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Dynamic Performance of Curved Building with Steel Plate Shear Wall with and without Openings

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Abstract -*Steel plate shear walls are very efficient in resisting lateral force , particularly in cases of high rise buildings in seismic hazard areas. . This paper describes the analysis and design of high rise curved 4 storey building with curved steel plate shear wall (SPSW). The analysis and design of high rise curved 4 storey building is carried out using software ETABS* Ultimate 17.0.1.. *Arrangement of shear wall across a multistorey building is proposed in this paper. Openings in shear wall, storey displacement, storey drift, base shear and time period were discussed in this paper*

Key Words: Steel plate shear walls –high rise buildings- dynamic analysis - lateral loading – ETABS.

1. INTRODUCTION

Steel plate shear walls are an efficient and widely constructed lateral force resisting system, particularly in areas of high seismic hazard. High strength, ductility and initial stiffness at relatively low cost and short construction time are the primary motivations for the construction type. A typical SPSW consists of infill steel plates connected to the beams, known as the horizontal boundary elements (HBE); and to the columns, as the vertical boundary elements (VBE). A properly designed steel plate shear wall has superior ductility, high stiffness, and good energy absorption capacity. These characteristics make the shear wall more attractive in seismic prone regions. Steel plate shear walls are a lot lighter than the commonly used reinforced concrete shear walls, which considerably reduce the lateral forces. This factor significantly reduces the construction costs and makes the system attractive for application in rehabilitation as well as new projects.

In recent studies flat steel plate shear walls are designed and analysed to compute the performance of shear wall against lateral load mainly in seismic hazard areas. No studies were conducted to find the performance of curved shear wall against lateral load and also the effect of opening in shear wall in different stories and their performances by using the parameters like different stories, storey displacement, storey drift, base shear and time period.

In this study, the proposed 4-storey steel building considered for analysis. The model of 4-storey steel building were developed using the software ETABS Ultimate 17.0.1. Arrangement of shear wall in single bay and two bay of the building were discussed. In single bay shear wall arrangement the shear wall is provided on curvature end only. In two bay shear wall arrangement the shear wall is provided on the middle and curvature ends. The purpose of this study to understand the best arrangement of shear walls in curved buildings, effects openings in shear walls in different stories, storey displacement, storey drift, base shear and time period

2. STRUCTURAL MODELLING AND ANALYSIS

2.1 Multi Storey Curved Steel Building

A 4 storey curved steel building is considered in the analysis. The plan, elevation and modelling of the building is shown in figure 1, figure 2 and figure 3 respectively. Different floors of the building are labelled as 1– 4. The span length of SPSW istaken as 3m. The material used was steel with properties as mentioned, the Young's modulus of 2x105 N/mm^2, Poisson's ratio of 0.3 was used. The yield stress of infill plate 325MPa was selected less than that of frame members 385MPa to reduce the forces induced by infill plates on the HBEs and VBEs. The model was analyzed and checked with the guidelines mentioned in AISC 14 for steel frame design.

Table -1: Design sections of building frame

Design sections			
Storey level	Column (mm)	Beam (mm)	Plate (mm)
1	BOX 350 x 25	W8 x 58	3.10
2	BOX 350 x25	W8 x 58	2.75
3	BOX 300 x30	W8 x 58	2.10
4	BOX 300 x 20	W8 x 58	1.18

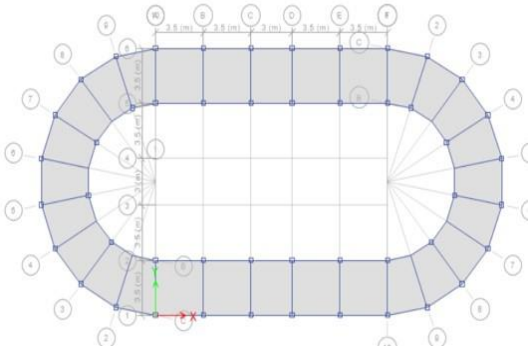

Fig -1: Plan layout of building

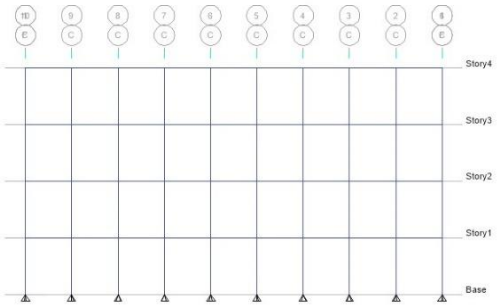

Fig -2: Elevation of building

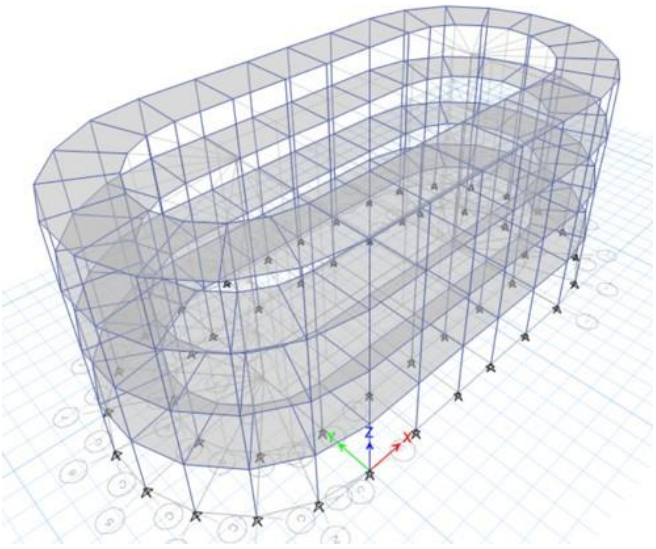

Fig -3: Model of building

2.2 Arrangement of SPSW

Shear walls are arranged in one and two bay of the curved building. In one bay arrangement the shear wall is provided in the middle of the curved surface of the building. In one bay shear wall arrangement, an opening is provided in each stories at a time to study the effect of opening at each storey level. In two bay shear wall arrangement shear wall is provided in the middle and at the side of the curved surface of the building.

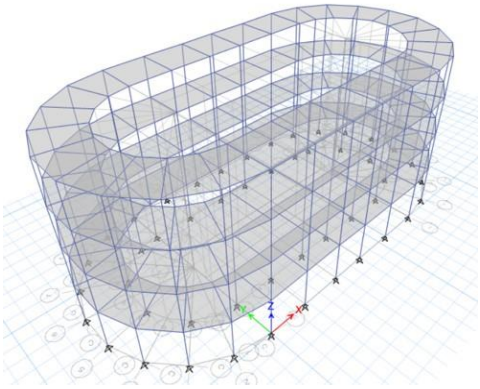

Fig - 4: Bare frame without SPSW

2.3 One bay SPSW

In one bay shear wall arrangement, SPSW is provided only on the middle of the curved surface of the building.

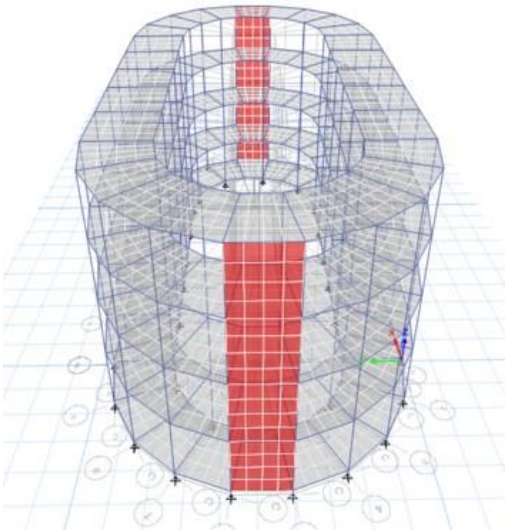

Fig -5: One bay SPSW without opening

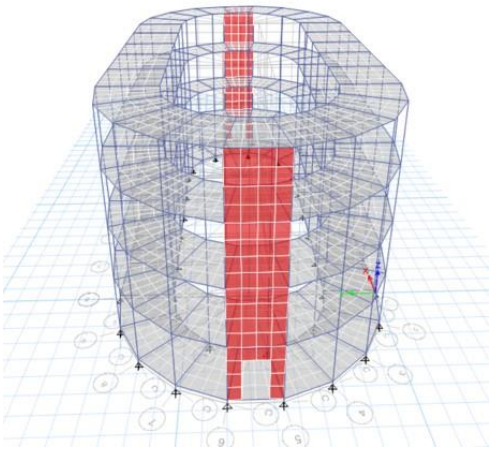

Fig -6: One bay SPSW with opening at storey 1

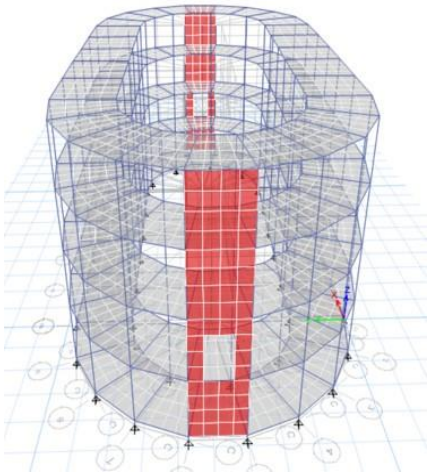

Fig -7: One bay SPSW with opening at storey 2

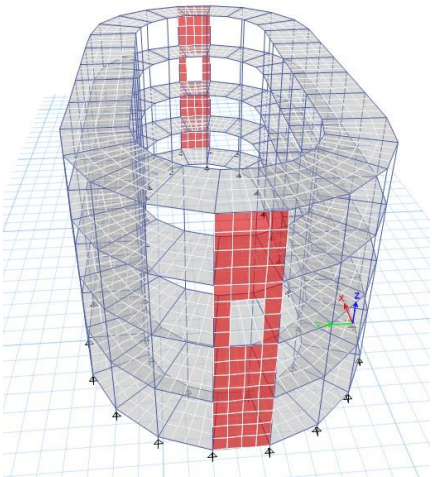

Fig -8: One bay SPSW with opening at storey 3

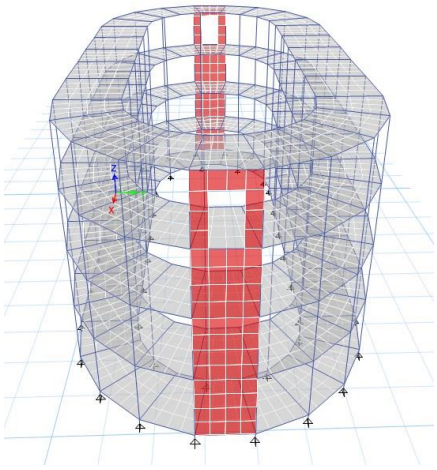

Fig -9: One bay SPSW with opening at storey 4

2.4 Two bay SPSW

In two bay shear wall arrangement, SPSW is provided on the middle and sides of the curved surface of the building.

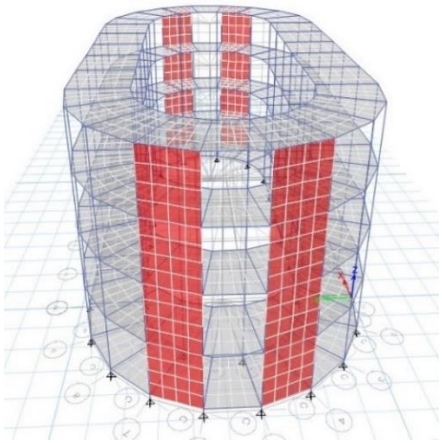

Fig -10: Two bay SPSW at middle without opening

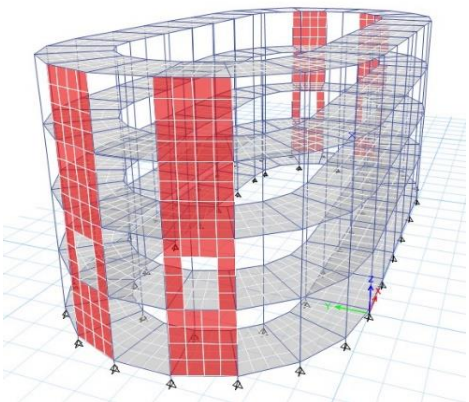

Fig -11: Two bay SPSW at middle with opening

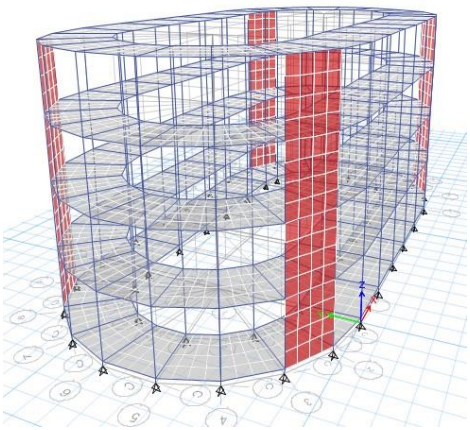

Fig -12: Two bay SPSW at side without opening

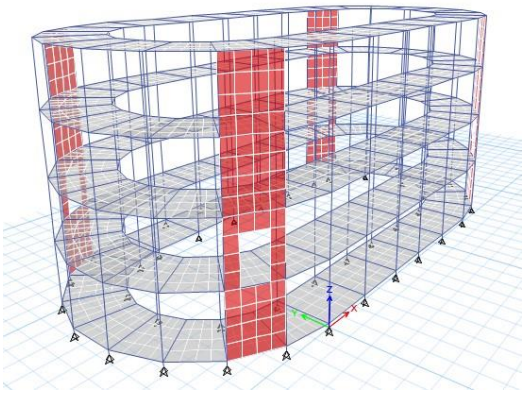

Fig -13: Two bay SPSW at side with opening

3. RESULTS AND DISCUSSIONS

The 4-storey building with SPSW and without SPSW were subjected to dynamic analysis. The results are obtained from the dynamic analysis of building models and compared for the parameters like storey displacement, storey drift, base shear and time period.

3.1 One bay SPSW

The 4-storey building with one bay SPSW were subjected to dynamic analysis. Six different models were subjected to dynamic analysis. The results are obtained from the dynamic analysis of building models and compared with six models for the parameters like storey displacement, storey drift, base shear and time period.

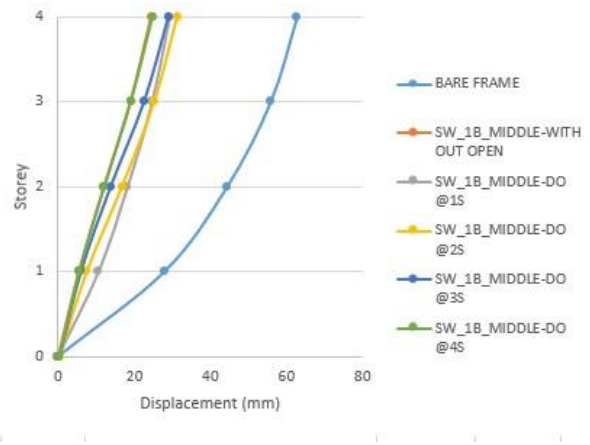

Chart -1: Displacement graph of one bay SPSW

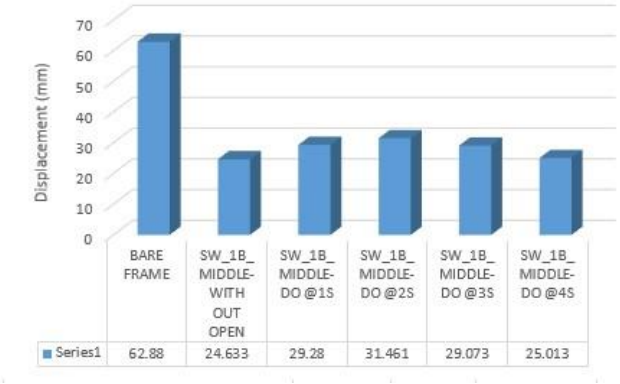

Chart -3: Displacement comparison of one bay SPSW with and without opening

By comparing results obtained from the six models it is found that bare frame has more displacement and one bay SPSW without opening at the middle of curved surface of building have less displacement.

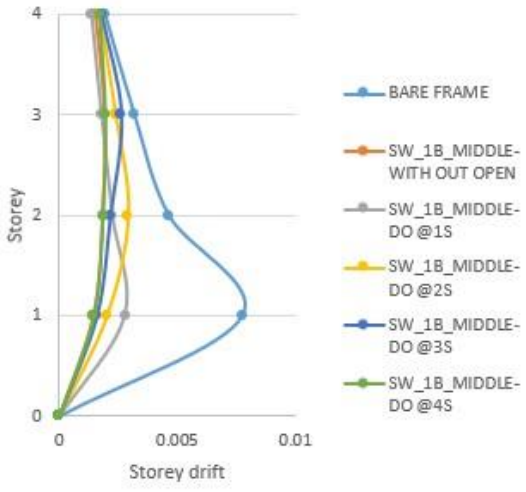

Chart -2: Storey drift graph of one bay SPSW

By comparing results obtained from the six models it is found that bare frame has more storey drift and one bay SPSW without opening at the middle of curved surface of building has less storey drift.

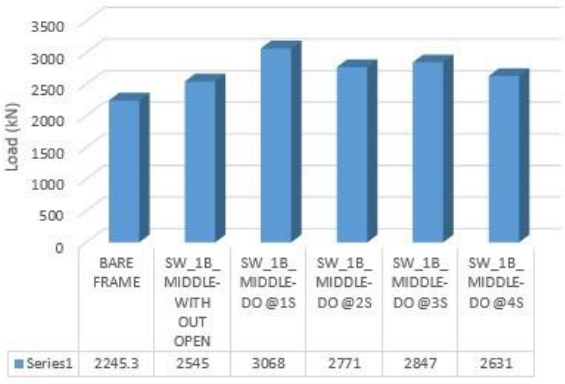

Chart -4: Base shear comparison of one bay SPSW with and without opening

By comparing results obtained from the six models it is found that one bay SPSW with opening in storey 1 at the middle of curved surface of building has more base shear and bare frame has less base shear.

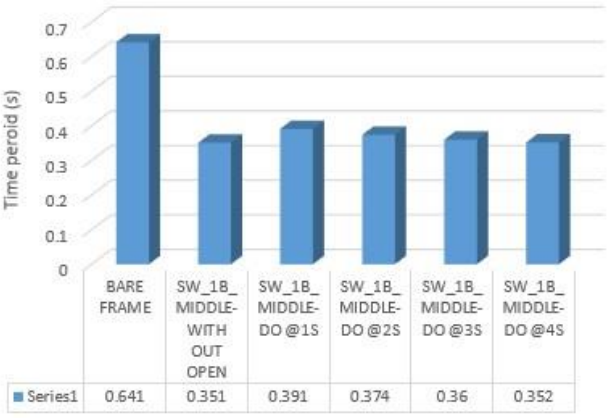

Chart -5: Time period comparison of one bay SPSW with and without opening

By comparing results obtained from the six models it is found that bare frame has more time period and one bay SPSW without opening have less time peroid.

3.2 Two bay SPSW

The 4-storey building with two bay SPSW were subjected to dynamic analysis. Five different building models were subjucted to dynamic analysis. The results are obtained from the dynamic analysis of building models and compared with five models for the parameters like storey displacement, storey drift, base shear and time period.

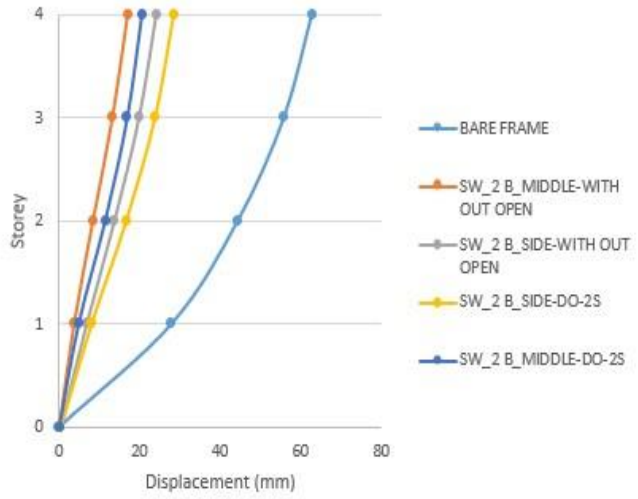

Chart -6: Displacement graph of two bay SPSW

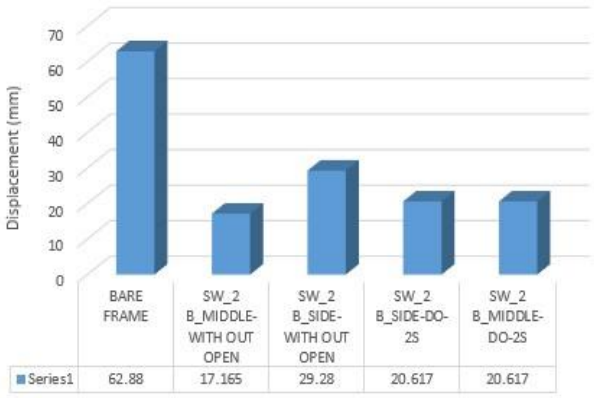

Chart -7: Displacement comparison of two bay SPSW with and without opening

By comparing results obtained from the five models it is found that bare frame has more displacement and two bay SPSW at middle of curved surface of building without opening have less displacement.

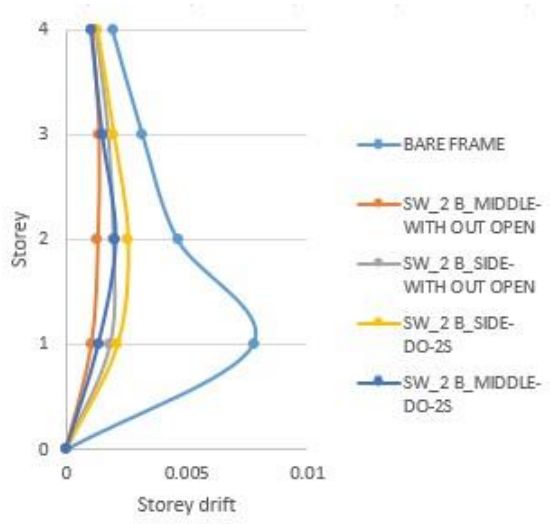

Chart -8: Storey drift graph of two bay SPSW

By comparing results obtained from the five models it is found that bare frame has more storey drift and two bay SPSW without opening at middle of curved surface of building has less storey drift.

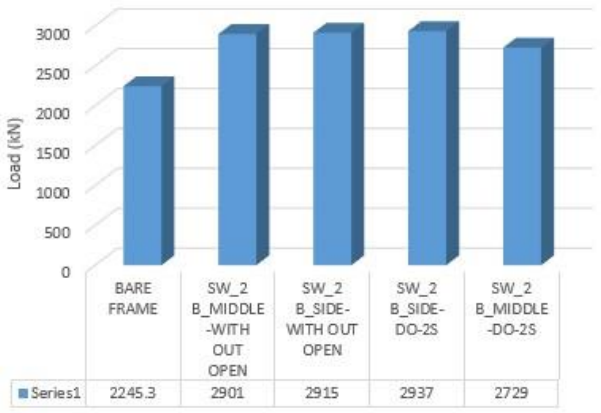

Chart -9: Base shear comparison of two bay SPSW with and without opening

By comparing results obtained from the five models it is found that the model two bay SPSW with opening at the side of curved surface of building has more base shear and bare frame have less base shear.

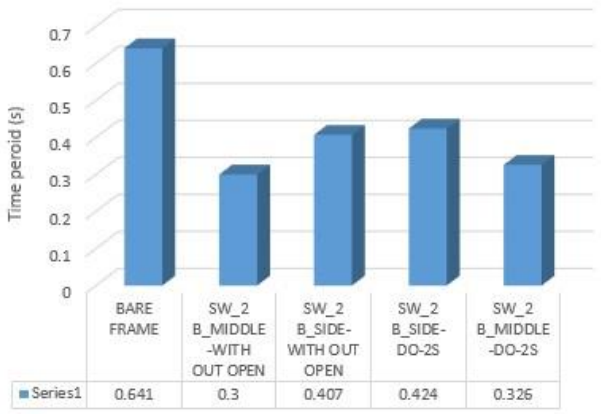

Chart -10: Time period comparison of two bay SPSW with and without opening

By comparing results obtained from the five models it is found that bare frame has more time period and two bay SPSW middle of curved surface of building without opening have less time period.

4. CONCLUSIONS

Based on the computed results and discussions the following conclusions are made from the study:

- SPSW has considerably increased the stiffness of the building as compared to the buildings without SPSW and has better resistance against lateral loads mainly in seismic prone areas.
- Differerent type of arrangement of SPSW are discussed in this paper
- Steel building with opening provided on SPSW in the second storey in one bay SPSW arrangement shows more displacement and storey drift as compared to other models with openings in one bay SPSW system.
- In one bay SPSW arrangement considering the parameters such as displacement ,storey drift and time period the SPSW without opening, on the middle of the curved surface of the building has better lateral load resistance.
- In two bay SPSW arrangement the displacement and storey drift is considerably reduced as compared to one bay SPSW arrangement.
- In two bay SPSW models it is ideal to provide SPSW in the middle without opening on the curved surface of the building because it has less displacement , storey drift and time period as compared to other models which has better lateral load resistance.

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