Influence of SPSW on Steel Framed Multistorey Building

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Abstract- *For a structure to avoid maximum damage during Earthquake, it should own or possess adequate strength, stability and sufficient ductility. A multi-story structure should assimilate Wind and Earthquake loads by a Lateral force resistant system. The several different Lateral force resisting systems are Shear Walls, Braced system, Moment Resisting Frame(MRF) and Tubular system. For most recent decades there is worldwide interest has grown for the SPSWs(Steel Plate Shear Walls) application to buildings as Lateral load resistant system. Consequently the present review depicts the investigation of multistorey steel frame building with and without Steel Plate Shear Walls(SPSW) and X-type bracing system. The project aim is to analyse steel framed structure by using Steel Plate Shear Walls(SPSWs) and X-bracing at various desired locations for same geometry and loading. In present study work the analysis of steel moment resisting building frame(SMRF) having G+7 story situated in Zone-5 is carried away by Equivalent Static and Response Spectrum Analysis. The software ETABs 2015 is used for the analysis purpose. Modeling of SPSWs(Steel Plate Shear Walls) model is done as Strip and Mesh modeling. To assess the seismic performance of the buildings the primary parameter considered are Displacement, Storey Drift and Base Shear. For the purpose of analysis of models IS1893:2002 and IS800:2007 is used.*

Keywords- Steel Plate Shear Wall(SPSW), Bare Framed Model, SPSW Mesh Framed Model, SPSW Strip Framed Model.

I. INTRODUCTION

1.1 GENERAL

Shear walls are constructed to oppose lateral loads acting on structures, since they carry large earthquake forces and have capacity to oppose large overturning effects. Shear walls opposes the horizontal forces by acting as vertical elements. The concept behind shear wall is that progression of plane walls that is idealized as vertical cantilevers supported at the base of structure. In a multi-storey building series of shear walls typically forms a core surrounding the central service area.

The steel possess some vital physical properties like high stregnth per unit weight and ductiility in comparison with RCC. The slender sections of steel are because of its high yield and ultimate strength. Due to ductile behavior of steel, structures notify its failure by means of immoderate deformation.

SPSW is one of the lateral load resistant system which comprises of vertical steel plate infill associated with the beams and columns of its encompassing /surrounding and are installed to the full height of building/structure in one or more bays. The periphery/boundary columns and SPSW combined act as Vertical Plate Girder(VPG). The SPSW act as web and columns as flange of vertical plate girder, whereas beams act or work as transverse stiffeners.

Several, recent researches have verified that Steel plate shear wall(SPSW) can act as effective and economic seismic load resisting system in high risk seismic zone. Since Steel Plate Shear Wall(SPSW) posse's high elastic stiffness, large displacement ductility, high energy dissipate capacity and stable hysteretic behavior.

Here in the present study, a hypothetical multistoried (G+7) steel frame building with and without Steel Plate Shear Walls(SPSWs) and with X-type bracing system situated in Zone-V of medium soil is analyzed as per load combinations given in code by Equivalent Static and Response Spectrum Analysis.

1.2 MODELLING METHOD OF SPSW

1.2.1 Mesh Modelling:

In ETABs 2015 after the plate is assigned at desired location, then provide the wall auto mesh to the assigned plate by selecting a bay or panel of particular storey or to its full height, adopt smaller sections instead of bigger for accurate result. The mesh size of 0.5X0.5 is adopted.

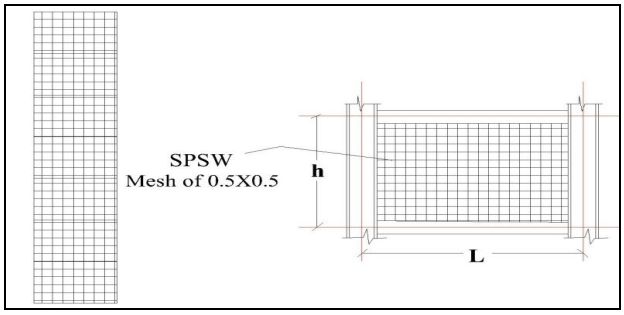


Fig.1.1 Mesh Frame SPSW-Model

1.2.2 Strip Modelling:

It is just on the basis of diagonal tension field action developed instantly after the clasping or buckling of plate. In the analysis programming software ETABs 2015, steel plate in the wall panel of bay is replaced by the strips of plate along the tension field. In single wall panel at least 10 strips should be provided. Thickness of the strips is maintain as same as of plate. The width of each strip should be equal to center to center spacing between consecutive strips. The strips are inclined with horizontal at 45 degree angle. The ends of the each strips connected to beams & columns of the panel are pinned. Also the beams-columns connection of that panel is kept pinned.

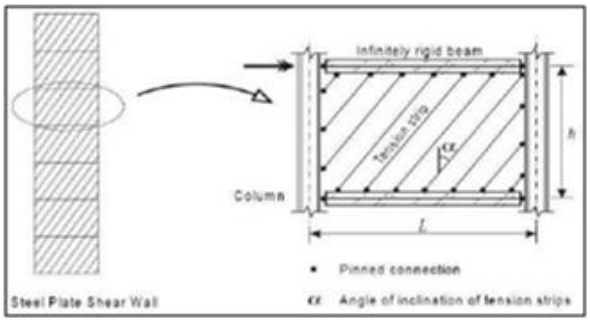


Fig.1.2 Strip Frame SPSW-Model

1.3 ANALYSIS METHOD

According to IS 1893:2002 following method of analysis have been recommended to find out the design lateral loads,

a. Equivalent Static Method
b. Response Spectrum Method

1.3.1 Seismic Analysis Using IS 1893 (Part 1): 2002:

Load Factor: For the design of steel building conforming to IS1893:2002 below listed load-combinations are mentioned.

1) 1.7DL+1.7LL
2) 1.7DL+1.7EQX
3) 1.7DL-1.7EQX
4) 1.7DL+1.7EQY
5) 1.7DL-1.7EQY
6) 1.3DL+1.3LL+1.3EQX
7) 1.3DL+1.3LL-1.3EQX
8) 1.3DL+1.3LL+1.3EQY
9) 1.3DL+1.3LL-1.3EQY

II. LITERATURE REVIEW

R. S. Londhe and A.P Chavan(2010) in their study i.e., "Behavior of Building Frames with Steel Plate Shear Walls" has done the investigation analyses of high rise steel frames buildings with SPSWs(Steel Plate Shear Walls) using finite element analysis(FEA) programme SAP2000. The variable of his analysis study with SPSWs(Steel Plate Shear Walls) was thickness of plate (5mm to10mm) and aspect ratio (0.833 to 1.667width to height ratio). He observed from obtained results that bending moment in beams were reduced with the use of (SPSW)Steel Plate Shear Walls, and with increase in thickness of Shear Wall observed minimum effect on Bending Moment and Shear Force of beams and also found small reduction in deflections. Whereas it is also found there is increment in storey drift as increase in aspect ratio.

Ms. Deepika C. Hiwrale and Prof. P. S. Pajgade(2012) in their study "Analysis and Design of steel framed buildings with and without Steel Plate Shear Walls" has carried out the investigation analyses of high rise steel buildings frame with and, without SPSWs by Equivalent Static Analysis for (G+6) story steel moment resisting building frame situated in Zone- III . Strip modeling method, is adopted for modeling using STAAD PRO V8i SELECT series II software. The parameters like bending moment, shear force, deflection, and axial force are considered to assess the seismic performance/behavior. At last concluded that under earthquake excitations there is large affect on performance/behavior of frames with the use of (SPSWs)Steel Plate Shear Walls. Generally, the structure stiffness increases with use of infill steel plate. Deflection is extremely less in SPSWs frame. The bending moment in columns and total steel weight in structure/building were reduced with the application of SPSWs.

Pundkar R.S and Alandkar P.M(2013) study's "Influence of Steel Plate Shear Wall on Multistorey Steel Building". In this study, they considered and analyzed 4 models of different SPSW position of same loading and same geometry, and had found out the ideal location of SPSW by contrasting the results of all 4 models with each other. The

ideal located SPSW model is then contrasted with different lateral load resisting systems like Moment Resisting Frame(MRF) and X-braced framed steel structure of same geometry and, of same loading. The models were analyzed by software SAP2000 V15 and the analysis method is response spectrum analysis. To compare/assess the seismic performances the parameters considered is only deflection and had concluded that deflection of SPSW building model is less as compared to Moment Resisting Frame(MRF), X-braced framed building. Steel building, with SPSWs(Steel Plate Shear Walls) found to be economical since the total weight of building is decreased and SPSW occupy considerably much less space.

Ugale Ashish B and Raut Harshalata R(2014) studied "Effect of Steel Plate Shear Wall on Behavior of Structure" has made (ES)Equivalent Static analysis of (G+6)steel moment resisting building frame storey sited in Zone-III. The analyses of SPSWs building was carried by Software STAAD PRO. The main parametric aspect studied was to compare, seismic performance of buildings such as Bending moment, Deflection, Shear Force and Axial force, given more attention on the impacts comes on steel structure with and, without shear wall & concluded that (SPSWs)steel plate shear walls have a large effect on the performances/behavior of frames under seismic/earthquake excitation. In general steel plate expand stiffness of structure, deflection in exclusive of SPSWs is large as when contrasted with SPSW structure. With the employ of SPSW the Bending Moments in, the column were reduced. Due to existence of SPSW, total steel weight in building was decreased than building exclusive of SPSWs. Hence steel structure with SPSWs(Steel Plate Shear Walls) is efficient and economical compare to exclusive of SPSWs.

Mohammed Abdul Rizwan and Tejas D.Doshi (2015) in their study "Seismic Behavior of SPSW Steel Framed Buildings" portrays the investigation and design of steel frame building with (SPSW)Steel Plate Shear Wall. They had adopted the Equivalent Static(ES)analysis and Response Spectrum(RS) analysis method for the analysis of steel moment resisting building frame situated in Zone- III having (G+6) storey. Both mesh & strip modeling is conducted using STAAD.Pro V8i software. The major parameters considered to assess the seismic performnces are Axial Force(AF), Displacement, Bending Moment(BM) and Maximum Stresses. To the end concluded that in the case of SPSW mesh frame, the displacement, stresses, axial force and bending moments are less as compared to SPSW strip frame. Hence SPSW mesh frame is favoured over SPSW strip frame.

III. ANALYTICAL MODELLING

Model 1: The structure is 7 storied steel framed building. It is modeled as "Bare Framed".
Model 2: The structure is 7 storied steel framed building. It is modeled as "SPSW Mesh Framed". In this model the SPSW is provided at centre along the four side of building.
Model 3: The structure is 7 storied steel framed building. It is modeled as "SPSW Mesh Framed". In this model the SPSW is provided at the corners of building as L-Shape.
Model 4: The structure is 7 storied steel framed building. It is modeled as "SPSW Mesh Framed". In this model the SPSW is provided at the core of building.
Model 5: The structure is 7 storied steel framed building. It is modeled as "SPSW Strip Framed". In this model the SPSW is provided at centre along the four side of building.
Model 6: The structure is 7 storied steel framed building. It is modeled as "SPSW Strip Framed". In this model the SPSW is provided at the corners of building as L-Shape.
Model 7: The structure is 7 storied steel framed building. It is modeled as "SPSW Strip Framed". In this model the SPSW is provided at the core of building.
Model 8: The structure is 7 storied steel framed building. It is modeled as "X-Braced Frame". In this model, X-Bracing is provided at centre along the four side of building.
Model 9: The structure is 7 storied steel framed building. It is modeled as "X-Braced Frame". In this model, X-Bracing is provided at the corners of building as L-Shape.
Model 10: The structure is 7 storied steel framed building. It is modeled as "X-Braced Frame". In this model, X-Bracing is provided at the core of building.

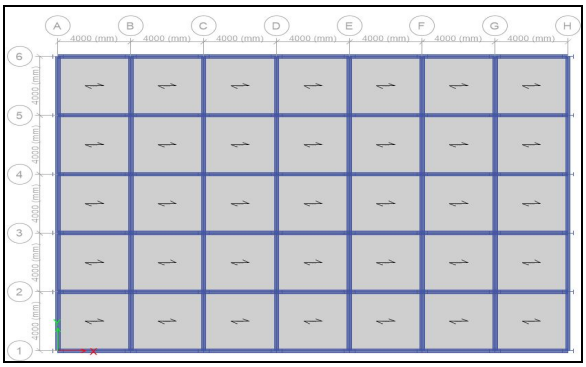


Fig. 3.1 Plan of G+7 storey Steel Building

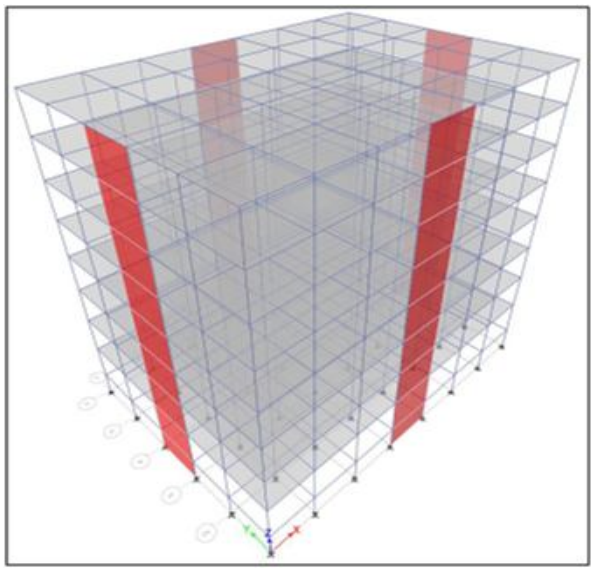


Fig.3.2. 3D-View of Mesh Framed SPSW Model

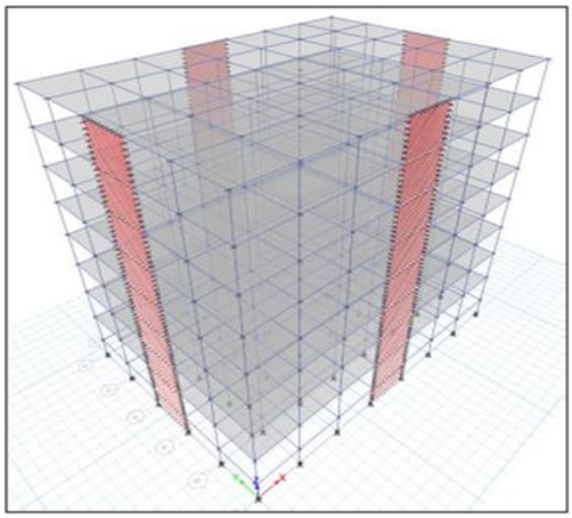


Fig.3.3. 3D-View of Strip Framed SPSW Model

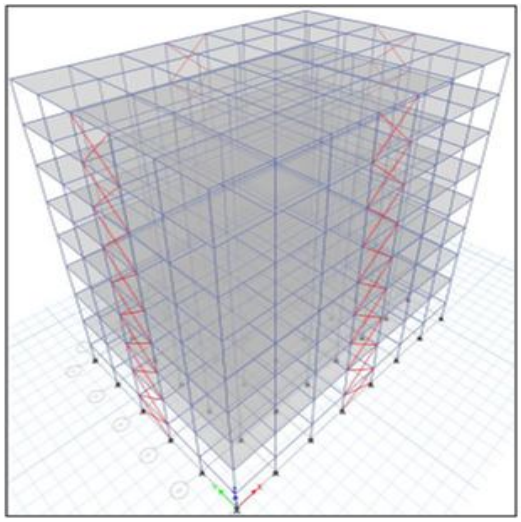


Fig.3.4. 3D-View of X-Braced Frame Model

3.1 Design Data

The building considered having G+7 stories. Height of each storey is 3.2 m. The building has plan dimensions 28mX20m. It is considered that building is located in seismic zone-V. Thickness of slab is 155mm. Live load intensity is taken as 4 kN/m2. Weight of floor finish is considered as 1 kN/m2. Type of soil is Medium soil. Thickness of wall is 230 mm. Shear wall(Plate) thickness is 10mm. Width of strips is 400mm. Angle of inclination of strips with horizontal(α) 45^0. Beam size ISHB 300-1 and Column size ISWB 600-2.

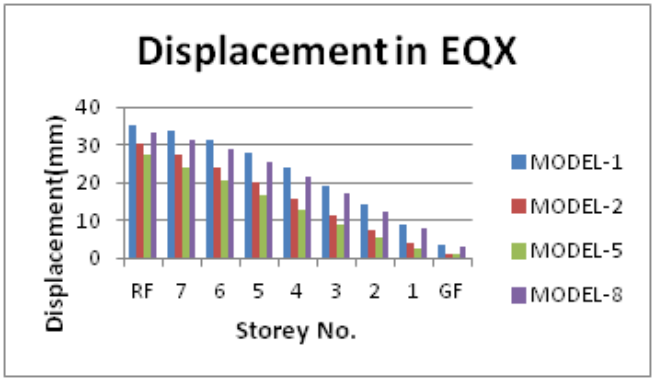
IV. RESULTS & DISCUSSION

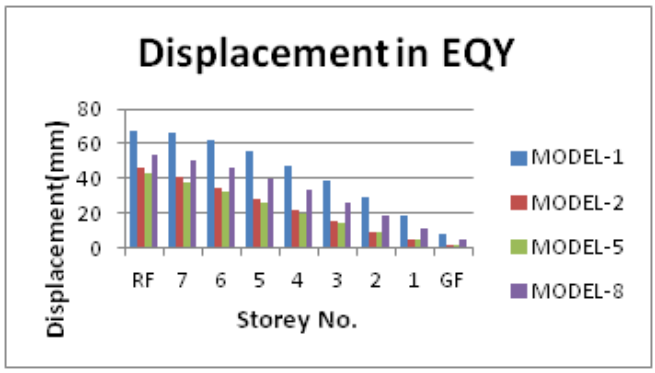
The results, Lateral Displacements, Storey Drifts and Base Shear for the distinctive building models for Equivalent Static & Response Spectrum analyses obtained are shown with the help of graphs.

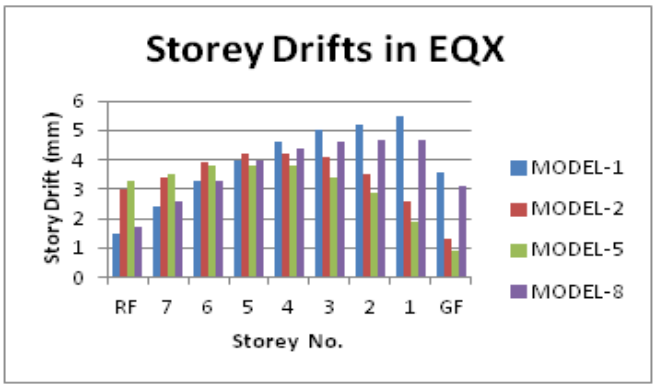
4.1 Lateral Displacement:

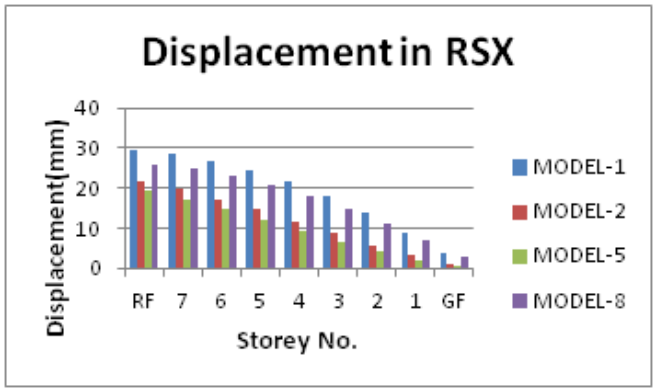
On comparing the displacement results of analytical models, the lateral displacement in SPSW (Steel Plate Shear Wall) Strip Model is observed to be less as compared to SPSW (Steel Plate Shear Wall) Mesh Model and X- Braced Model at all different position in building.

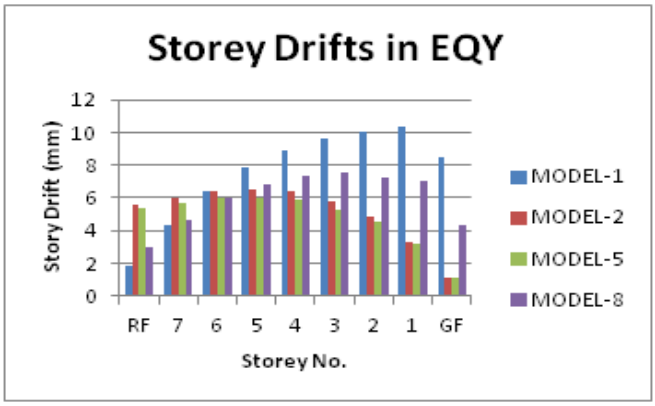
Below charts represents the displacement results of analytical models 1,2,5,8, where the SPSW & X-Brace is located at centre along four side of building as shown in fig. 3.2; 3.3; 3.4.

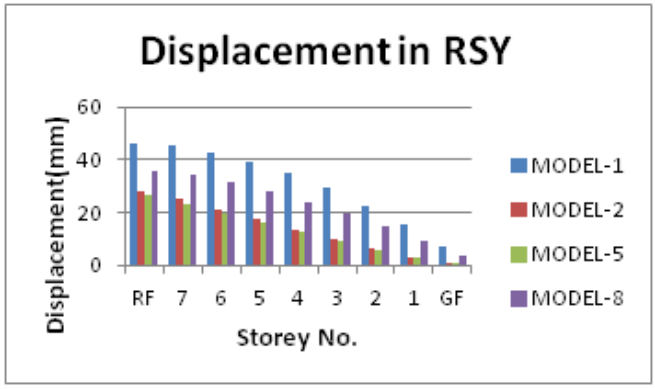


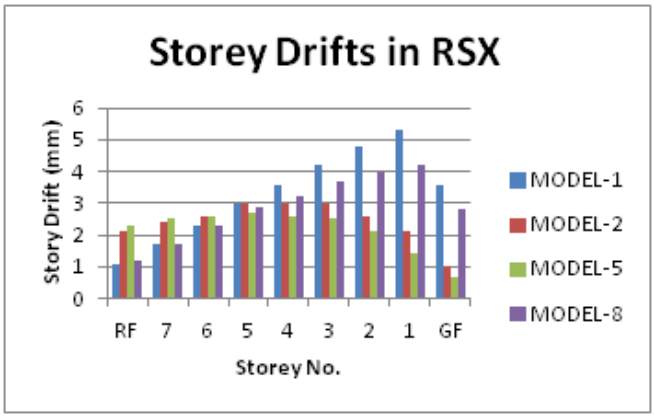








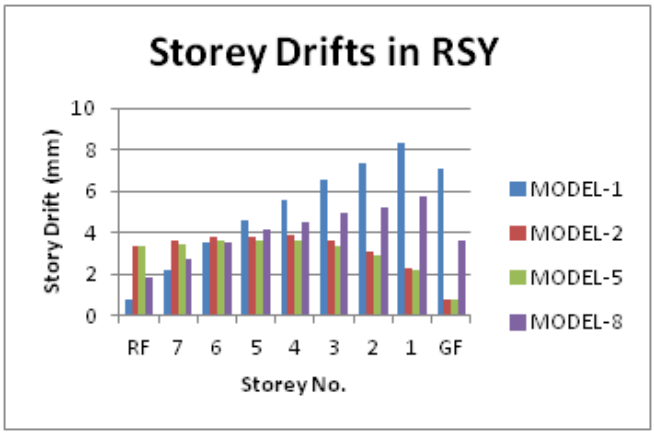




4.2 Storey Drifts:

Here also, on comparing the Storey Drifts results of analytical models, the Storey Drifts in SPSW (Steel Plate Shear Wall) Strip Model is observed to be less as compared to SPSW (Steel Plate Shear Wall) Mesh Model and X- Braced Model at all different position in building.

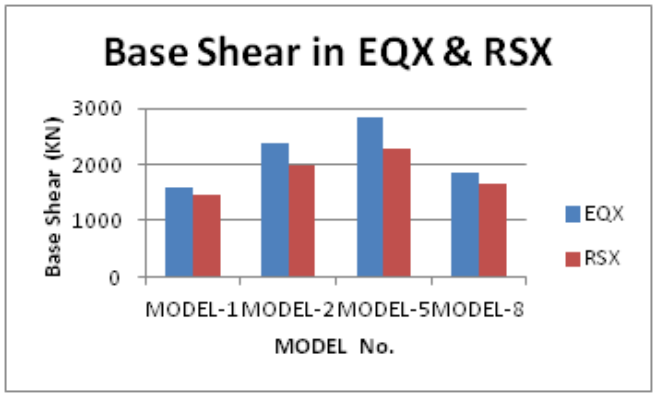
Below charts represents the Storey Drifts results of analytical models 1,2,5,8, where the SPSW & X-Brace is located at centre along four side of building as shown in fig. 3.2; 3.3; 3.4.

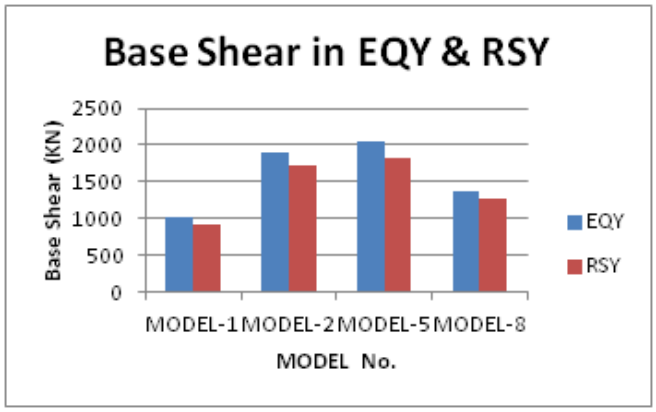


4.3 Base Shear:

Base Shear in case of Strip framed models is more as compared to Mesh Framed and X- Braced Framed Models.

Below charts represents the Base Shear results of analytical models 1,2,5,8, where the SPSW & X-Brace is located at centre along four side of building as shown in fig. 3.2; 3.3; 3.4.





V. CONCLUSION

- The work outcomes show that SPSWs(Steel Plate Shear Walls) has, an immense impact on the performnce of frames, under seismic excitation.
- Generally, the stiffness of structure is increased by Steel Plate.
- SPSW(Steel Plate Shear Wall) appreciably reduces the displacement in the structure.
- The Displacement in SPSW (Steel Plate Shear Wall) Strip Model is observed to be less as compared to SPSW (Steel Plate Shear Wall) Mesh Model and X- Braced Model at all different position in building.
- Also the Displacement among Strip Frame Models is observed to be less in MODEL-6, where the SPSW (Steel Plate Shear Wall) is located as L- Shape at corners.
- It is found that placing of SPSW (Steel Plate Shear Wall) in X- direction reduces displacement as compared to in Y- direction.
- As per code, IS 1893-2002(Part-1) Clause No. 7.11.1, the Storey drifts is within the limit in both Equivalent Static as well as Response Spectrum method. Maximum Drift Permitted = 0.004 x h = 0.004 x 3200 = 12.80 mm.
- Base Shear in case Strip frame models is more as compared to Mesh Framed and X- Braced Framed Models.
- Thus from above result, it is found that steel structure with “Steel Plate Shear Walls” is economical as compared with without SPSWs.
- As per architectural perspective, as compared to X-Braced moment resistig frame and RC Shear Walls, Steel Plate Shear Walls occupies less space because of its small thickness.

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