Yash B. Soni, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 10, Issue 5, (Series-II) May 2020, pp. 07-12

RESEARCH ARTICLE OPEN ACCESS

Comparison of Braced Steel Building with Steel Plate Shear Wall

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ABSTRACT
In this present study the comparative analysis of steel plate shear wall and steel bracings is analyzed for steel structure. The conventional steel building is prepared by considering 5 numbers of bays each at 3.5 meters in X-direction and numbers of 4 bays each at 3.5 meters in Y-direction. The analysis is carried out using linear static method considering G+13 storey conventional steel building in ETABS software. For the analysis of conventional steel building various loads and load combinations are considered according to Indian standard codal provision. The comparision of the X-bracing system with steel plate shear wall placed at different location such as outer edge, and at center in X and Y direction. The various results are obtained by considering the parameters like storey displacement and storey drift.

Keywords – Steel plate shear wall, Bracings, Linear static method, Optimum location

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Date of Submission: 29-04-2020 Date of Acceptance: 13-05-2020

I. INTRODUCTION

As compare to the Reinforced Cement Concrete (RCC) the steel has got some important physical properties like the high strength per unit weight and ductility. The high yield and ultimate strength result in slender sections.

Nowadays High-Rise Steel frame building is well establishing in metro cities. For construction of high-rise building, bracing and steel plate shear walls are constructed for stiffness and lateral load resistance purpose. For Lateral load resisting systems, following two components are compared:

1. Steel X- Bracings
2. Steel Plate Shear Walls

X-bracing (or Cross-bracing) uses two diagonal members crossing each other. These only need to be resistant to tension, one brace at a time acting to resist sideways forces, depending on the direction of loading. Fig-1 shows the typical X-bracing system used in the structure.[11]

The main function of steel plate shear wall is to resist horizontal story shear and overturning moment due to lateral loads. In general, steel plate shear wall system consists of a steel plate wall, two boundary columns and horizontal floor beams. Together, the steel plate walls and two boundary columns act as a vertical plate girder. The columns act as flanges of the vertical plate girder and the steel plate wall acts as its web. The horizontal floor beams act, more-or-less, as transverse stiffeners in a plate girder. Figure-2 shows the arrangement of SPSW.

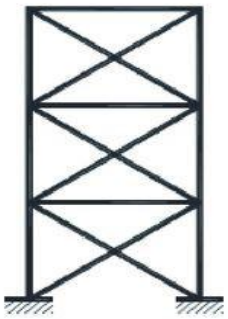

Fig-1: X-bracings

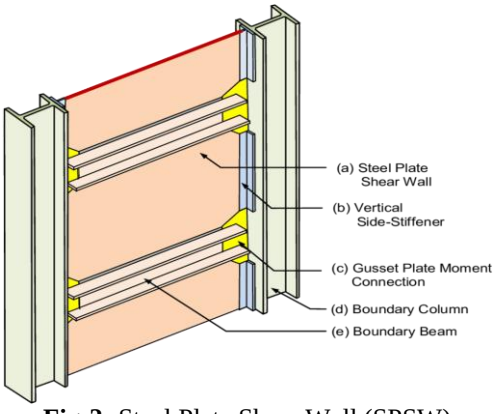

Fig-2: Steel Plate Shear Wall (SPSW)

II. LITERATURE REVIEW

Bing Qu and Michel Bruneau in 2009 have investigated the relative and respective contributions of boundary frame moment resisting action and infill panel tension field action to the overall plastic strength of SPSWs, followed by a proposed procedure to make use of the strength provided by the boundary frame moment resisting action. It was concluded that the lateral load carrying capacity of SPSW provided by the boundary frame moment resisting is very high.[1]

Atik M.; Ratul M. and Tafeem Z. in 2018 have investigated the effectiveness of various types of bracing system on the structure. Also, the structural performance of the steel building using different types of bracing system such as crossed bracing, V-type bracing, and eccentric bracing. It was concluded that among all the structures considered, X-Braced structure is the best option among all from the structural point of view.[2]

Metre S.; Ghule S. C. and Kiran R. in 2017 have studied the comparison for different types of bracing such as X, inverted V and Single diagonal bracing by placing in different locations like outer edge, inner edge and at center in X and Y-directions. Results are obtained by considering the parameters like storey displacement, storey drift and storey shear.It was concluded that by using V bracing it is possible to adopt openings for windows and doors which are critical in XBS because X-bracings run across the entire wall area.[3]

Jagdish J.S. and Doshi Tejas in 2013 have showed that the effect of different types of bracing systems in multi storied steel buildings. For this purpose, the G+15 stories steel building models is used with same configuration and different bracing systems such as Single-Diagonal, X bracing, Double X bracing, K bracing, V bracing is used. It was concluded that bracings are good to reduce the displacement and in case of K and V-bracing, the displacement is higher than without bracing because of irregularity in shape of the structure.[4]

Ugale Ashish B. and Raut Harshalata R. in 2014 have presented the analysis and design of high-rise steel building frame with and without Steel plate shear wall (SPSW). Also done an equivalent static analysis for steel moment resisting building frame having (G+6) storey. And the results from this investigation are that steel plate shear walls have a large effect on the behavior of frames under earthquake excitation. In general, steel plate increase stiffness of the structure. Deflection in case of without SPSW is very large & in case of with SPSW deflection is very less.[5]

III. STRUCTURAL MODELLING

There is a study of three dimensional rectangular shaped framed structures with 17.5m x 14m plan size and 14 numbers of stories is selected for the study. Storey height for ground floor is 4 m and typical floor height is 3.1m, is provided for the steel structure. The columns and beams are designed to withstand the live and dead loads adequately. The lateral loads to be applied on the building are based on the Indian standards. The study is performed for seismic zone III as per IS-1893 (Part1):2016[6] and basic wind speed is 50m/s as per IS-875 (Part-III): 2015[7]. The frames are assumed to be firmly fixed and having medium type of soil. The load combinations and other design parameters associated with the steel structure are as per IS-800:2007[8].The analysis is done by linear static analysis method in ETABS software.

Following are the physical properties considered for analysis of steel building as shown in below:

- Column (Base) = Steel Column 500 x 300 mm
- Columns (Storeys:1-3) = Steel Column 400 x 200 mm
- Columns (Storeys:4-7) = Steel Column 350 x 200 mm
- Columns (Storeys:8-14) = Steel Column 300 x 200 mm
- Beams (Base) = ISMB 500
- Beams (Storeys:1-7) = ISMB 400
- Beams (Storeys:8-14) = ISMB 300
- Bracings (Base) = 200 x 200 x 25
- Bracings (Storeys:1-10) = 200 x 200 x 15
- Bracings (Storeys:11-14) = 130 x 130 x 10
- SPSW (Steel Plate Shear Wall) = 4mm thick
- Slab thickness = 125 mm
- Dead Load on Beam (115mm wall) = 6.2 kN/ m^2 [9]
- Floor finish = 1 kN/m^2
- Live load = 3 kN/m^2 [10]
- Response Reduction Factor = 5

In this paper X-bracing and SPSW at different location like outer edge and center have been considered. Fig.-3 to Fig.-6 shows the elevation and 3-D view of different models.Where XE indicates the X-Bracing System at Edge, XC indicates the X-Bracing System at Center, SPSWE indicates the SPSW System at Edge and SPSWC indicates the SPSW System at Center.

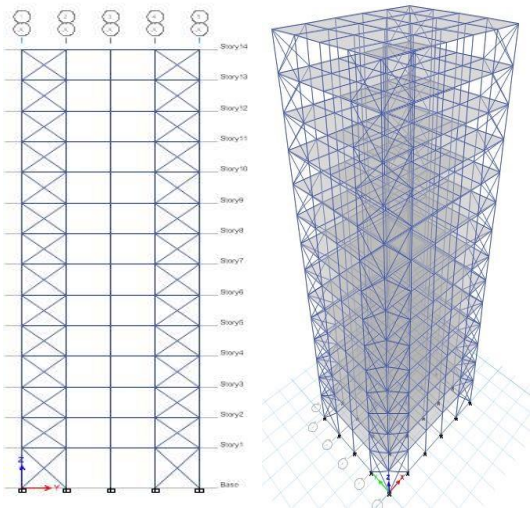

Fig-3: XE (X-Bracing System at Edge)

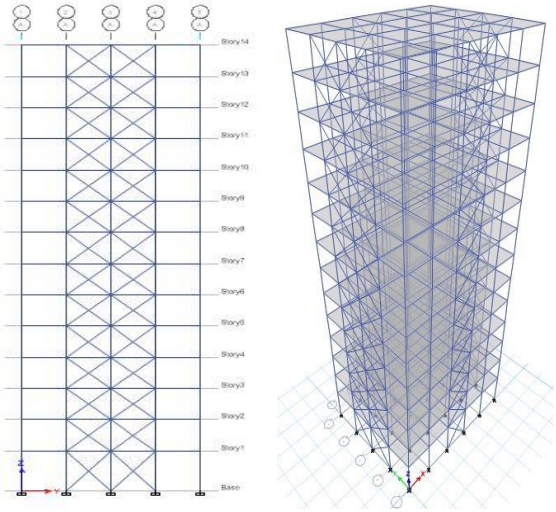

Fig-4: XC (X-Bracing System at Center)

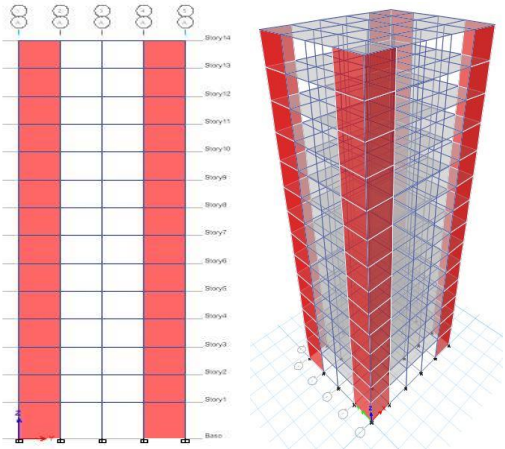

Fig-5: SPSWE (SPSW System at Edge)

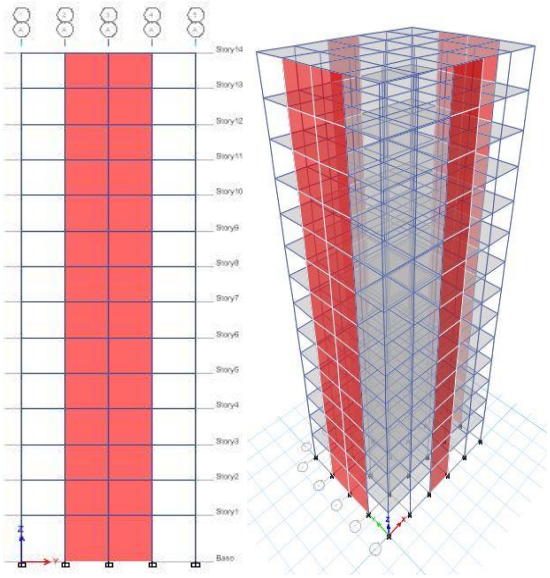

Fig-6: SPSWC (SPSW System at Center)

Storey drift and storey displacement of different models are shown in Fig.-7 to Fig.-14.. Drift means relative displacement between two stories. As the height of the building increases, drift stories also increases up to certain then decreases. Storey displacement means the displacement of the building relative to ground. Displacement is the main parameter which helps to know the structural behaviour due to the lateral loads acting on the structure.

For model XE, it is observed from the Fig.-7 that for X direction the maximum storey drift is 0.001241 and for Y direction maximum storey drift is 0.002707.

Refer Fig.-8 of model XE, it is observed that the maximum storey displacement in Y direction is 94.781 mm and 42.972 mm in X direction.

For model XC, it is observed from the Fig.-9 that for X direction the maximum storey drift is 0.001642 and for Y direction the maximum storey drift is 0.001932.

Refer Fig.-10 of model XC, it is observed that the maximum storey displacement in Y direction is 69.298 mm and 54.404 mm in X direction.

For model SPSWE, it is observed from the Fig.-11 that for X direction the maximum storey drift is 0.001078 and for Y direction the maximum storey drift is 0.002296.

Refer Fig.-12 of model SPSWE, it is observed that the maximum storey displacement in Y direction is 81.468 mm and 37.819 mm in X direction.

For model SPSWC, it is observed from the Fig.-13 that for X direction the maximum storey

drift is 0.001522 and for Y direction the maximum storey drift is 0.001684.
Refer Fig.-14 of model SPSWC, it is observed that the maximum storey displacement in Y direction is 60.896 mm and 48.323 mm in X direction.

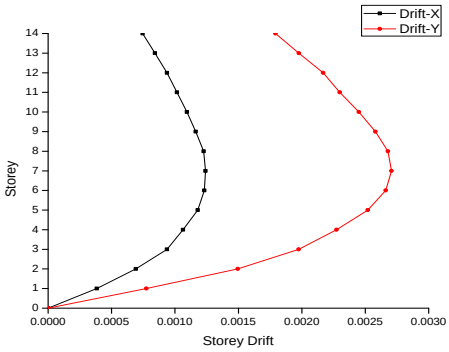

Fig-7: Storey drift in X & Y directions for XE

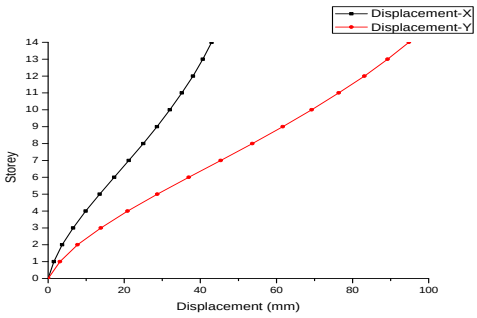

Fig-8: Storey displacement in X & Y directions for XE

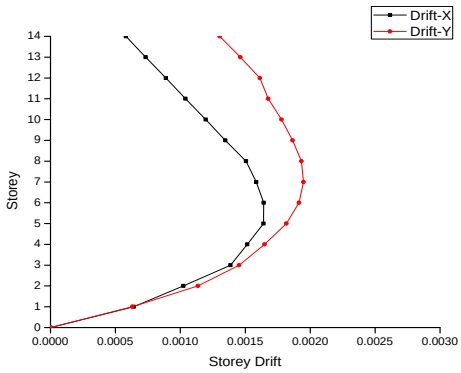

Fig-9: Storey drift in X & Y directions for XC

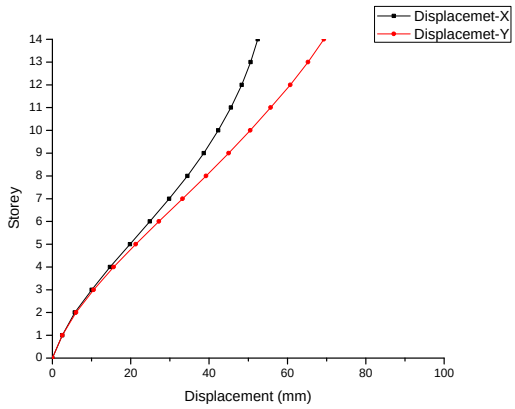

Fig-10: Storey displacement in X & Y directions for XC

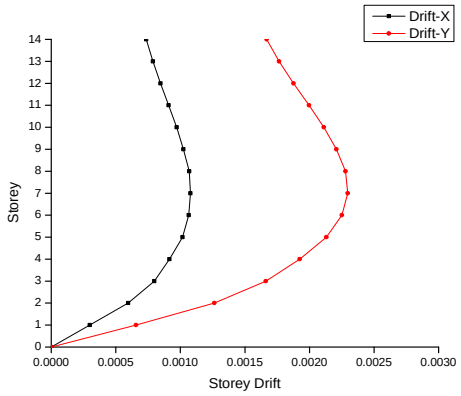

Fig-11: Storey drift in X & Y directions for SPSWE

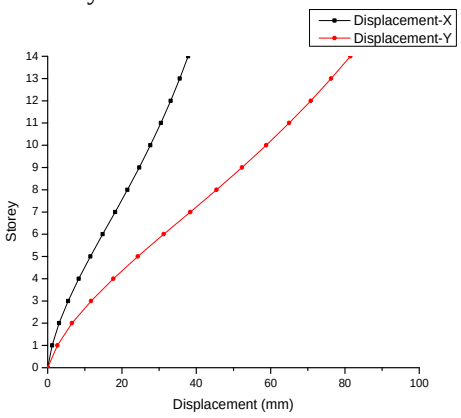

Fig-12: Storey displacement in X & Y directions for SPSWE

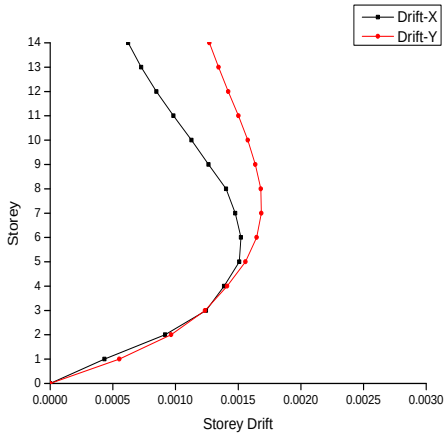

Fig-13: Storey drift in X & Y directions for SPSWC

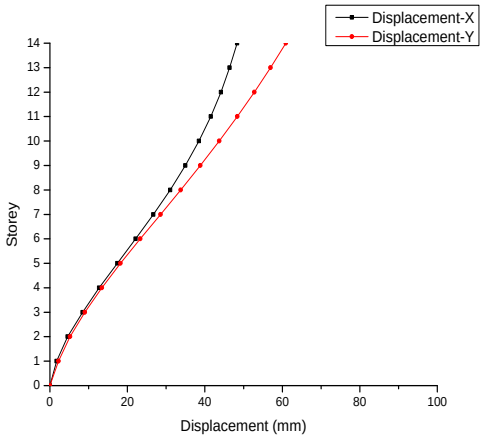

Fig-14: Storey displacement in X & Y directions for SPSWC

IV. RESULT AND DISCUSSION

- Displacement in Y-direction is more than, that of X direction because it has 4-bays in Y direction and 5-bays in X directions.
- According to Indian standard code maximum permissible displacement is 110 mm. It can be observed from the results that it is under permissible limit.
- Also, storey drift is in the permissible limit as per Indian standard.
- Storey drift of model SPSWE is found as 15.12% lesser than model XE for X direction.
- Storey drift of model SPSWC is found as 36.34% lesser than model SPSWE for Y direction.
- Storey displacement of model SPSWC is found as 13.8% less than model XC for Y direction.
- Storey displacement of model XE is found as 12% greater than model SPSWE for X direction.

V. CONCLUSION

On the basis of the present study for comparison of X-bracing with steel plate shear wall we can conclude that:-

1. SPSW is effective in reducing displacement reponse.
2. SPSW steel building is more effective than braced steel building for storey drift and storey displacement.
3. SPSW steel building and braced steel building is more effective for reducing responses when it is provided at centre than edge.
4. SPSW structure gives more resistance than braced steel building for lateral deflection. Also it suitable in earthquake and wind prone areas.

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