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# Numerical Study on Seismic Behaviour of Stiffened Steel Plate Shear Wall

Rahul Bhoite[1]
[1]M.E (Structure) Student,
Department of Civil Engineering,
JSPM's Rajarshi Shahu College of Engineering,
Tathawade, Pune-411033, India

Seema Patil[2]
[2]Assistant Professor,
Department of Civil Engineering,
JSPM's Rajarshi Shahu College of Engineering,
Tathawade, Pune-411033, India

Nilima Pote[3]
[3]Assistant Professor,
Department of Civil Engineering,
JSPM's Rajarshi Shahu College of Engineering,
Tathawade, Pune-411033, India

***Abstract*— Any structure can be analyzed for vertical down-ward gravity load due to imposed & service load as well as lateral load due to earthquake and wind load. In the last four decades, attention has been paid to Steel Plate Shear Walls (SPSW) as means of resisting earthquake and wind forces in buildings, and especially in high-rise buildings. Aim of this work to study the influence of regularly planed steel plate and to adding various pattern of channel-shaped stiffeners on the seismic behaviour of steel plate shear walls (SPSWs). This dissertation aims at developing an understanding of dynamic analysis & response spectrum solution for structural process plant building having steel plate share wall in different four condition 1) Plane Steel Plate Shear Wall 2) Diagonally Stiffened Steel Plate Shear Wall 3) Horizontally Stiffened Steel Plate Shear wall 4) Vertically Stiffened Steel Plate Shear wall. Process plant structure, are important for the continues operation of any industrial process system in event of earthquakes. The analytical results show that the Stiffened steel plate shear wall deformation rotation and lesser developed yield stress compeer to plane steel plate. The main object of this paper is–1) To study behaviour of the structure to provided Plane steel plate shear wall (SPSW) under the action of lateral load due to seismic load on structure. 2) To study behaviour of SPSW with different method of placements of stiffener that is horizontal, vertically and diagonal. 3) To compare the analysis result of SPSW with conventional bracing system in economical point of view.**

***Keywords: Shear Walls, stiffener, response spectrum.***

## I. INTRODUCTION

A steel plate shear wall (SPSW) system is a type of lateral force resistant structure that comprises infill plates and boundary elements. SPSWs provide quick installation and it is easy to standardize production. Five story industrial structure was a diagonally, horizontal, vertical channel stiffened SPSW. In this project, the structural model is done in STAADpro software. The study parameter are maximum Displacement of structure, Torsion or Rotation, Max Shear, Max Bending moment and Von Mis Stresses in plate and Base shear and study the stiffening pattern for lateral resistance of seismic forces.

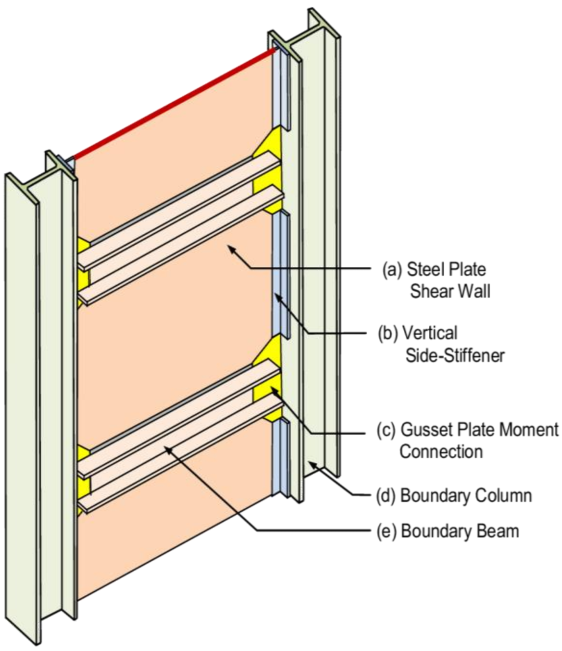


Fig. 1 Stiffener Steel Plate Shear Wall.

### *A. Aim and Objective*

Aim and Objectives of study behavior of the structure to provided Plane steel shear wall SPSW under the action of lateral load due to seismic load on structure and compare the analysis result of SPSW with conventional bracing system. Study behavior of SPSW with different method of placements of stiffener that is horizontal, vertically and diagonally.

### *B. Need of the work*

It will help structural designer in future to provide more options other than traditionally used structural member bracing, plane SPSW etc. For high seismivity zone and industrial structure SPSW to control displacement and to provide great shear strength and ductility to structure subjected to lateral load as well as to provide economical solution. Due to improve aesthetic appearance of structure.

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## II. PROBLEM STATEMENT

### *A. General*

Analysis design of six story industrial process plant in Staad connect soft ware, whose major equipment are rest on First floor and minor equipment are rest on particular floor as shown in various floor plans. In this paper. To study behaviour of SPSW with different method of placements of stiffener that is horizontal, vertically and diagonal. Elevation of Structure is shown in figure 2.

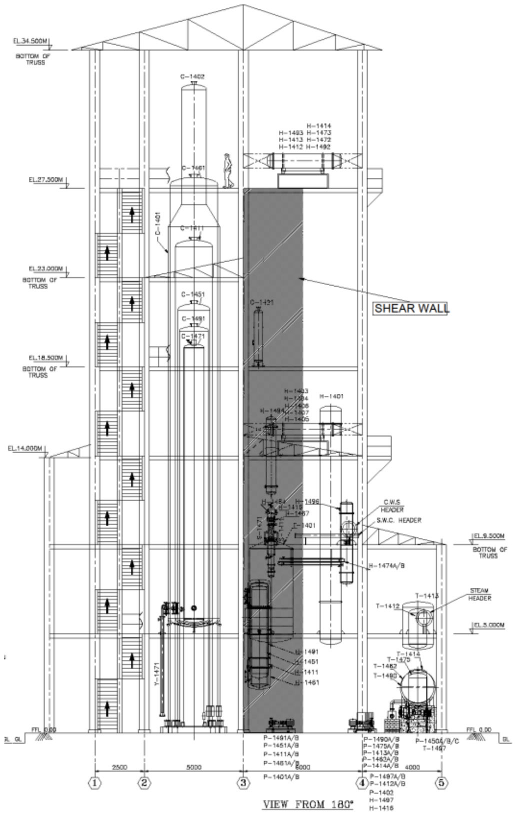
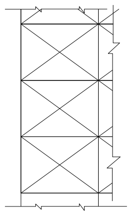
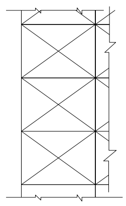



Fig. 2. Front Elevation of Structure

### *B. Following are the Six models proposed for study.*

Model -1 with vertical bracing system. As shown in below fig 3.a.





a. Model- 1 b. Model- 6

Fig.3 Structure with Conventional bracing system

c a. Model-2 b. Model-3 c. Model-4 d. Model-.5
Fig.4 Steel Plate Shear Wall System

Model -2 with Plane Steel Plate Shear Wall. as shown in fig. 4.a.

Model -3 with Horizontally Stiffened Steel Plate Shear wall. as shown in fig. 4.b.

Model-4 with Vertically Stiffened Steel Plate Shear wall as shown in fig. 4.c.

Model-5 with Diagonally Stiffened Steel Plate Shear Wall. as shown in fig. 4.d.

Model-6 with vertical bracing system using Same Structural member size for Various Pattern of SPSW system. as shown in fig. 3.b.

### *C. Modeling Methods*

The SPSW's are typically designed using one of two methods, the Strip Member Analysis Model and the Orthotropic Plate Model. We use orthotropic plate model method with software was STAAD Pro v8i. These modeling methods were used to determine the forces and deflection in the SPSW analysis.

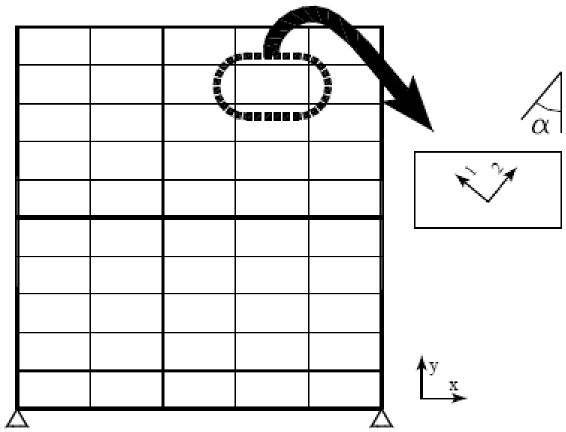



Fig.5. Typical Orthotropic Membrane Model

The orthotropic plate models were analysis using STAAD Pro Connect and the procedures detailed in Design Guide 20.

### *D. Analysis*

Industrial Distillation plant structure is structural steel frame is of 19mx18m rectangular dimension. Structure is Ground+6 story and depth of foundation is 2.5 m below floor finish level. Structure is modelled in STAAD Connect 2018 and analysis and design is done considering earthquake. Earthquake analysis is done by Response Spectrum method.

Six different model are proposed for analysis and study. Dead, Live and Equipment Load Calculations and apply on structure.

- **Design Data:** Steel Grade: Fe 500, Structural Steel Fy 250, Soil strata: Medium, Density of structural Steel : 78.5 kN/m3, Live load: 3 or 2.5 kN/m$^2$, Height of Process plant 34.5 m (above ground level), and founding depth is 2.5m(below ground level), Floor interval 4.5 m each and SPSW thickness: 4mm

- **Wind Load Data:** As per considered location and as per IS 875 (Part III).Design wind Pressure Pz =1.0 KN/m2
- **Seismic Load Data:** Seismic load as per IS1893-2002 part-1 and part-4 and Parameter considered. Use Response Spectrum method for analysis. Nodes are very closely than CSM method is use. The structure was excited by response spectrum in X-direction and Z-direction. As per IS 1893 response spectrum is used otherwise the real data.

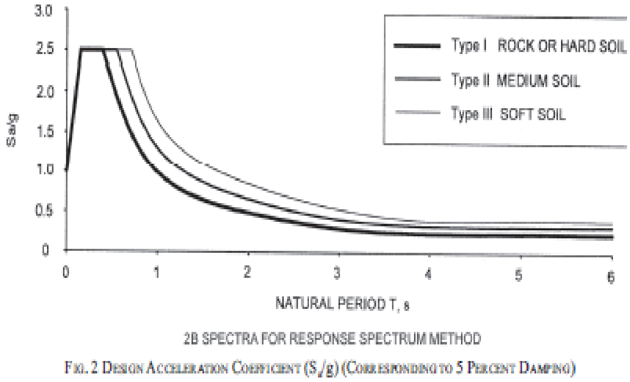



Fig. 6 Design acceleration Coefficient (Sa/g) Vs Natural time

TABLE I. Basic Load Combination

| SR. No | LOAD COMBINATIONS |
|---|---|
| 1 | 1.5( DL + LL ) |
| 2 | 1.2( DL + LL ± EQ) |
| 3 | 1.5(DL ± EQ ) |
| 4 | 0.9DL ± 1.5EQ |

### *E. Analysis/Design Iteration*

The preferred method is the orthotropic plate method due to its quick iteration process. The process plant for Five different model are proposed for analysis and study. At time of design each modes Iterate as per satisfying member sizes and to complied codes requirements.

## III. RESULT AND DISCUSSION

The results obtained from the analysis are taken into consideration based on the aim of the research as follow. Result are obtained from the analysis for parameter displacement, torsion, base shear, SPSW wall plate stresses, and weight of required for each system and its economic.

### *A. Displacement*

Over all Displacement of node of various cases are Calculated on software Soil

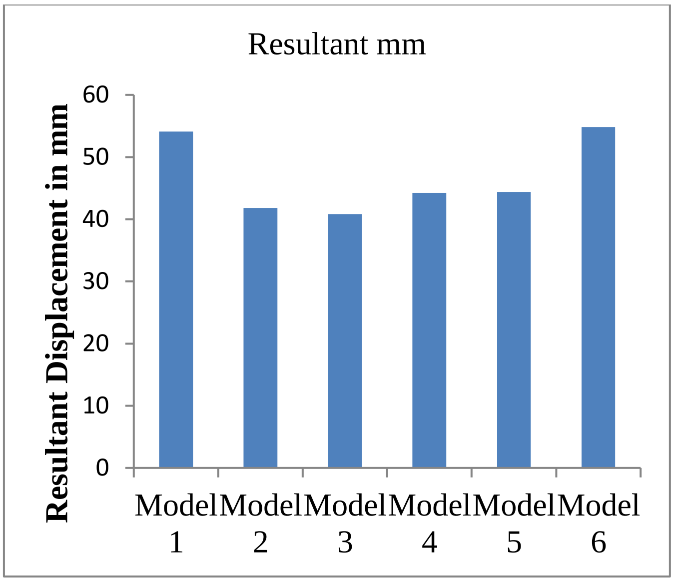



Fig. 7 Graph for Resultant Displacement in mm

### *B. Torsion (Rotation)*

Over all Torsion of node of various cases are Calculated on software and its Result as shown in below graph.

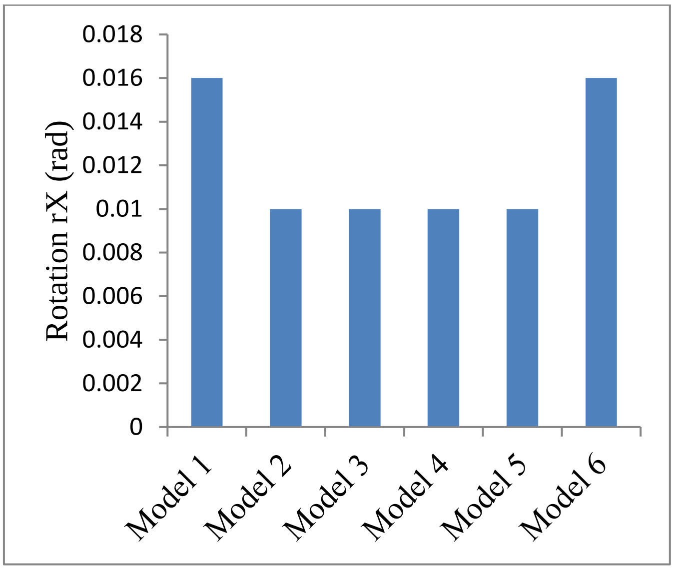



Fig. 8 Graph for Rotation rX (rad)

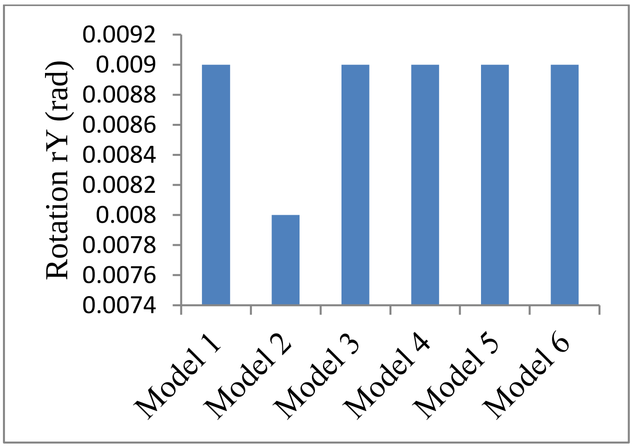



Fig. 9 Graph for Rotation rY (rad)

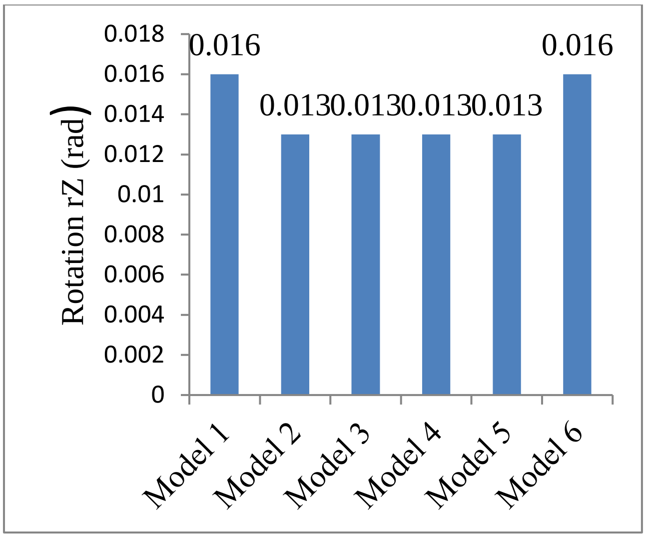



Fig. 10 Graph for Rotation rZ (rad)

### C. Base Shear

Finding result from software Base shear verses percentage participation factor and Pick story shear verses story.

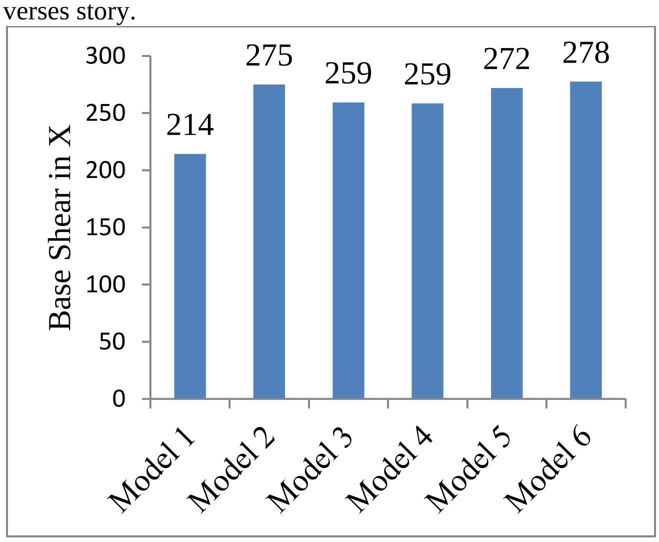



Fig. 11 Graph for Base Shear in X Direction

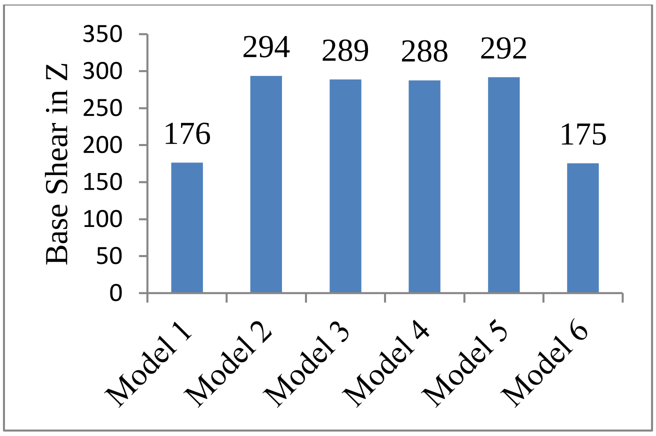



Fig. 12 Graph for Base Shear in Z Direction

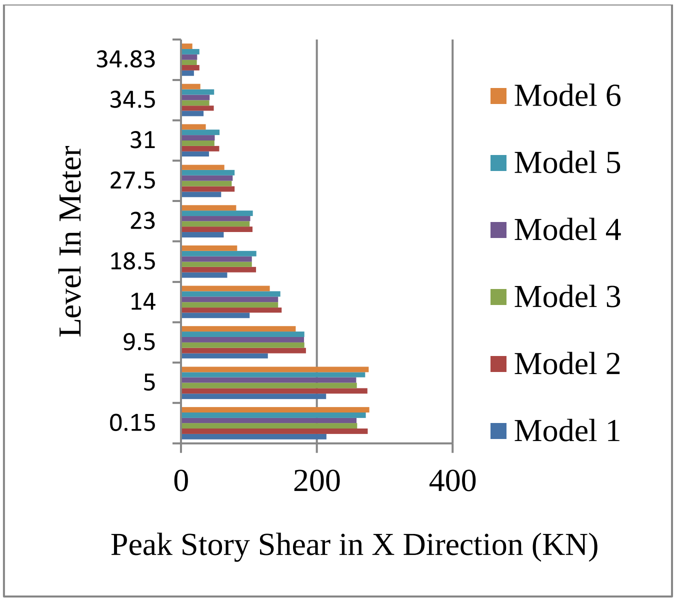



Fig.13 Graph for Peak Story Shear in X Direction (KN)

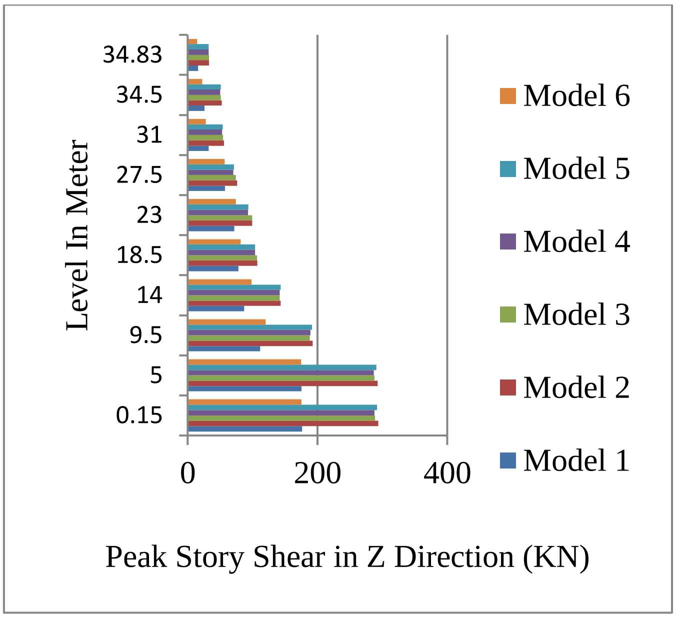



Fig. 14 Graph for Peak Story Shear in Z Direction (KN)

### D. SPSW Plate Shear Stress and Bending moment Result

Shear Stress and Bending moment Result of SPSW cases Model-2 to Model-5 are given from analysis software and as per software out-put studded seismic cases only.

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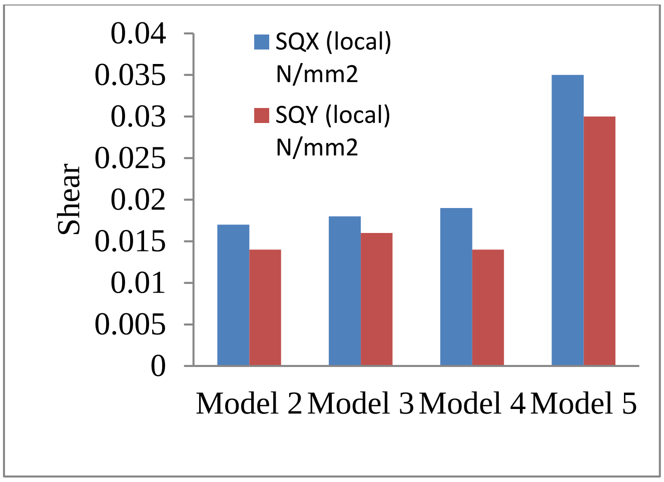


Fig. 15 Shear in X & Y Direction

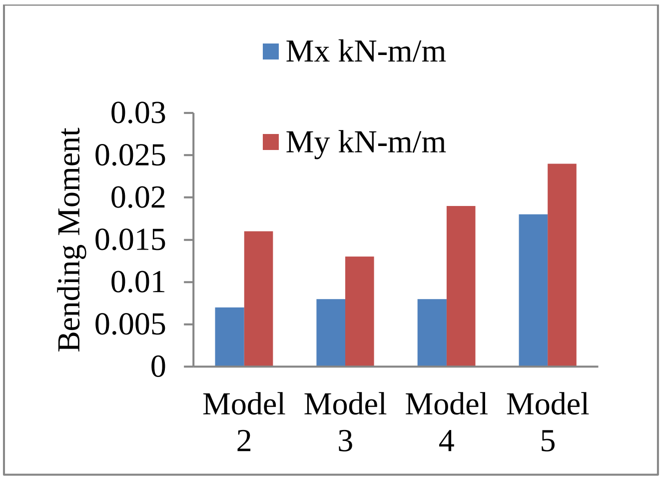


Fig. 16 Graph Bending Moment in X & Y Direction

### *E. Principal, Von Mis and Tresca Stresses in plate*

Maximum yield stress check by checking Principal, Von Mis and Tresca Stresses in plate. In general practice von Mis stress are check for steel material yield stress. Result are find out from all four SPSW cases out-put studded seismic load only.

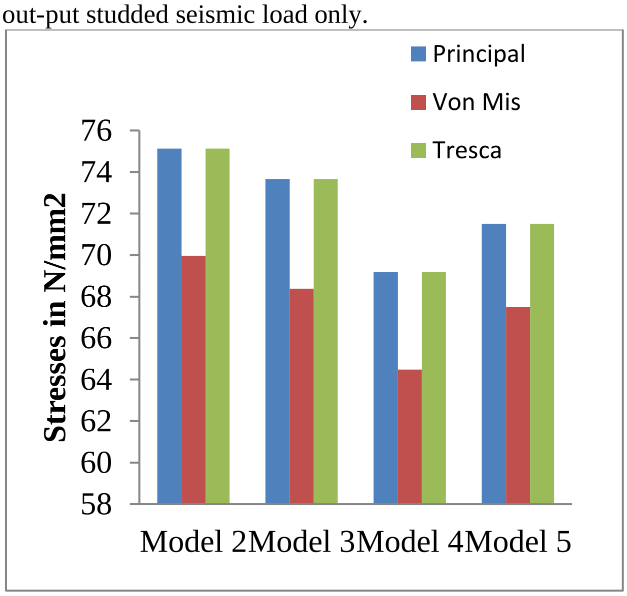


Fig. 17 Graph Principal, Von Mis and Tresca Stresses ( N/mm2)

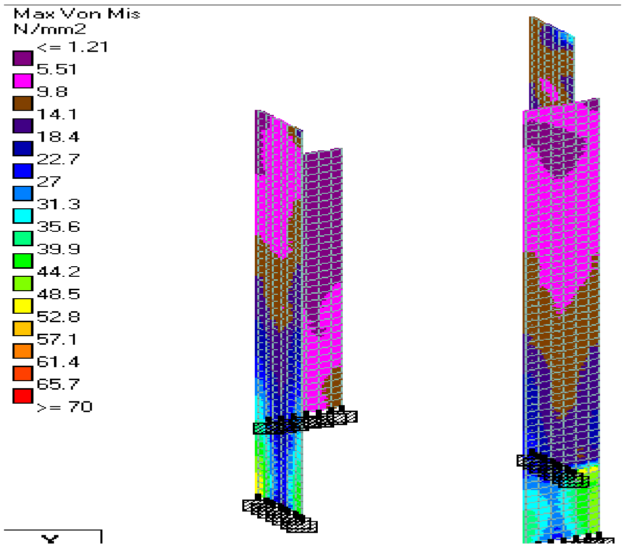


Fig.18 Von Mis Stress Model-2

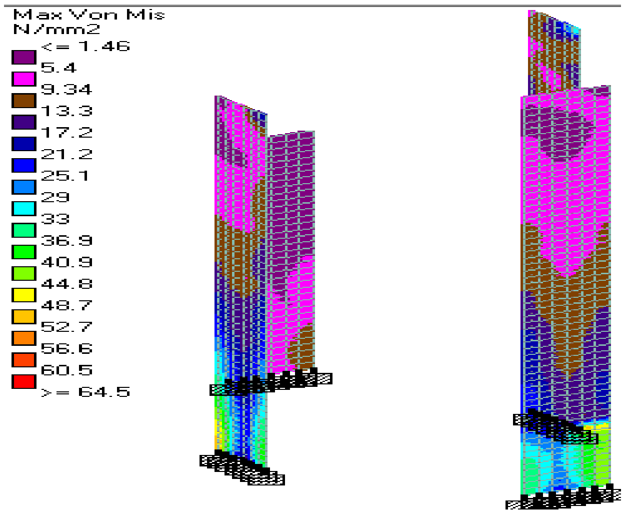


Fig.19 Von Mis Stress Model-4

### *F. Structural Steel Required for Conventional bracing system and all SPSW system*

This requirement of structural steel is majorly compeering only Conventional bracing system and General SPSW system refer fig. 20. But don't conclude the plane SPSW and Stiffened SPSW system because we assigning same member for all Stiffened SPSW system for study purpose. In that case we study utilization ratio only.

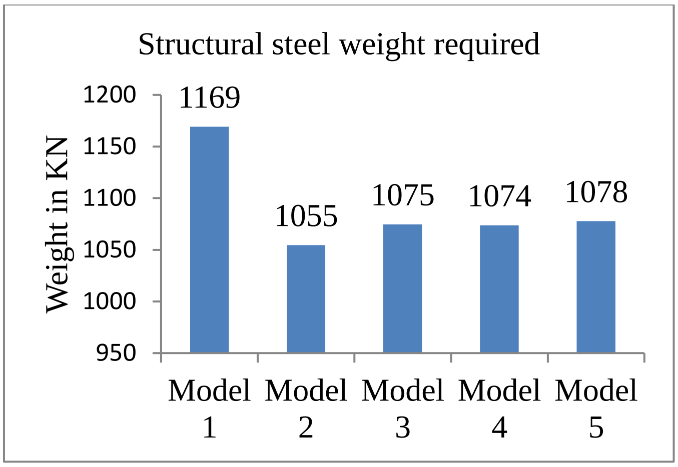


Fig.20 Graph Structural steel consumption verses STAAD model type.

## IV. CONCLUSION

Based on the results and discussion following conclusions are drawn.

1. Displacement and Tensional in conventional brace system is greater than other SPSW system. In SPAW system vertical and diagonal pattern system displacement is greater than horizontal. SPSW system tensional effect is nearly same to all cases.
2. Base shear resistance of conventional system is lesser than all SPSW system and in SPSW system diagonal system base shear and Pick story shear caring is quit higher than other SPSW system.
3. Due to diagonal stiffener shear stress is increased in plate and horizontal stiffener pattern is less shear stress is observed as well as in vertical and plane geometry, hence diagonal brace system.
4. Bending moment and Von Mis stress greater developed in diagonal SPSW system compare to other SPSW system and in horizontal stiffener pattern system is lesser than all other SPSW system.
5. SPSW Stiffen System is economical than Conventional bracing system and utilization ration of structural member in SPSW Stiffen System is lesser than Conventional bracing system.

as per above result and discussion SPSW system is good result than conventional bracing system.

### *Scope of Future Work*

From the results of this study, following can be the future scope: Existing plant structure is selected seismic zone is in third zone due to existing plant structure is selected and comparing the conventional and SPSW stiffening system in economy point of view. It is necessary to further analyze and study the structure for high seismic zone for Better clarity and result for comparison of SPSW pattern system. In SPSW system, there is another scope is different shape of stiffener and different materials property used and further analyzes and study as well as changing position of shear wall and study.

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