# A RESEARCH ON COMPARING THE EFFECT OF SEISMIC WAVES ON MULTISTORIED BUILDINGS WITH & WITHOUT SHEAR WALL AND FLANGED CONCRETE COLUMN

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**Abstract:-** *The stability and stiffness of any structure is the major issue of concern in any high rise buildings. Shear walls are structural members which resist lateral forces predominant on moment resisting frame. Shear walls are most preferred structural walls for earthquake resistance. This research is related to comparison of shear wall type structure with moment resisting type of building. In the seismic design of buildings, reinforced concrete structural walls, or shear walls, act as major earthquake resisting members. Structural walls provide an efficient bracing system and offer great potential for lateral load resistance. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the walls appropriately. The present study states three type of models, moment resisting frame i.e. model 1, Shear wall building concentrically located along X- axis on outer periphery of building i.e. model 2, and Concrete column flange concentrically located on outer periphery along the X-axis i.e. model 3. Models of the three structures with same loading were created on STAAD-Pro and were analyzed and further they where compared for their suitability. For 10 storey building and 3 bays along X-axis of 4m each and 4 bays along Z-axis of 4m each were considered and loads were applied as per the IS specifications. The analysis was conducted as per the specifications of IS standards IS 456, IS 875, IS 1893, IS 13920. From the result it is seen that there is decrease of approximately 10% in Lateral storey shear and Base shear when the moment resisting frame was introduced with shear wall. Thus the model 2 and model 3 possessed 10% less lateral force and base shear as compared to the model 1. Also the results of Axial force, bending moment, Node displacement were found satisfactorily less than the moment resisting frame. If cost is been compared, then model 3 can be stated as economical in all sense since for the same configuration and load it greater stability andstiffness as checked from the node displacement results.*

***Key Words*: Seismic Waves, Shear wall, Without-Shear wall, flanged concrete column & STAAD-Pro.**

## 1. INTRODUCTION

Earthquake never kills people, the weak structures do. Earthquakes are vibrations or oscillations of ground surface caused by temporary disturbance of the elastic or gravitational equilibrium of the rocks at or beneath the surface of the earth. This disturbances and movements cause elastic impulses or waves. These waves are known as seismic waves. Based on the peak ground acceleration or movement there are certain zones of the earth, named as seismic zones. In India there are four zones, II, III, IV, V – last one being the most devastating.

In most instances only the structural response to the horizontal components of ground motion is considered since buildings are not sensitive to horizontal or lateral distortions. In virtually all earthquake design practice the structure is analysed as an elastic system; it is acknowledged that the structural response to strong earthquakes involves yielding of the structure, so that the response is inelastic. The effect of yielding in a structure is two- fold. On one hand, stiffness is reduced so that displacements tend to increase. The properties of a building are lateral stiffness, lateral strength and ductility.

Shearwall is a structural member positioned at different places in a building from foundation level to top parapet level, used to resist lateral forces i.e. parallel to the plane of the wall. Shear walls resist lateral forces through combined axial-flexure-shear action. Earthquake resistant buildings should possess, at least a minimum lateral stiffness, so that they do no swing too much during small levels of shaking. Moment frame buildings may not be able to offer this always. Also, structural walls help reduce shear and moment demands on beams and columns in the moment frames of the building, when provided along with moment frames as lateral load resisting system.

Shear walls should be provided throughout the height of buildings for best earthquake performance. Also, shear walls offer best performance when rested on hard soil strata. Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes. Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large.

Thus, design of their foundations requires special attention. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. Under the large overturning effects caused by horizontal earthquake forces, edges of shear walls experience high compressive and tensile stresses. To ensure that shear walls behave in a ductile way, concrete in the wall end regions must be reinforced in a special manner to sustain these load reversals without losing strength. Based on materials used for construction shear walls are classified as follows,

*A.RCC Shear Wall*

*B.RC Hollow Concrete Block Masonry Wall*

*C. Steel Plate Shear Wall*

Shear walls with openings are not generally preferred because they are unable to transfer loads and generally fail. Shear wall with openings are also known as coupled shear wall. Flanged concrete column is similar to coupled shear wall, onlychange is the depth of beam may be restricted and attempts are made in this research work to check the strength of flanged concrete column with the regular solid shear wall. Model of a flanged concrete column is shown in figure 1. Flanges in the column can be on single side of column or on both side of the column. These flanges can be assigned on three mutual sides of the column. The main purposes of providing such flanges in column are to reduce joint displacement and to prevent plastic hinge formation near the support. This will help in improving the stiffness in the structure and provide access to the building from the opening.

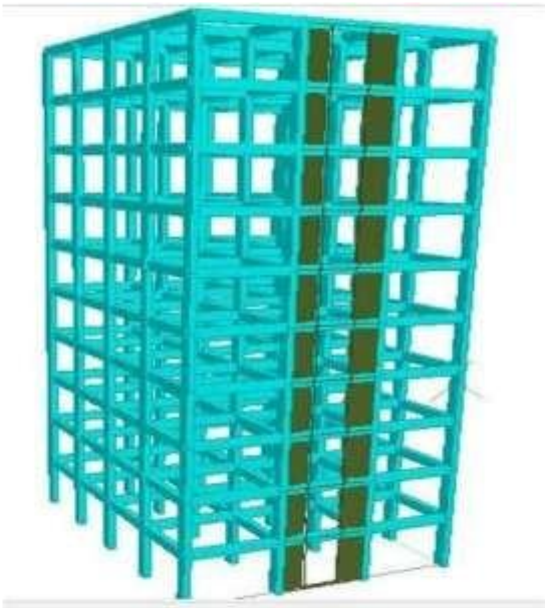

**Figure 1:-** Column with flange or Flanged column

**II. PROBLEM STATEMENT AND METHODOLOGY**

Analysis of any structure for resisting earthquake is the basic need of this study. In this project analysis of a seismic resistant structure is a need of concern, and thereby establishing a comparison between structures with normal shear wall with flanged concrete column. In high rise structures most adoptable type to resist earthquake is to provide shear wall. Basically many analysis and design software's can be adopted to analyzeanddesignany earthquake resistant structure.

The structure selected for this project is a simple office building (Banking hall type) with the following description as stated below.

**Table -1:**

PROBLEM STATEMENT FOR THE PROJECT MODELS

| Sr. No. | Description of structure | Values |
|---|---|---|
| 1 | Number of bays in X direction and its width | 4bays of 4 m each |
| 2 | Number of bays in X direction and its width | 4bays of 4 m each |

| | | |
|---|---|---|
| 3 | Number of bays in Z direction and its width | 3 bays of 4 m each |
| 4 | Story height | 3 m each |
| 5 | Number of storey (Excluding the plinth and substructure and including the Ground floor) | 10 |
| 6 | Depth of foundation from ground level | 2.2 m |
| 7 | Plinth height | 800 mm |
| 8 | Column size | 400 mm x 400 mm |
| 9 | Beam size | 230 mm x 400 mm |
| 10 | Thickness of Slab | 150 mm |
| 11 | Density of concrete | 25 $kN/m^3$ |
| 12 | Live load on roof | 1.5 $kN/m^2$ |
| 13 | Live load on floors | 3 $kN/m^2$ |
| 14 | Floor finish | 1 $kN/m^2$ |
| 15 | Brick wall on peripheral beams | 230 mm |
| 16 | Brick wall on internal beams | 115 mm |
| 17 | Density of brick wall | 20 $kN/m^3$ |
| 18 | Internal Plaster | 12mm |
| 19 | External Plaster | 15mm |
| 20 | Density of Plaster | 18 $kN/m^3$ |

For the present study following values for seismic analysis are assumed. The values are assumed on the basis of reference steps given in IS 1893-2002 and 13920-1993 and IS 456:2000. Since Nagpur or vidarbha is less vulnerable to earthquakes, for this present study assigning zone III for moderate seismic intensity as stated in table 2 of IS 1893 – 2002.

**TABLE 2**

SEISMIC PARAMETERS

| | | |
|---|---|---|
| 1 | Zone factor for zone III | 0.16 (Table 2, P.16) |
| 2 | Importance factor for office building | 1 (Table 6, P.18) |
| 3 | Special Reinforced Concrete Moment resisting Frame | |
| 4 | SMRF is a moment resisting frame detailed to provide ductile behavior and comply with the requirements of 13920-1993 | |
| 5 | Response reduction factor for ductile shear wall with SMRF | 5 |
| 6 | Type of soil | Medium (Type II) |
| 8 | Damping percent | 5 % (0.05) |
| 9 | Thickness of Shear wall | 230 mm |
| 10 | Brick infill panel building type. | |
| 1 | Zone factor for zone III | 0.16 (Table 2, P.16) |

**A) Plan and Model Generated for Problem Statement**

From the values mentioned in the problem definition three models are generated to study the behavior of earthquake resistant structure. Figure 4.1 shows plan of the structure generated in STAADPro. Following are the models generated.

*1) Model 1:* Simple structure withoutany shear wall. Figure 4.2 illustrates this model. In this model all the parameters are considered for designing the structure as earthquake proof as per IS1893:2003.

*2) Model 2:* Structure with symmetrical shear wall on opposite side of building on outer walls of structure concentrically located. Figure 4.3 illustrates the model. In this model all the parameters are same as model 1 also parameters of shear wall are added for design of shear wall as per IS 13920:1993.

*3) Model 3:* Structure with symmetrical concrete column flanges (like shear wall with opening). Since shear wall starts from foundation level, in this type of model the structure up to plinth level has solid shear wall and the structure above plinth level have column flanges. Figure-1 illustrates the type. In this model all parameters are same as model 2 but only difference is the shear walls provided are having opening seems like flanges to the column.

**B) Calculation of Load and Earthquake related Parameters**:-

Dead load of slab = (0.15 x 1 x 25) = 3.75 kN/m$^2$ Dead load of Outer Brick wall can be calculated as =

(0.23) x (2.65) x 20 = 12.19 kN/m$^2$

Dead load of Inner Brick wall can be calculated as = (0.115) x (2.65) x 20 = 6. 1 kN/m$^2$

Dead load of Parapet wall can be calculated as = (0.23) x (1) x (20) = 4.6 kN/m$^2$

Dead load of Plaster for outer walls can be calculated as = (0.015+0.012) x (2.65) x 18 = 1.3 kN/m$^2$

Dead load of Plaster for inner walls and parapet wall can be calculated as = (0.012+0.012) x (2.65) x 18 = 1.15kN/m$^2$

Total Dead Load for outer walls = 12.19 +1.3 = 13.49 (considering 85% of weight due to openings) i.e 11.46 kN/m$^2$ Total Dead Load for inner walls = 6.1+1.15 = 7.25 kN/m$^2$ (Least openings are there in Partitions)

Total Dead Load for Parapet walls = 4.6 +1.15 = 5.75 kN/m$^2$

***1. Seismic Weight Calculation:*** As per the norms given in the IS 1893:2003 for live load greater than 3, 50% of the live load is added for seismic weight. And for live load up to and less than 3, 25% live load is added for seismic weight.

Total Seismic weight floors = 3.75 + (0.25 x3) = 4.5 kN/m$^2$.

## II. RESULT AND DISCUSSION

The equivalent static method or seismic coefficient method had been used to find the design lateral forces along the storey in X and Z direction of the building since the building is unsymmetrical. A 10 storied RCC building in zone III is modelled using STAADPro software and the results are computed. The configurations of all the models are discussed in previous. Three models were prepared based on different configuration, Model 1 for non-shear wall type of multi-storeyed building, Model 2 for same building with Shear wall type and model 3 for same building with Column flange type. These models are analysed and designed as per the specifications of Indian Standard codes *IS 456, IS 875, IS 1893, &IS 13920.*

### *A. Lateral Force and Base Shear*

Elements or members of building should be designed and constructed to resist the effects of design lateral force. STAADPro gives the lateral force distribution at various levels and at each storey level. Lateral force of earthquake is predominant force which needs to be resisted for any structure to be earthquake resistant. The equivalent static method had been adopted to find out the lateral force in STAADPro. The Table No.3 shows Storey height and the distribution of the lateral force and the base shear at each storey level in X-direction. The average percentage decrease in lateral force for model 2 and model 3, when compared with model 1, shows that there is approximate decrease of 10% for both the models.

In this project storey height versus Lateral force in X-Direction and it is evident that the lateral force for Model 1, Model 2, and Model 3 differs from each other storey wise. It is seen that for a particular model as the storey height increases the lateral force also increases except in the parapet level since the loads on the parapet level are less. Lateral force or storey shear for model 1, model 2 and model 3 are different and approximately 10% decrease in lateral force for model 2 and model 3 is seen at each storey level when compared with model 1.

Somewhere table shows base shear values at different floor level along X- Direction. Base shear is cumulative of lateral force from top storey to bottom storey. Thus the value of bottom floor shear is maximum and value of top storey shear is minimum. Introducing shear wall and column flange shows approximate 10% reduction in the base shear for model 2 and model 3 when compared with model 1. The values for each storey is cumulative of top storey thus it differs from storey to storey.

After introducing shear walls the base shear is reduced by 10%. It is evident that the base shear and lateral force reduces after introducing shear wall butthere is reductionof base shear even for the column flange type model (Model 3).

A table shows Storey height and the distribution of the lateral force and the base shear at each storey level in Z-direction. The percentage decrease in lateral force for model 2 and model 3, when compared with model 1, shows that there is approximate decrease of 10% for both the models, on each storey.

A figure shows a graph of storey height Vs Lateral force in Z-Direction and it is evident that the lateral force for Model 1, Model 2, and Model 3 differs from each other storey wise. It is seen that for a particular model as the storey height increases the lateral force also increases except in the parapet level since the loads on the parapet level are less. Lateral force or storey shear for model 1, model 2 and model 3 are different and approximately 10% decrease in lateral force for model 2 and model 3 is seen at each storey level when compared with model 1.

A Table shows base shear values at different floor level along "Z"- Direction. Base shear is cumulative of lateral force from top storey to bottom storey. Thus the value of bottom floor shear is maximum and value of top storey shear is minimum. Introducing shear wall and column flange shows approximate 10% reduction in the base shear for model 2 and model 3 when compared with model 1. The values for each storey is cumulative of top storey thus it differs from storey to storey.

A figure shows base shear along "Z"-Direction storey wise. After introducing shear walls the base shear is reduced by 10%. It is evident that the base shear and lateral force reduces after introducing shear wall but there is reduction of base shear even for the column flange type model (Model 3).

### *B. Shear Force and Bending Moment calculation*

Maximum shear force and bending moment in any building is responsible for the stability of the members of any structure. The Shear force and bending moment are useful parameters for design of any member of the structure. The least the moment the lesser will be the cost ofstructure.

It is clear that when the model 2 and model 3 are compared with model 1, there is percentage decrease in shear force. Using graphical representation of the table.

From the table it is clear that when the model 2 and model 3 are compared with model 1, there is percentage decrease in shear force in "Y"- direction and increase in "Z"-direction. Also for model 3 there is reduction in bending moment percentage than in case of model 3. Thus it shows that model 3 is most preferable.

### *C. Maximum Node Displacement*

Node displacement of any structure represents the deflection of the structure whenever any load or load combination is applied on the structure. Since the building is analyzed for Earthquake resistance, displacements in all the three directions are shown in Table Maximum displacements in "X"- Direction and "Z"- Direction for load combinations are stated in the table.

## III. CONCLUSIONS

Three different models are studied in this present research. A building with moment resisting frame named as model 1, for the same building shear walls are introduced symmetrically concentrically at outer edge and named as model 2, third type of model named model 3 is newly introduced as column flange type providing opening for shear wall. STAADPro software is used for analysis and the results obtained were satisfactory and following are the concluded remarks that can be established from the results.

A. Lateral force or storey shear at each consecutive storey level for model 1 is more as compared to model 2 and model 3. Model 3 has least lateral force on consecutive storeys as compared to model 1 and model 2.

B. Approximately on an average 10% lateral force or storey shear is decreased by introducing Shear wall for same configuration as of model 1. Model 2 and Model 3 have 10% less storey shear as compared to Model 1.

C. Base shear for model 1 is higher than model 2 and model 3. Approximately 10% decrease in base shear is calculated after introducing shear wall (Model 2) and flange column (model 3).

D. Storey shear and base shear in both the directions

E. i.e. along X-direction and along Z-direction for model 2 and model 3 are decreased by nearly same amount i.e. approximately 10% when compared to model 1.

F. Model 2 and model 3 shows 2% - 3% reduction in axial force when compared with Model 1.

G. The parameter shear force shows decrease in X- direction and increase in Y-direction for model 2 and model 3 as compared to model 1.

H. The parameter of bending moment shows increase in Z-Direction and reduction in Y-direction. For model 2 and model 3 when compared with model 1.

I. There is a pattern of reduction in node displacement for model 2 and model 3 when compared with model 1. This briefly states that the building is stiff with shear walls and column flanges. Whereas the model 3 becomes economical as the concrete is reduced being approximate similar stiffness is acquired due to less consumption of concrete.

## IV. ACKNOWLEDGMENT

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## REFERENCES

1) B. Ramamohana Reddy, M. Visweswara Rao, "Earthquake resistant design of a building using shear wall". IJMETR, Volume no: 2 (2015), Issue no: 10,October 2015, ISSN no: 2348-4845.

2) P. P. Chandurkar, Dr. P. S. Pajgade, "Seismic analysis of RCC Building with and without shear wall". IJMER, Vol.3, Issue 3, May-june 2013,pp-1805-1810,2013.

3) Manoj S. Medhekar, Sudhir K. Jain, "Seismic behaviour design and detailing of RC shear wall, Part 1: Behaviour and Strength" . The Indian Concrete Journal, July 1993.

4) Venkata Sairam Kumar.N, Surendra Babu.R, Usha Kranti.J, " Shear Wall- A Review". IJIRSET, Vol. 3, Issue 2, February 2014, ISSN: 2319-8753.

5) Bhruguli H. Gandhi, "Effect of opening on behaviour of shear wall". IJTRE, Volume 3, Issue 4, December-2015, ISSN: 2347 – 4718.

6) S. M. Khatami, A. Kheyroddin "The Effect of Flange Thickness on the Behavior of Flanged- Section Shear Walls". ELSEVIER, Procedia Engineering 14 (2011) 2994–3000.

7) Shyam Bhat M, N. A. Premanand Shenoy, Asha U Rao, "Earthquake behaviour of buildings with and without shear walls". IOSR-JMCE, e-ISSN: 2278-1684.

8) Vinoth Kumar M, Ramesh B, Senthil Kumaran N.S, "Influence of Shear Wall and Coupling Beam Dimensions on Seismic Behaviour". JCHPS Special, Issue 6, November 2016, ISSN: 0974-2115.

9) Vishal A. Itware, Dr. Uttam B. Kalwane, "Effects of Openings in Shear Wall on Seismic Response of Structure". IJERA, Vol. 5, Issue 7, (Part - 1) July 2015, pp.41-45, ISSN : 2248-9622

10) S.Saileysh Sivaraja, S. Sengolmurugan, Seismic Behavior of Structures with Moment Resisting Frame (MRF) and Shear Wall (SW) IJTRD, Volume 4(1), Jan-Feb 2017, ISSN: 2394-9333.

11) V. R. Murty, Rupen Goswami, A. R. Vijayanarayanan, Vipul V. Mehta, "Earthquake Behaviour of Buildings". GSDMA, Government of Gujarat, September 2012.

12) S.K. Duggal, "Earthquake Resistant Design of Structures", Second Edition, 2013, Oxford University Press, ISBN- 0-

19-808352-1

13) IS 13920, (1993), "Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces," Bureau of Indian Standards, New Delhi.

14) IS 875 (Part 2):1987, Code of Practice for design loads for buildings and structures, Second revision. Bureau of Indian Standards, New Delhi.

15) IS 1893:2002 (Part 1), Criteria for earthquake resistant design of structures, Fifth revision. Bureau of Indian Standards, New Delhi.

16) IS 456:2000, Plain and reinforced concrete code of practice, Fourth revision, Bureau of Indian Standards, New Delhi.