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Performance Evaluation of Steel Plate Shear Wall Using Fea Techniques

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Abstract: *The steel plate shear walls has various advantages like high stiffness, high ductility and energy dissipation. The objective of current research is to investigate the strength of SPSW using techniques of Finite Element Analysis (FEA). The design of SPSW is developed in creo design software and structural analysis of SPSW under lateral load conditions is conducted using ANSYS simulation package. The effect of circular opening on strength of SPSW is evaluated on the basis of stresses and deformation. The presence of opening in SPSW causes reduction in strength of SPSW. The incorporation of circular opening has led to an increase in equivalent stress and deformation of plate significantly. Therefore, while creating any opening on SPSW the reduction in strength of plate needs to be considered.*

Key Words*: Shear wall, stability, FEA, ANSYS*

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I. Introduction

The use of steel plates compared to reinforced concrete has many benefits. Structural characteristics of steel plate shear walls include high initial stiffness, high ductility, high dissipation of energy, and good resistance to degradation when subjected to cyclic loading. These are all "positive traits for a lateral load resisting system for seismic design. The use of thin steel plates also increases the amount of usable floor space. Since the amount of steel needed to resist design forces weighs considerably less than that of reinforced concrete, dead loads are decreased as well, leading to a decrease in foundation costs and seismic loads. Construction time is also reduced due to the elimination of the curing period involved with reinforced concrete. When constructing a steel structure, using steel plate shear walls can be beneficial, as well, since there is only a need for one trade on site. This form of lateral load resisting system is also easily applied to the seismic retrofit of older buildings or the repair of damaged structures" [1].

II. Literature Review

Mimura and Akiyama [1] have conducted experimental investigation on evaluating strength of SPSW. The effect of filler plates on structural stability and cyclic behavior of steel sheet is evaluated. The hysteresis model is developed on the basis of experimental findings as shown in figure 1.

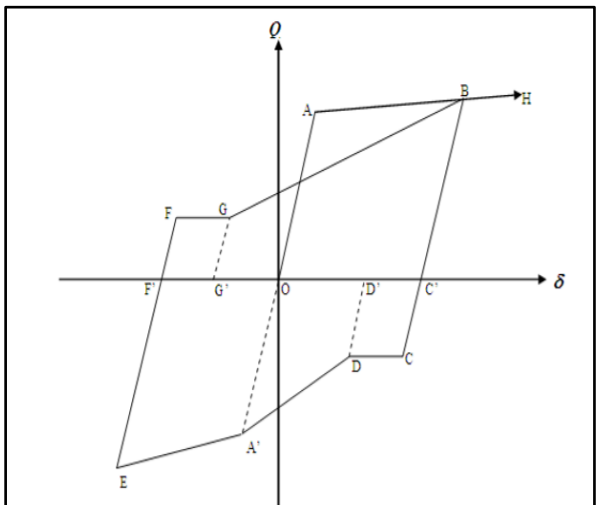

Figure 1:Hysteresis model [1]

Thorburn et al. [2] have conducted analytical evaluation of SPSW to determine the shear behavior. The "diagonal stress" field theory is used to evaluated the SPSW and the output parameters evaluated are deformation, stresses.

Elgaaly et al. [3] have conducted experimental investigation on SPSW to determine the effect of inclination angle and lattice on slenderness of cutting panels. The research findings have shown that inclination angle has very little effect on stiffness of SPSW.

Rezai [4]have conducted numerical investigation on SPSW to determine the effect of structural properties on inclination angle. The"CSA 2001 (Canadian Standard) recommends minimum ten strips for modelling of web plate. This helps to approximate the distributed load on frame boundary elements.The widely used idealization for analysis of SPSW is multi-strip modelling technique" [4].

Sabouri-Ghomi et al. [5] have conducted analytical investigation of plate and steel frame using "frame plate interaction" model. The structural behavior of plate is evaluated by studying the interaction of both elements. The plate frame interaction model application is shown in figure 2.

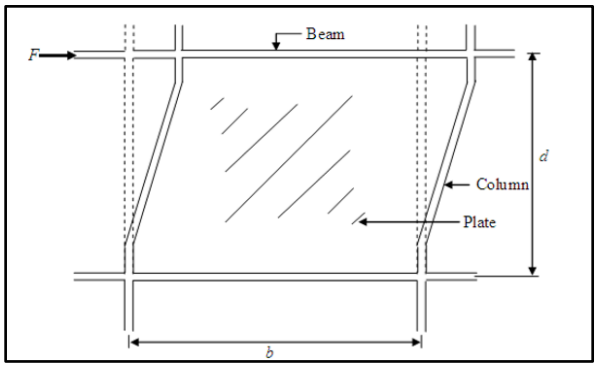

Figure 2:Plate frame interaction model as per Sabouri-Ghomi and Roberts. [5]

Kharrazi et al. [6]have conducted numerical investigation on SPSW using ABAQUS FEA simulation package. The technique used in the analysis was "MPFI or modified plate frame interaction" in design of SPSW of different system heights. The research findings have shown that results obtained from FEA analysis are in close agreement with results obtained from MPFI technique.

III. Objectives

The objective of current research is to investigate the strength of SPSW using techniques of Finite Element Analysis (FEA). The design of SPSW is developed in creo design software and structural analysis of SPSW under lateral load conditions is conducted using ANSYS simulation package. The effect of circular opening on strength of SPSW is evaluated on the basis of stresses and deformation.

IV. Methodology

The design of steel plate is developed and checked for geometric errors. The imported model of SPSW is shown in figure 3 in which central rectangular section is defined with steel material.

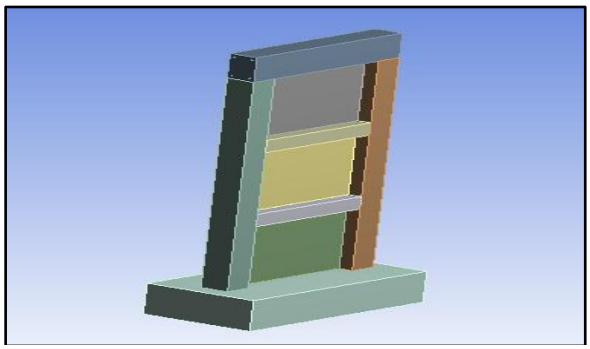

Figure 3: Design of SPSW without opening

The SPSW is meshed with high relevance and fine sizing. The model is meshed using hexahedral brick element type as shown in figure 4. The minimum edge length for meshing is set to 2mm and number of nodes generated is 141641.

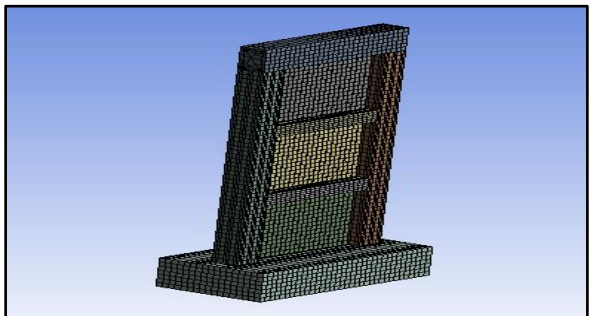

Figure 4: Hexa element mesh in SPSW

The structural loads and boundary conditions are applied on the SPSW without plates. The lateral load is applied on the structure which is a type of static push over analysis. The base of the structure is applied with fixed support and top left face is applied with force of 600000N.

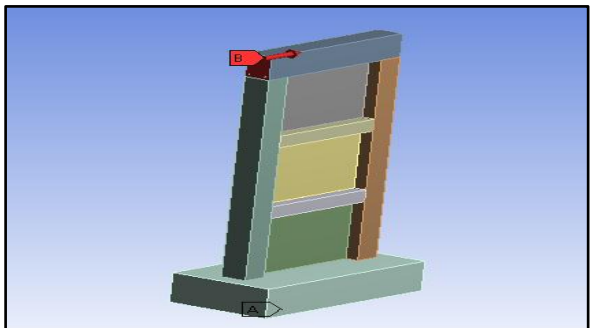

Figure 5: Application of lateral loads on SPSW without opening

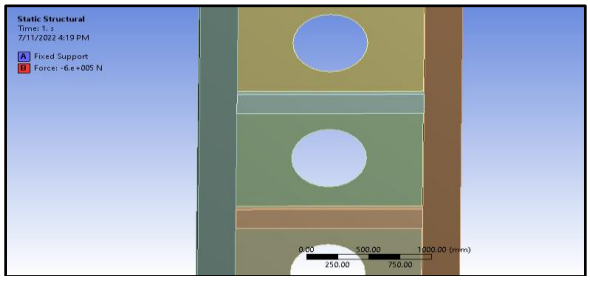

Figure 6: Application of lateral loads on SPSW with circular opening

The similar loading conditions are applied on SPSW with circular opening as shown in figure 6 above. For this design also, the

V. Results And Discussion

From the structural analysis conducted on SPSW using FEA technique, the equivalent stress and deformation values are obtained for both design configuration i.e. SPSW without opening and SPSW with opening.

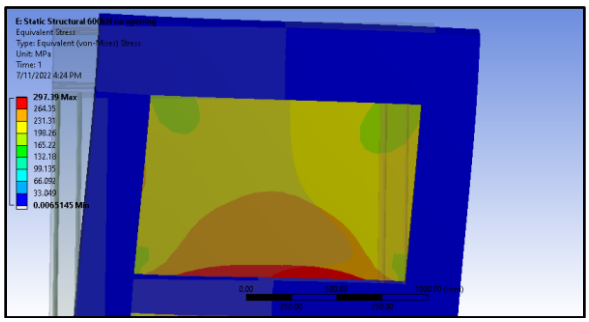

Figure 7: Equivalent stress on SPSW without opening

The equivalent stress plot is obtained for SPSW without opening and the maximum stress is observed at the plate and near the beam member.

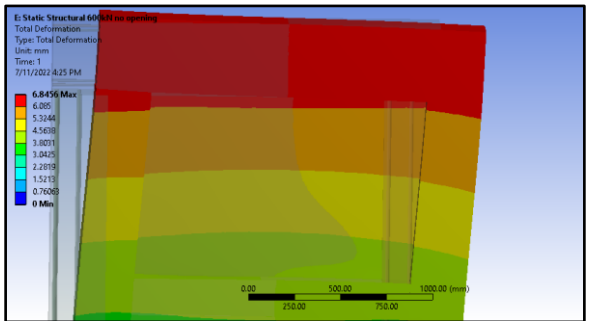

Figure 8: Total deformation on SPSW without opening

The deformation plot is obtained for SPSW without opening subjected to lateral load conditions. From the SPSW deformation plot, the maximum deformation is obtained at the top most region of plate where in the deformation is more than 5.3244mm.

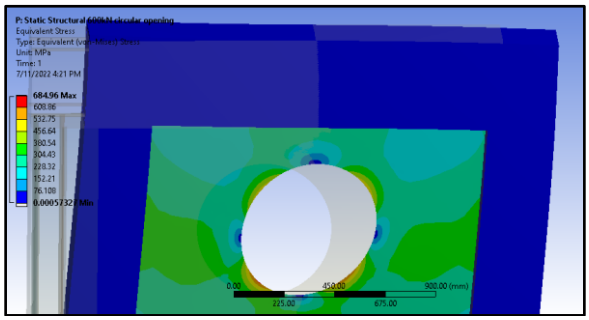

Figure 7: Equivalent stress on SPSW with circular opening

The equivalent stress plot is obtained for SPSW with circular opening is obtained as shown in figure 7 above. The maximum equivalent stress is obtained near the circular opening with magnitude of more than 608.8MPa. The equivalent stress reduces

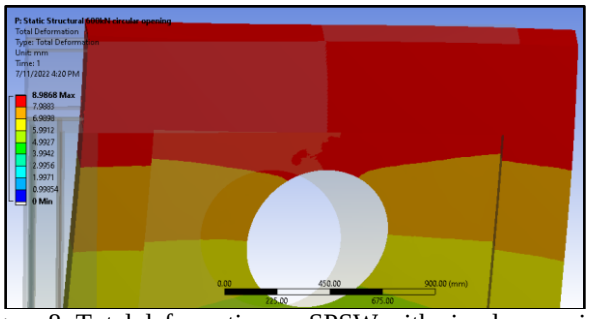

Figure 8: Total deformation on SPSW with circular opening

The deformation plot is obtained for SPSW with circular opening subjected to lateral load conditions. From the SPSW deformation plot, the maximum deformation is obtained at the top most region of plate where in the deformation is more than 7.988mm. The deformation at other region is less than 5.99mm which is shown in dark orange coloured region.

VI. Conclusion

The application of steel plate can improve the lateral load resisting of SPSW. The structural behaviour of SPSW is analysed using techniques of FEA which is cost effective and time saving. However, the presence of opening in SPSW causes reduction in strength of SPSW. The incorporation of circular opening has led to an increase in equivalent stress and deformation of plate significantly. Therefore, while creating any opening on SPSW the reduction in strength of plate needs to be considered and taken account of.

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