

Study of the Effect of Shape of the Structure and the Position of Shear Wall in a High Rise Building under Wind Load

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ABSTRACT: Shear wall systems are one of the most commonly used lateral load resistance system in high rise buildings. Shear wall is considered as better in plane stiffness and strength which can be used to simultaneously resist large support gravity and horizontal loads.

Incorporation of Shear wall has become inevitable in multi-storey buildings for resisting large lateral forces. It is very necessary to determine effective, efficient and ideal location of shear wall.

In this study, G+ 4 storeys building in Zone IV has been presented with some preliminary investigations, which is analyzed by changing the various position of shear wall with different shapes for determining parameters like axial loads and moments. This analysis is performed by using Standard package STADD.Pro V8i software.

KEYWORDS: Shear wall, Wind loading, Lateral loading, Drift, Axial loading, STAAD.Pro V8i.

I. INTRODUCTION

Shear walls are a sort of structural system that has lateral resistance to the building or structure. They are vertical components of the structure i.e. the horizontal force resisting system. They are made to counteract the result of lateral masses engaged on the structure.

In residential construction, shear walls are straight external walls that usually provide all of the lateral support for the buildings.

The aim of the design is that the action of an appropriate likelihood that structures are being so designed can perform satisfactorily throughout their design life with an applicable degree of safety, they must be ready to sustain all deformations of traditional construction and usefulness and have enough sturdiness and adequate resistance to the result of seismic masses and wind loads.

Shear walls are sometimes provided on each length and breadth of buildings and resist the lateral forces produced during wind and earthquake. Shear walls behaviour depends upon the material used, wall thickness, wall length and wall positioning in building frame also.

The design of these shear wall for wind is designed as simple concrete walls. The design of these walls for the seismic forces requires the special considerations as they should be safe under repeated loads. Shear walls may be imperative from point of view of economy and control of lateral deflection.

II. RELATED WORK

Some of the important literatures on the topic are as follows:-

[1]. K. Rama Raju, et al. (2013), carried out the limit state method of analysis and design of 3B+G+40-storey RC (reinforced concrete) high rise building under the wind and seismic loads as per IS code of practice. They checked the

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safety in the structure for base shear, inter-storey drifts, roof displacements, accelerations against the allowable limits and the other relative references in literature on effect of wind and earthquake loadings on the building. [2]. Bedabrata Bhatta charjee (2007), analyzed and designed of a G+21 Multi-storey building using STAAD.Pro. Initially he analyzed of 2-D frames and manually checked the accuracy of the software with his results. The results obtained were accurate of G+7 storey building in initial analysis for all possible load combinations (dead, live, wind and seismic loads) then he continued the work on multi-storey 2-D and 3-D frames under the various load combinations. They found the wind intensities at different heights by specification of IS 875 and seismic loads were calculated by IS 1893-2000 and results are easily and accurately found by using STAAD.Pro software. [3]. Dr. Hadihusseini et al. (2014), studied the improvement in structural performance of the building with the frame system using shear wall. The results in terms of Shear force, Torsion, Moment on the beam are obtained on a beam in the frame structure. In this study, the structural performance in the framed building with shear wall has been analyzed. [4]. Tarun Shrivastav et al. Bajpai (2015), analyzed shear-wall frame multi-storey building subjected to wind loading. They prepared different cases with different configuration of shear wall and represented the comparative graphical representation of different models through different parameters such as lateral deformations, maximum bending moment, shear forces and storey drift index. [5]. Venkata Sairam Kumar. N et al. (2013), represented the relationship between base shear & base moment, minimum thickness of shear wall considered to neglect buckling of shear walls adopted with dimensions classified as class A, class B and class C as per IS: 875: 1987 (Part-3). They considered both lateral loads like wind and seismic by considering all zones as per IS: 875-1987 (Part-3) and IS: 1893-2002 respectively. They have shown minimum thickness of RC shear wall for both wind and seismic loads and regression chart equations were also shown for both base shear and base moment. [6]. Rajesh Jayarambhai Prajapati et al. (2013), discussed about importance of lateral stiffness of a building under wind and earthquake. For reducing damages due to wind and earthquake, it is necessary to have large a lateral stiffness. He discussed that shear wall contributes significant strength, lateral stiffness, overall ductility and energy dissipation capacity. He also studied effects of shear wall on deflection in A, B, C & D models of 30-storey building. [7]. P.M.B. Raj Kiran Nanduri, B.Suresh et al. (2013), carried out study for the behaviour of outrigger location optimization and the efficiency of each outrigger in which 3 outriggers are using in the structure. He analyzed nine 30-story 3-D models of out riggers & belt truss system which is subjected to wind and earth quake load & compared them to find lateral displacement reduction related to outrigger and belt truss system location.

III. MODELLING AND LOADING DETAILS

For the study we have taken two cases of a same building with different positions of shear walls. The building considered is a 3×3 bay building with 5 stories. Plan and perspective view of the building are shown below:

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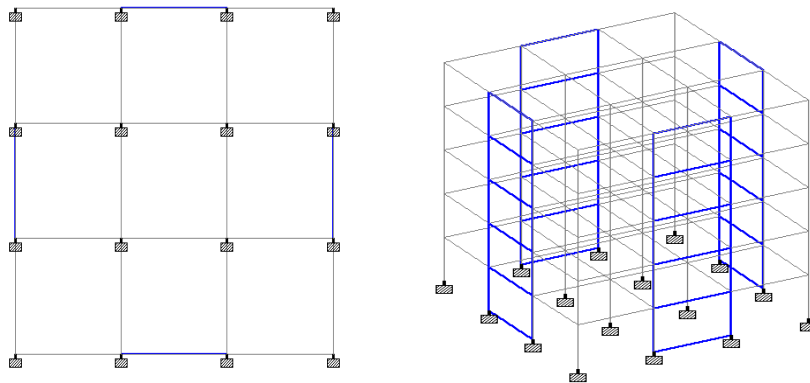


Fig. 3.1: Plan and Perspective view of case 1

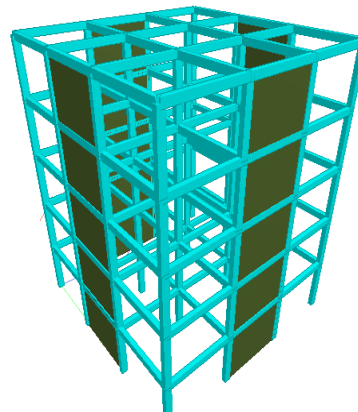


Fig. 3.2: 3D view of the case 1

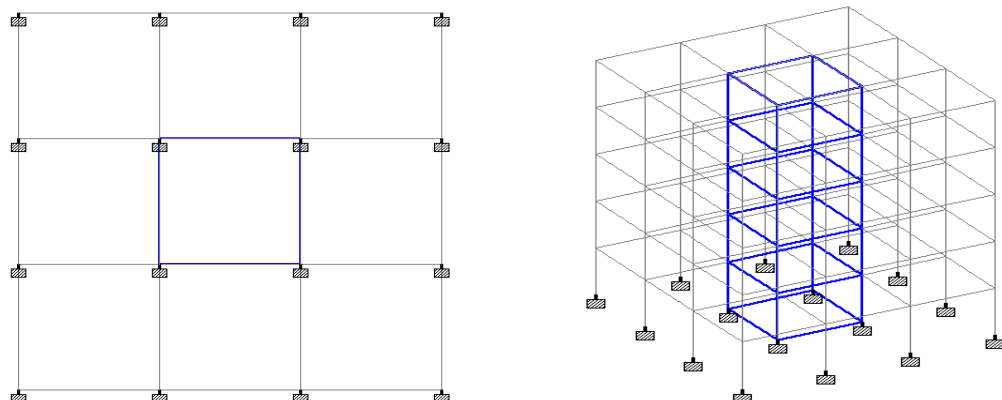


Fig. 3.3: Plan and Perspective view of case 2

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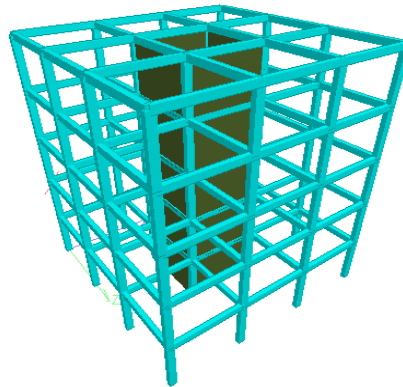


Fig. 3.4: 3D view of case 2

All cases are defined below:

Case 1

Number of Column = 16

Number of Beam = 120

Height of Column = 3m

Length of Beam = 4m

Size of the beams= 350mm × 230mm (depth × width)

Size of the columns= 350mm × 230mm

Thickness of shear walls=150mm

Position of shear walls: all 4 middle spans of the outer faces of the building

Case 2

Number of Column = 16

Number of Beam = 120

Height of Column = 3m

Length of Beam = 4m

Size of the beams= 350mm × 230mm (depth × width)

Size of the columns=350mm × 230mm

Thickness of shear walls= 150mm

Position of shear walls: Centre core of the building

Case 3

Number of Column = 8

Number of Beam = 65

Height of Column = 3m

Side of the hexagon = 3m

Size of the beams= 350mm × 230mm (depth × width)

Size of the columns=350mm × 230mm

Thickness of shear walls= 150mm

Case 4

Number of Column = 8

Number of Beam = 65

Height of Column = 3m

Side of the hexagon = 3m

Size of the beams= 350mm × 230mm (depth × width)

Size of the columns=350mm × 230mm

Thickness of shear walls= 150mm

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Case 3

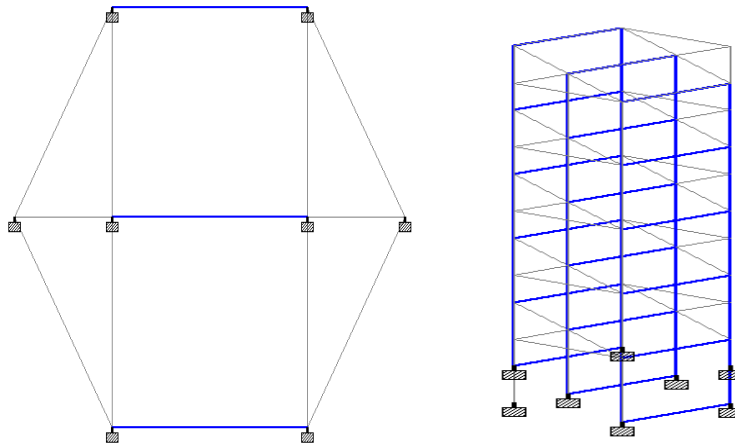


Fig. 3.5: Plan and Perspective view of case 3

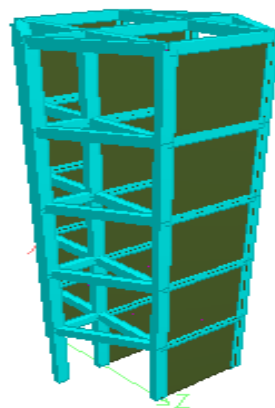


Fig. 3.6: 3D view of case 3

Case 4

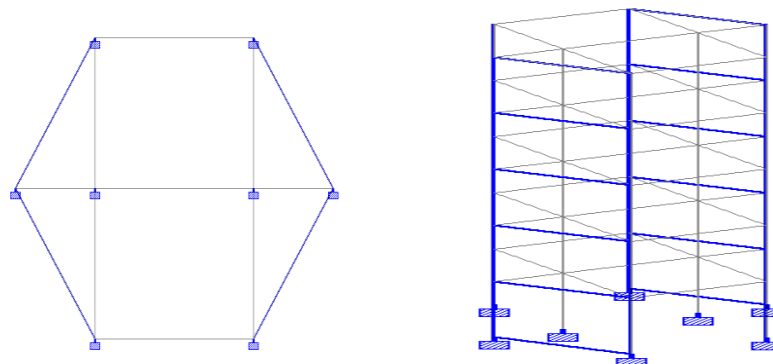


Fig. 3.7: Plan and Perspective view of case 4

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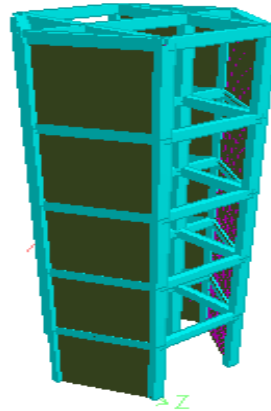


Fig. 3.8: 3D view of case 4

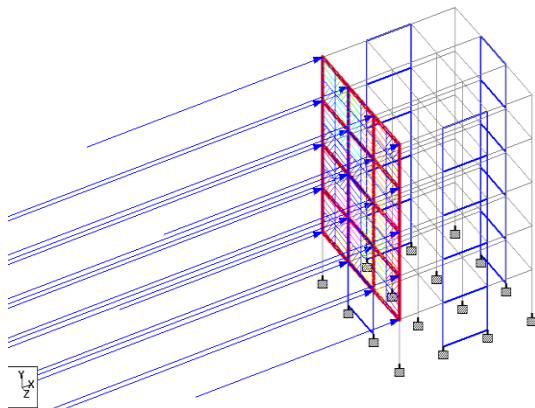


Fig. 3.9: Wind load in +X direction

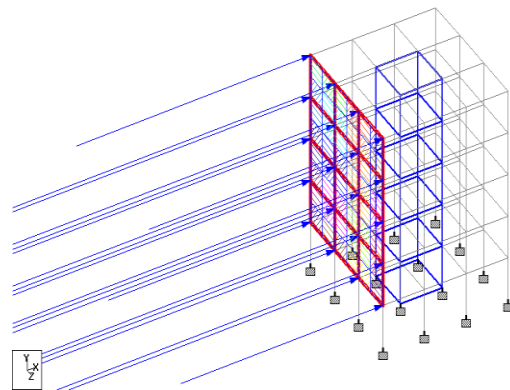


Fig. 3.10: Wind load in +X direction

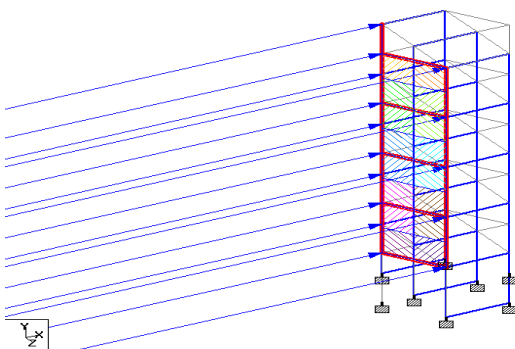


Fig. 3.11: Wind load in +X direction

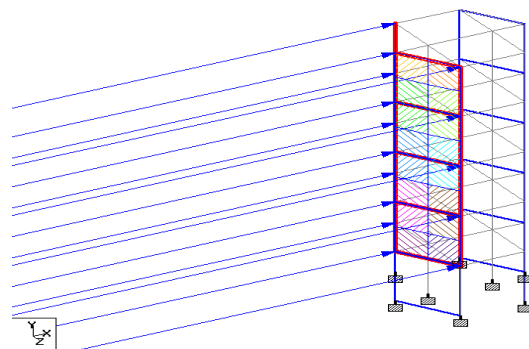


Fig. 3.12: Wind load in +X direction

All cases are analyzed using STAAD pro v8i.

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IV. RESULTS AND DISCUSSIONS

The behaviour of building under different loading conditions has been analyzed for the wind effect with different parameters. The tables, graphs and the discussions with respect to variations are given as follows:

4.1 Comparison of axial load and moments.

Case 1: Shear wall placed at middle span of outer surface of the building.

The results of the analysis of the case 1 are listed below in form of table 4.1 and table 4.2. Table 4.1 has the summary of nodal displacement of the building structure. And table 4.2 have the summary of shear force and bending moment in the beam and columns of the building structure.

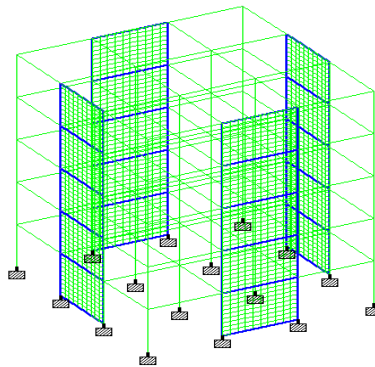


Fig. 4.1.: Case 1

Fig. 4.2 shows the contour map for maximum absolute stress in the shear walls:

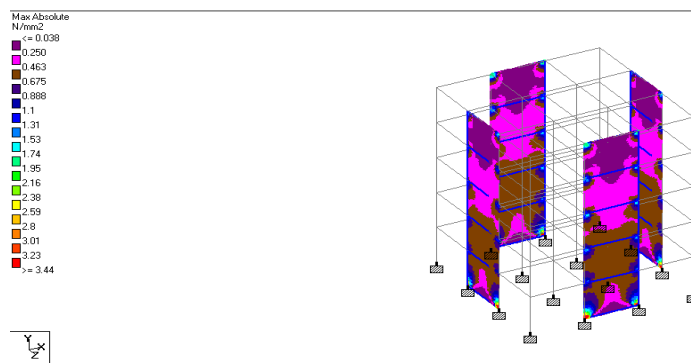


Fig. 4.2: Stress distribution in shear walls

Case 2: Shear wall placed at the centre of the building.

The results of the analysis of the case 1 are listed below in form of table 4.3 and table 4.4. Table 4.3 has the summary of nodal displacement of the building structure. And table 4.4 have the summary of shear force and bending moment in the beam and columns of the building structure.

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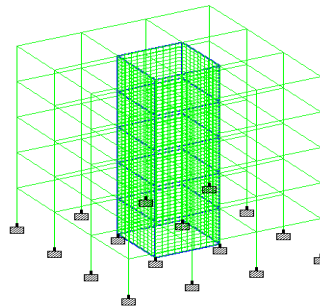


Fig. 4.3: Case 2

Fig. 4.4 shows the contour map for maximum absolute stress in the shear walls:

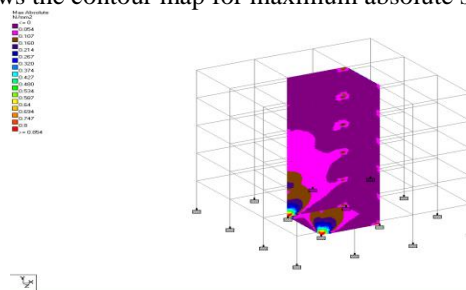


Fig. 4.4: Stress distribution in shear walls

Case 3: Shear wall is placed at parallel side of building.

The results of the analysis of the case 3 are listed below in form of table 4.5 and table 4.6. Table 4.5 has the summary of nodal displacement of the building structure. Table 4.6 have the summary of shear force and bending moment in the beam and columns of the building structure.

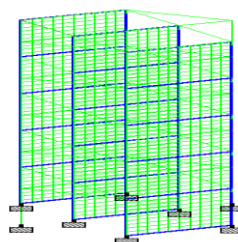


Fig. 4.5: Case 3

Fig. 4.6: Shows the contour map for maximum absolute stress in the shear walls:

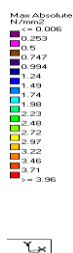


Fig. 4.6: Stress distribution in shear walls

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Case 4: Shear wall is placed at opposite apex side of the building.

The results of the analysis of the case 4 are listed below in form of table 4.7 and table 4.8. Table 4.7 has the summary of nodal displacement of the building structure. And table 4.8 have the summary of shear force and bending moment in the beam and columns of the building structure.

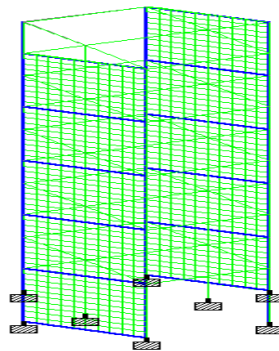


Fig. 4.7: Case 3

Fig. 4.8: Shows the contour map for maximum absolute stress in the shear walls:

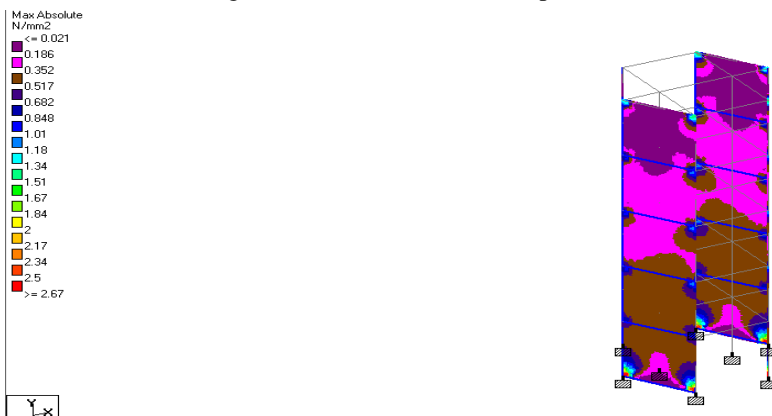


Fig. 4.8: Stress distribution in shear walls

Table 1: Max. Shear Force, Bending Moment and Absolute Max Stress in beams

Cases	Max S.F(kN)	Max B.M (kN-m)	Max. Absolute Stress (N/mm ²)
Case 1	54.685	48.405	3.44
Case 2	56.911	48.267	0.954
Case 3	34.747	29.347	3.96
Case 4	42.536	26.625	2.67

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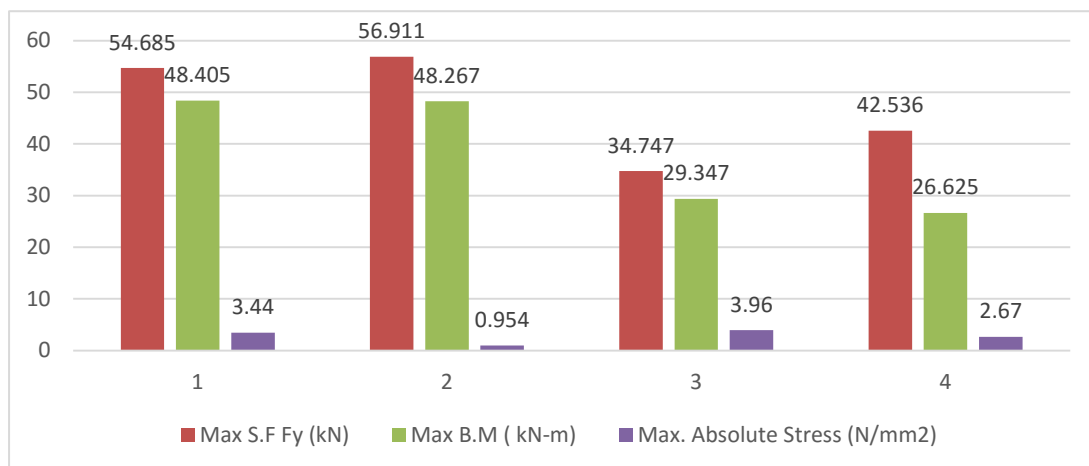


Fig. 4.9: Max. Shear Force, Bending Moment and Absolute Max Stress Chart

We can see the maximum Shear Force is in case 2, Maximum Bending Moment is in case 1 & Absolute Maximum stress is in case 3.

Table 2: Max. Joint Displacement

Cases	Max. X(mm)	Max. Y(mm)	Max. Z(mm)
Case 1	4.253	0.175	4.706
Case 2	2.384	0.101	2.621
Case 3	1.159	0.088	15.984
Case 4	3.059	1.056	8.251

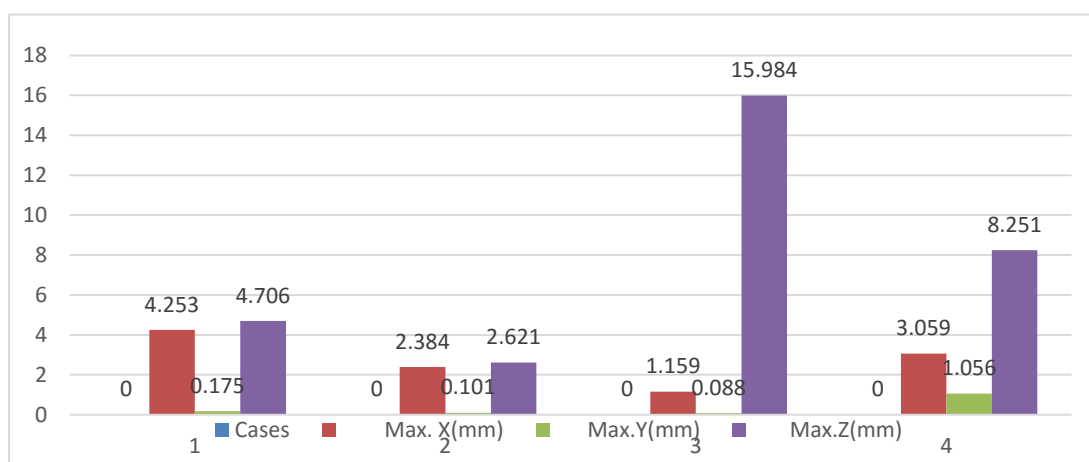


Fig. 4.10: Joint Displacement Chart

We can see the maximum joint Displacement in X-direction is in case 1, maximum joint displacement in Y-direction in case 4 & maximum joint displacement in Z-direction in case 3.

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Table 3: Max. Shear Force

Cases	Max. S.F. (kN)
Case 1	54.685
Case 2	56.911
Case 3	34.747
Case 4	42.536

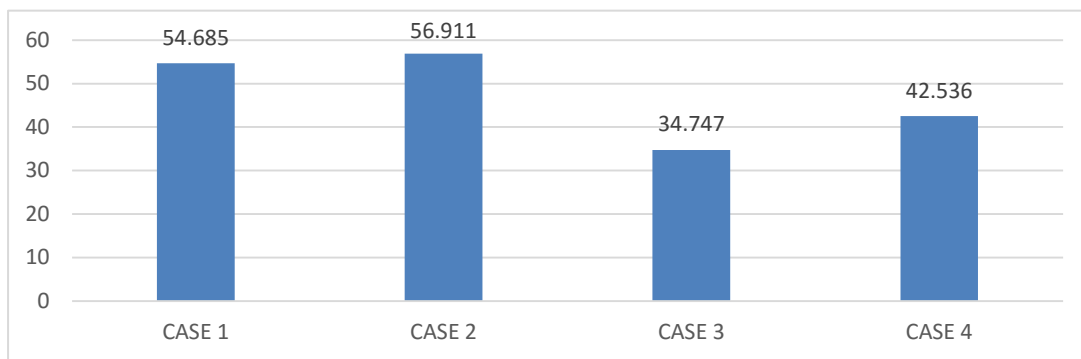


Fig. 4.11: Maximum Shear Force

We can see that the maximum shear force in Y-direction is in case 2.

Table 4: Max. Bending Moment in Beams.

Cases	Max. B.M in X-direction (kN-m)	Max. B.M in Z- direction (kN-m)
Case 1	1.695	48.405
Case 2	0.764	48.267
Case 3	0.920	29.347
Case 4	0.903	26.625

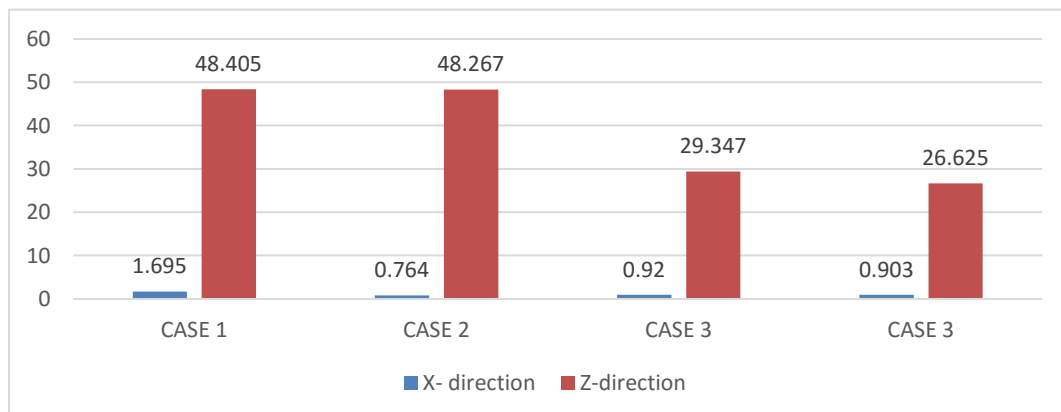


Fig. 4.12: Bending Moment in beams

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We can see that the maximum Bending moment was generated in case 1 that too in Z direction, when the wind was flowing in positive Z direction.

V. CONCLUSIONS

The followings are the salient conclusions of this study:

On the basis of the analysis, following conclusions had been obtained:

- [1.] The variation in the location of the shear wall has a considerable effect on the axial load in the columns, bending moment and shear force in beams and deflection of the joints.
- [2.] The presence of shear wall also decreases deflection in lateral directions.
- [3.] The change in the geometry of the building shows decrease in bending moment and shear force in one direction but if the wind is flowing in the perpendicular direction due to increase in surface area, we can analyse maximum shear forces and bending moment caused by maximum deflection.
- [4.] It was also observed that in square geometry when the shear walls were located at the core, the steel required in the structural members were substantially more than in the case when the shear walls were located at the outer face of the geometry.
- [5.] In hexagonal geometry, when the shear walls were located at the inner spans, the reinforcement requirement was noticeably reduced other than in the case, where the shear walls were located at the outer face of the geometry.

On the basis of the literature and the analysis done it could be concluded that:

- [1.] Shear walls are easy to construct, because reinforcement detailing of walls are relatively straight forward and therefore easily implemented at site shear wall is one of the most effective building element in resisting lateral forces during earthquake.
- [2.] By constructing shear walls, damages by the effects of lateral forces due to earthquake and high winds can be minimized. Shear walls construction will provide the larger stiffness to the building structures there by reducing the damage to structure and its contents.
- [3.] By the use of aero-dynamics the load over the high-rise structure due to high wind velocity can be abridged significantly.

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BIOGRAPHY

Sourabh Rajoriya received his B.Tech-CE Degree in 2013 from TRUBA college Bhopal and completed M. E. from NITTTR (MHRDC, Govt. of India) in structural Engineering. His research interests are only in structural field related to software like STAAD.Pro etc.



Uttam received his B.Tech-CE Degree in 2016 and his area of interest in structural field particularly in software related work.