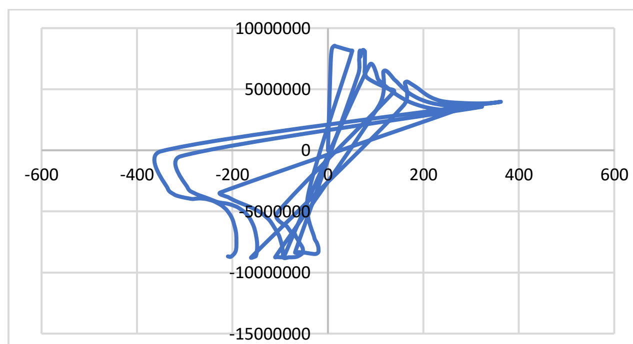

Figure 15. Load-Displacement curve

Table 3. Deformation results

Core shape	Maximum deformation under axial loading (mm)	Maximum deformation under monotonic loading (mm)	Maximum deformation under cyclic loading (mm)
Corrugated	27.575	27.194	115.12
Honeycomb	27.149	14.492	160.68

The main objective for constructing shear wall is to withstand lateral loads. It could be monotonic or cyclic load. But during seismic activities, shear walls will be subjected to huge amount of cyclic load. Here the value of deformation for ASSW with corrugated shear wall under cyclic load is 115.12mm only, which is less compared to ASSW with honeycomb core. Hence ASSW with corrugated core shape will be more effective in resisting seismic load or cyclic load.

4 Conclusion

Aluminium sandwich steel shear wall provided with two different core shapes were analysed under three different loading conditions. The conclusions made are as follows.

- Under axial loading and monotonic loading conditions, maximum deformation is found for ASSW with corrugated core and least deformation is found for ASSW with Honey comb shaped core.
- Under cyclic loading, maximum deformation is found for ASSW with honeycomb shaped core and least deformation is found for ASSW with corrugated core.
- ASSW with corrugated core shape will be more effective in resisting seismic load or cyclic load.

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