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# Analysis of Steel Plate Shear Wall System Using Finite Element Analysis

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***Abstract:** A seismic wall is a lateral load resistance system used in high-rise buildings in earthquake-prone areas. The aim of the current research is to investigate the shear behavior of his SPSW using finite element method techniques. SPSW modeling and structural analysis are performed in software ANSYS 18. Critical areas of high stress and deformation are determined from the FEM analysis. The mode shapes and natural frequencies of SPSW are determined. Both structural and modal analyses, the highest deflection was observed at the top plate of the SPSW, indicating that this is the most fragile region under static and dynamic loading conditions.*
***Keywords:** Steel Plate Shear wall, stability, FEA.*

## I. INTRODUCTION

SPSWs are considered the most efficient side protection systems used since the 1970s and offer many advantages over other systems, eg, solid and sturdy frames and reinforced concrete barbecue walls, in terms of cost, performance, and ease of design. Increased research work has been done on the structural and operational behavior of these systems and the results of these studies are embedded in the design and specification codes. The use of SPSWs is based on two different design philosophies and detailed strategies. Strong and / or solid web SPSWs with robust stability and high seismic performance characteristics, as widely used in Japan, and lightweight and thin SPSWs with low web performance compared to dynamic forces, as widely used in the United States and Canada.

The finite element method (FEM) is "a numerical method for solving problems that can be described by partial differential equations or formulated as function minimization. A region of interest is represented as a set of finite elements" [32 ]. Node values are determined against physical fields. A continuous physics problem is transformed into a discretized problem (elements and nodes) with unknown node values.

His following features of the FEM are:

*1)* Simple approximation functions can be used to improve the accuracy of physical problems.
*2)* Using sparse equations can fix the problem of unknown node variables.

## II. LITERATURE REVIEW

Zirakian T and Boyajian D: Steel Plate Shear Walls (SPSW) are used as primary or part of the Primary Lateral Bearing System in building design and retrofits. Currently, the development and use of low yield strength (LYP) steels with significantly lower yield strength and higher elongation capacity in present an opportunity to design SPSW systems with improved maintainability, structural performance and energy absorption characteristics of . provided. This paper provides an overview of the recent work done by the first author on the seismic design and modification of his SPSW system using LYP steel material. The results and findings of these studies will form the basis for future research on the design and refinement of the low-cost, high-performance his SPSW system.

Abbas O. Dawooda et.al.: This study deals with the static behavior of a self-supporting traditional clay brick-gypsum mortar masonry chimneys representative of the large number of chimneys currently used in industrial field in Iraq which plays an important role in dispersion of flue gases and smoke releasing to the atmosphere. The first part of the present study is devoted to review the construction process of chimneys, their shapes and dimensions, and properties of masonry units in which chimneys with heights 45, 50, 60, 70 and 80 m were studied. The second part focused on the wind loading analysis using CFD modelling and compared it with wind loads obtained by ASCE7-10, where three wind velocities were taken 30, 42, and 50 m/s. The third part related to 3D numerical model using finite elements method via ANSYS 2020R1 software to study the structural behavior of chimneys under gravity and wind loads in term of deflections and stresses.

 

It is found that chimneys with slenderness ratio up to 11.6 (height = 60 m) re satisfied the design codes requirements for all wind velocities 30 50 m/s for permissible tensile stress, namely with a the factor safety greater than 2.The lateral deflection at the top of the chimney, of heights 45 m and 50 m, for all wind velocities is within permissible limit i.e. (H/650).Wind loadings estimated by CFD analysis is greater than that calculated by ASCE7 10 by about 37 %.

A.K. Bhowmick st.al. The behavior of an unreinforced steel wall panel with circular perforations in the infill panel was investigated. The shear strength model is developed based on the strip model where all perforated strips are discounted. To evaluate the proposed shear strength model, his eight drilling patterns of single-story steel shear walls with two different aspect ratios were analyzed using a nonlinear finite element model. A comparison of the nonlinear pushover analysis with the proposed equation shows excellent agreement. Shear strength model, proposed for a perforated shear wall, is used to design the boundary columns of a four-story shear wall. The predicted design forces (axial forces and bending moments) of the restraining columns of a four-story perforated shear wall are compared with the forces obtained from the nonlinear seismic analysis. The proposed model provides excellent predictions for column design forces.

P.PChandurkar have conducted FEA analysis on 10 storey building with shear wall using ETabs software. The seismic analysis conducted was of non-linear type considering zone 1, zone 2, zone 3 and zone 4. The story drift is evaluated and effect of shear wall size on stability is determined.

Varsha R. Harneanalysed have conducted FEA analysis on 6 storey building with shear walls using Staad Pro simulation software. The seismic analysis was conducted on building using IS 1893 Part II code. In total 4 different cases are considered for analysis i.e. “barbed-wire building, an L-shaped bar-shaped structure, a bar-shaped bar near the surrounding area, and a bar-shaped bar-shaped structure”. The research findings have shown that using shear walls would reduce lateral deformation of building subjected to seismic excitation.

Anshuman S.et al. have conducted elasto-plasto analysis of 15 storey building using SAP 10 software. The building analysed was located at earthquake zone IV region. The research findings have shown that with the use of shear walls the shear strength and bending time reduced.

Drs. B. Kameswari et.al have conducted numerical investigation on high rise structure to investigate the inter storey drift. The high rise structure was investigated with and without shear walls. Different design configurations of SPSW are considered i.e.“(1) Standard haircuts (2) Other haircuts (3) Diagonal layout of haircuts (4) Zigzag layout of haircuts (5) Influence of lifting walls

## III.OBJECTIVES

The objective of current research is to investigate the shear behaviour of SPSW using techniques of Finite Element Method. The modelling and structural analysis of SPSW is conducted using ANSYS 18 software.

## IV.METHODOLOGY

The analysis of steel plate shear wall involves 3 different stages i.e. pre-processing, solution and post-processing. The model of SPSW is imported in ANSYS design modeller as shown in figure 1 below.

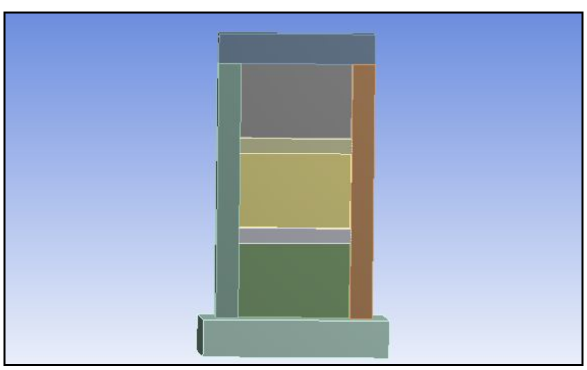

Figure 1: Model of SPSW

The next step after modelling of SPSW is meshing. The SPSW model is meshed using brick elements with fine sizing and adaptive shape function. The meshed model of SPSW is shown in figure 2. The meshed model of SPSW comprises of 21577 elements and 114883 nodes.

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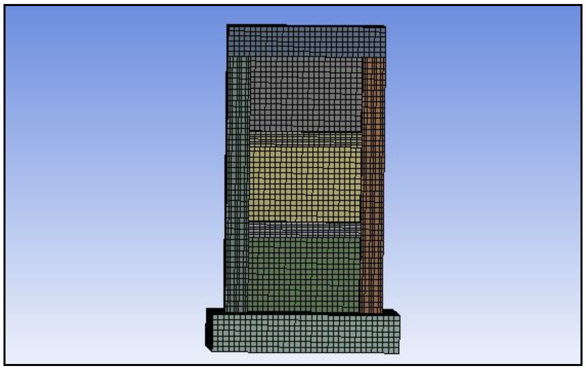

Figure 2: Meshed model of SPSW

The SPSW model is applied with lateral load of 200kN at top left face of SPSW as shown in figure 3 below. The base of SPSW is applied with fixed support.

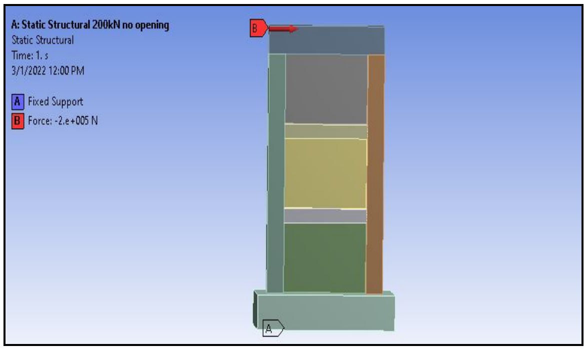


Figure 3: Lateral load on SPSW

The solver set up is conducted at this stage and sparse matrix solver is invoked. The simulation is run and element stiffness matrix is formulated. This element stiffness matrix is assembled to form global stiffness matrix and nodal calculations are made for determining deformation and stresses.

## V. RESULTS AND DISCUSSION

The static structural analysis is conducted on SPSW to determine deformation, shear stress and equivalent stress.

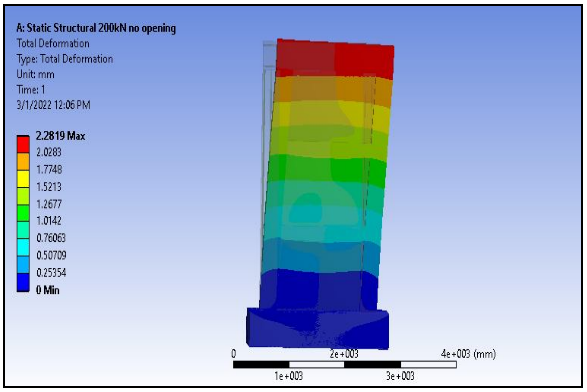


Figure 4: Lateral deformation of SPSW

From static structural analysis, the maximum deformation is obtained on topmost zone of SPSW with magnitude of 2.2819mm as shown in figure 4 above.

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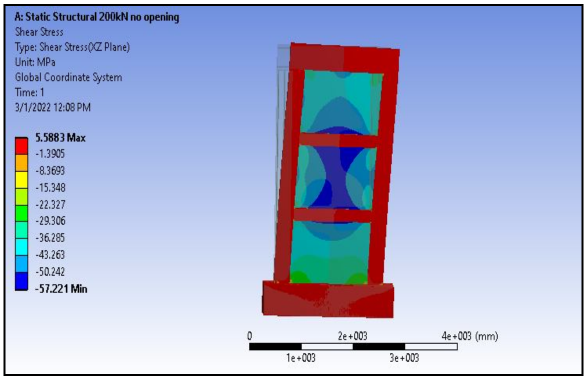


Figure 5: Shear stress on SPSW

The shear stress plot of SPSW is shown in figure 5 above. The maximum shear stress is observed at the bottom corner region of SPSW. The maximum shear stress obtained from SPSW is 22.32MPa. The shear stress is minimum at the mid plate of SPSW.

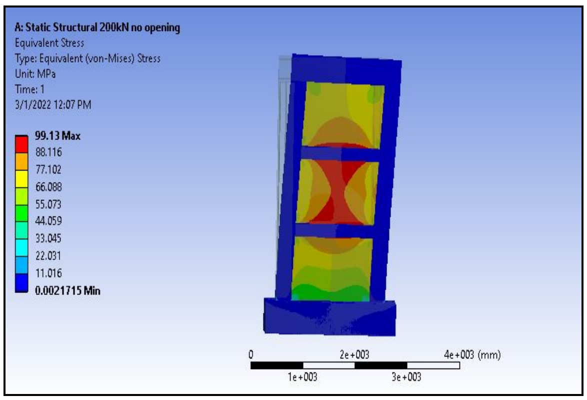


Figure 6: Equivalent stress on SPSW

The equivalent stress plot is generated for SPSW without opening as shown in figure 9 above. The maximum equivalent stress is observed at the centre plate of SPSW with magnitude of 99.13MPa and is lower at the edges of the SPSW.

The modal analysis is conducted for SPSW to determine natural frequency and mode shapes.

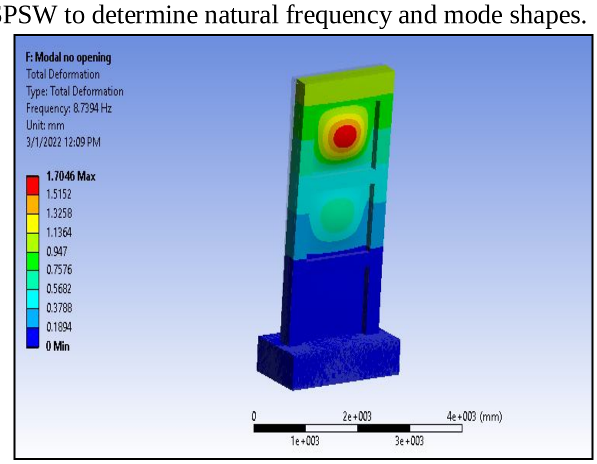


Figure 7: 1st mode shape of SPSW

For 1st natural frequency, the maximum deformation is observed on 1st plate of SPSW as shown in figure 7 above. The maximum deformation is observed to be 1.7046mm with natural frequency of 8.7394Hz.

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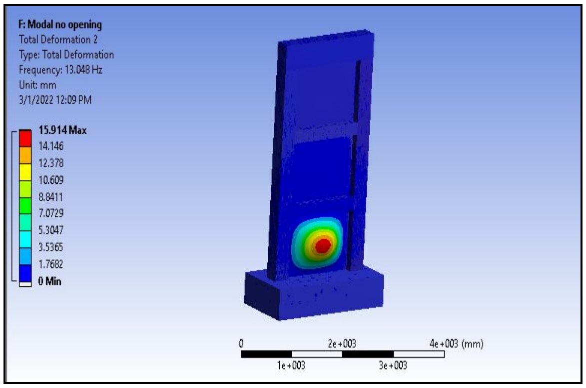


Figure 8: 2nd mode shape of SPSW

For 2ndnatural frequency, the maximum deformation is observed on 3rd plate of SPSW as shown in figure 8 above. The maximum deformation is observed to be 15.914mm with natural frequency of 13.048Hz.

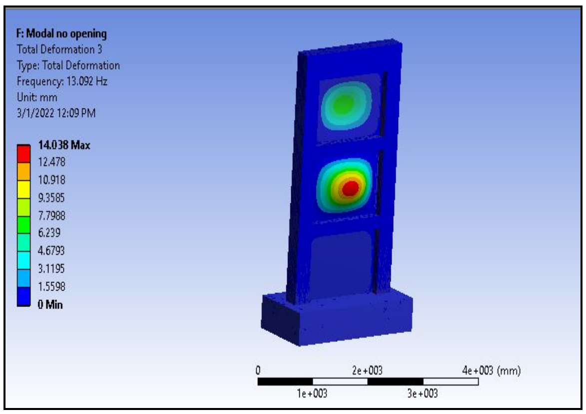


Figure 9: 3rd mode shape of SPSW

For 3rdnatural frequency, the maximum deformation is observed on 2ndplate of SPSW as shown in figure 9 above. The maximum deformation is observed to be 14.038mm with natural frequency of 13.092Hz.

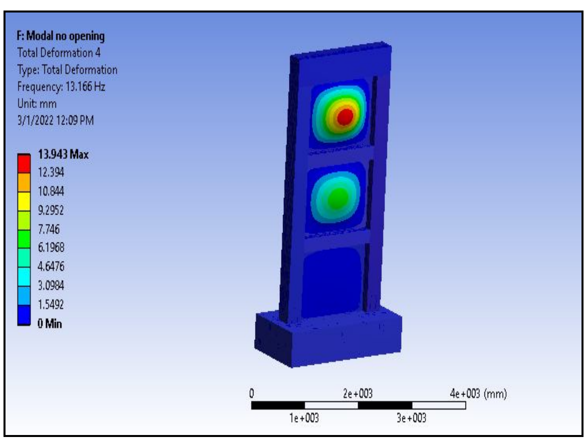


Figure 10: 4th mode shape of SPSW

For 4thnatural frequency, the maximum deformation is observed on 3rdplate of SPSW as shown in figure 10 above. The maximum deformation is observed to be 13.943mm with natural frequency of 13.166Hz.

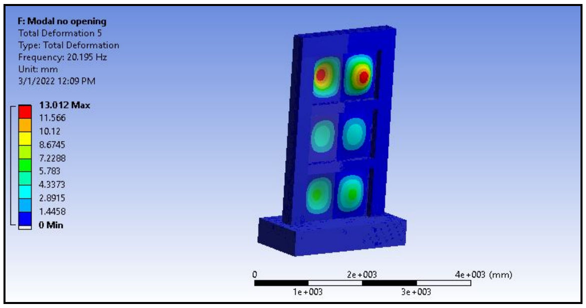

Figure 11: 5th mode shape of SPSW

For 5th natural frequency, the maximum deformation is observed on 3rd plate of SPSW as shown in figure 10 above. The maximum deformation is observed to be 13.012mm with natural frequency of 20.195Hz.

## VI. CONCLUSION

The FEA is viable tool in determine structural and vibration characteristics of steel plate shear wall. From the FEA analysis critical regions of high stresses and deformation are determined. The mode shapes and natural frequency of SPSW are determined. From both structural and modal analysis the maximum deformation is observed on top plate of SPSW which shows it is the most prone region subjected to failure under static and dynamic loading conditions.

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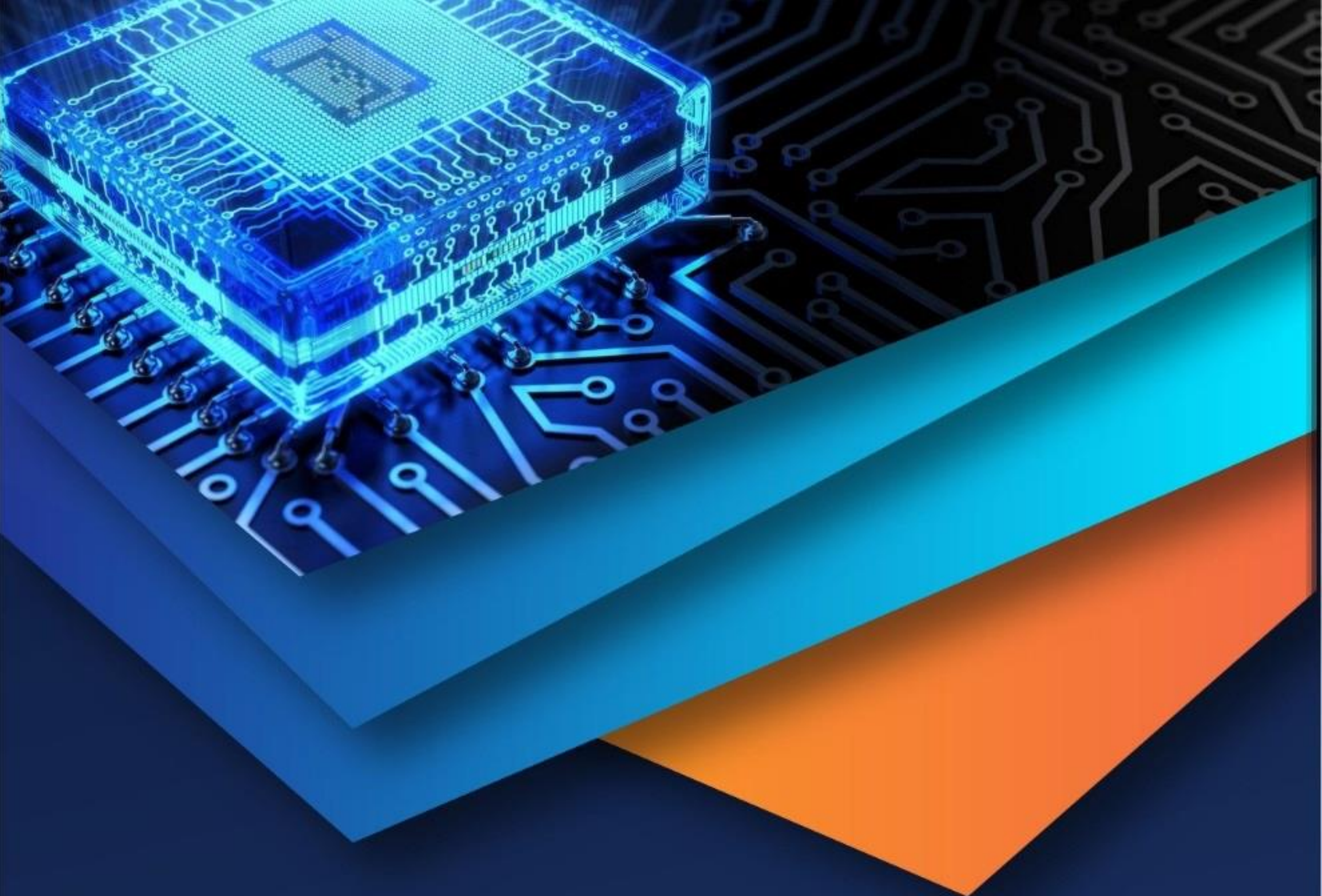



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