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Comparing the Effect of Earthquake on High Rise Buildings With & Without Shear Wall and Flanged Concrete Column Using STAAD Pro

Sumit A. Paul[1], Amey R. Khedikar[2]
[1]*M-Tech Research Scholar (Structural Engineering), Department of Civil Engineering, Tulsiramji Gaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, MH.* sumitpaul393@gmail.com
[2]*Asst. Professor, Department of Civil Engineering,*
Tulsiramji Gaikwad-Patil College of Engineering and Technology, Mohgaon, Nagpur, MH.

Abstract: *The earthquake never kills people, but the defective structures. The stability and rigidity of any structure is the main concern in every high-rise building. Partitions are structural elements that resist lateral forces that dominate the resisting frame at the moment. The shear walls are the most preferred structural walls for earthquake resistance. This research concerns the comparison of the shear wall speed structure with durable construction time type. The present study states three type of model, moment resisting frame i.e. model I, Shear wall building concentrically located along X- axis on outer periphery of building i.e. model II and concrete column flange concentrically located on outer periphery along the X-axis i.e. model III. Model of the three structures with same loading were created on STAAD Pro and were analyzed and further they were compared for their suitability. For the construction of 10 floors and 5 bays along the X axis of 4 m each and 5 bays along the Z axis of 4 meters each were considered and loads were applied as per IS specification.*
The analysis was conducted as per the specifications of IS 13920, IS 1893, IS 875, IS 456. From The result shows a decrease of approximately 60% in Lateral storey shear and Base shear when the moment resisting frame was introduced with shear wall. Thus, the model II and model III possessed 55% less lateral force and base shear as compared to the model I. The results of the Axial force, bending moment, Node displacement were found satisfactorily less than the moment resisting frame. If cost is been compared, then model III can be stated as economical in all sense since for the same configuration and load it greater stability and stiffness as checked from the node displacement results.
Keywords: *RC Shear wall, Flanged concrete column, Analysis and Comparison, STAAD Pro V8i SS5, Lateral Forces and Earthquake Loading.*

I. Introduction

Earthquakes are the most deadly natural disasters that occur on earth. Some of the earthquakes of the past had severely destroyed the structures on earth; Build by the human being for their livelihood. Safety and suitability are the concern behind structures so designed resistant to earthquakes. Moreover, the earthquake never kills people, weak structures do it. The earthquakes are vibrations or oscillations of the surface of the ground caused by the temporary disturbance of the elastic or gravitational equilibrium of the rocks at or below the earth's surface. These disturbances and movements cause impulses or elastic waves. These waves are known as seismic waves and are classified as waves of the body (travel within the terrestrial body and surface waves) on the earth's surface. Based on the acceleration or movement in the ground, there are some areas of the earth, called seismic zones. In India there are four zones II, III, IV, V, the last one is the most devastating.

At any particular point, ground acceleration can be described by horizontal components along two perpendicular directions and a vertical component. In most cases, only the structural response to the horizontal components of soil movement is considered, as buildings are not sensitive to horizontal or lateral distortions. In almost all earthquake design practices, the structure is analyzed as an elastic system; It is recognized that the structural response to strong earthquakes implies the performance of the structure, so the answer is inelastic. The effect of yielding in a structure is double. On the one hand, the rigidity is reduced so that the displacements tend to increase. The properties of a building are lateral stiffness, lateral resistance and ductility. The design of buildings resistant to earthquakes depends largely on the ductility to accommodate the displacement load imposed on the structure. Shear wall is a structural element located at different points of a building from the level of the foundation to the level of the upper parapet, used to withstand lateral forces, i.e. parallel to the plane of the wall.

Based on materials used for construction shear walls are classified as follows,

1. RCC Shear Wall
Consists of reinforced concrete slabs and walls. The wall thickness is more than 200 mm, depending on the number of floors, the age of the building and the thermal insulation requirements.

2. RC Hollow Concrete Block Masonry Wall
The RHCBM walls are built by reinforcing the masonry of empty concrete blocks, taking advantage of the empty spaces and the shapes of the hollow blocks.

3. Steel Plate Shear Wall
In general, the sheet steel shear wall system consists of a sheet steel wall, contour columns and horizontal joists. Together, the steel plate wall and the boundary columns act as a vertical plate beam. The main purpose of providing such flanges in the column is to reduce the displacement of the joint and to avoid the formation of plastic hinges near the support. This will help to improve the rigidity of the structure and allow access to the building from opening.

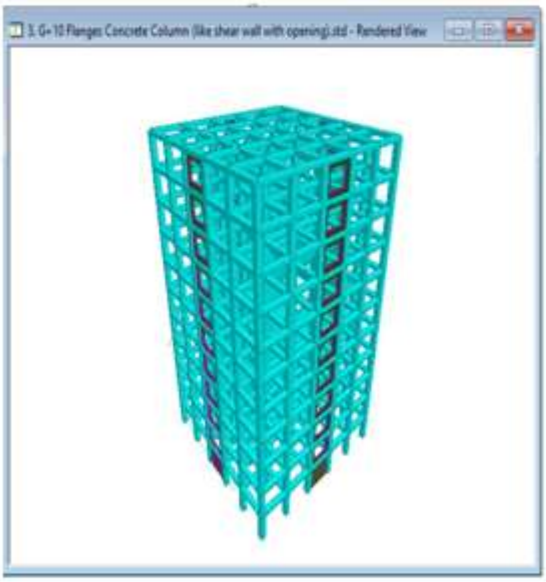


Figure 1: - Column with flange or Flanged column

1.1. Objectives:
The primary objectives of this project can be summarized as follows:
1. To analyze an earthquake resistant structure.
2. To analyze same structure with rectangular shear wall for earthquake resistance.
3. To analyze same structure column and beam structure with flanges to the column as shear wall in other words we can say it shear wall with opening. 4. Comparing the effect earthquake forces for shear wall building and flanged column building.
5. Establishing a comparison between the three types of structure and analyzing the result and establishing a needful resemblance with effectiveness.

II. Literature Review

Concrete shear walls are the most common and useful shear wall for any multi-story building. Many researchers and scholars have studied the configuration of the shear wall in any building and type of shear wall. The ability of the shear wall to withstand the lateral forces generated by the earthquake and wind force is studied. An effort was made to study these literatures and conclude on this subject.

B. Ramamohana Reddy[1] Analysis of the STADD. Pro shear wall earthquake-resistant structures. Software STADD. Pro. The construction behavior has been verified to determine the stiffness factor, the reactions, the shear wall center, the shear force and the bending moment. The analysis of the position of the shear wall in a multi-storey building based on its elastic, elastic and plastic behaviors was also considered. The earthquake load was calculated and applied for the same building with 3 spans and 3 floors. The model results were obtained and analyzed for the actual position of the shear wall. They compared the result and found that the supply of the shear wall in the building will make the structure completely resistant to the earthquake in

Zone II and that the results of STAAD Pro and Manual will be almost the same, the STAAD. Pro. Professional results save a significant amount of reinforcement.

P. P. Chandurkar[2] Modeling and analysis of a building with and without Shear wall in ETABS Software and the results were compared. According to his study, the main objective was to determine the solution for the location of the shear wall in multi-storey buildings. The effectiveness of the shear wall has been studied with the help of four different models. One model was the bare-frame structural system and three other models were of a double-type structural system. When the earthquake load was applied to the ten-storey building located in zone II, zone III, zone IV and zone V, in both cases parameters such as lateral displacement, historical drift and total cost required for the ground floor. column with shear wall. They observed that in a 10-storey building, the shear wall in a short section in the corner (model 4) is cheap compared to other models. Therefore, a large size of the shear wall is not effective on 10 floors or under 10-storey buildings. They observed that the shear wall is cheap and effective in high-rise buildings.

Alokkumar A. Mondal[3] Masonry structure shear with respect to the type of resistant construction STAAD. Pro. They presented three types of models, the current-resistant frame, the model 1, the construction of a shear wall positioned concentrically along the X axis in the outer periphery of the building, i.e. the model 2 and the flange of the positioned concrete column concentrically in the outer periphery along the X axis, i.e. the model 3. The models of the three structures with the same load were created in STAAD. Pro and analyzed and compared to determine their suitability. For the construction of 10 floors and 3 bays along the X axis of 4 m each and four bays along the Z axis of 4 meters each were considered and loads were applied as specified by IS. The analysis was performed according to the IS specifications 13920, IS 1893, IS 875, IS 456. It was found that there is a decrease of about 10% in shear the side platform and shear the base when the frame is resistant to moment it was introduced with a wall cut. Therefore, model 2 and model 3 had 10% less lateral force and basic shear compared to model 1. Moreover, the results of the axial force, the bending moment, the node displacement were satisfactorily lower than the frame resistant to the moment. Model 3 proved to be economical.

III. 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 analyse and design any 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	Grade of concrete	M30
2	Grade of steel	Fe415
3	Number of bays in X direction and its width	5 bays of 4 m each
4	Number of bays in X direction and its width	5 bays of 4 m each
5	Number of bays in Z direction and its width	5 bays of 4 m each
6	Story height	3 m each
7	Number of storey (Excluding the plinth and substructure and including the Ground floor)	10
8	Depth of foundation from ground level	2.2 m
9	Plinth height	800 mm
10	Column size	600 mm x 600 mm
11	Beam size	400 mm x 600 mm
12	Thickness of Slab	150 mm
13	Density of concrete	25 kN/m^3
14	Live load on roof	1.5 kN/m^2
15	Live load on floors	3 kN/m^2

16	Floor finish	1 kN/m^2
17	Brick wall on peripheral beams	230 mm
18	Brick wall on internal beams	115 mm
19	Density of brick wall	20 kN/m^3
20	Internal Plaster	12mm
21	External Plaster	15mm
22	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, 13920-1993 and IS 456:2000. Since Delhi is less vulnerable to earthquakes, for this present study assigning zone IV for moderate seismic intensity as stated in table 2 of IS 1893 – 2002.

Table 2: Seismic Parameters

1	Zone factor for zone IV	0.24 (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 ordinary shear wall with SMRF	4
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. 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 2 shows plan of the structure generated in STAAD Pro V8i SS5. Following are the models generated.

i. Model I: Simple structure without any shear wall. Figure 2 (Model I) illustrates this model. In this model all the parameters are considered for designing the structure as earthquake proof as per IS1893:2002.

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

iii. Model III: 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 II but only difference is the shear walls provided are having opening seems like flanges to the column.

2. Calculation of Load and Earthquake related Parameters: -

i. Dead load of slab = (0.15 x 1 x 25)
= 3.75 kN/m2

ii. Dead load of Outer Brick wall can
be calculated as = (0.23) x (3-0.6) x 20
= 11.04 kN/m

iii. Dead load of Inner Brick wall can

be calculated as = (0.115) x (3-0.6) x 20
= 5.52 kN/m

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

v. Dead load of Plaster for outer walls can
be calculated as = (0.015+0.012) x (3-0.6) x 18
= 1.17 kN/m

vi. Dead load of Plaster for inner walls
and parapet wall can be calculated as
= (0.012+0.012) x (3-0.6) x 18
= 1.04 kN/m

vii. Total Dead Load for outer walls
= 11.04 +1.17 = 12.21 (considering 85% of weight due to openings) i.e. 10.38 kN/m

viii. Total Dead Load for inner walls
= 5.52+1.04 = 6.56 kN/m (Least openings are there in Partitions)

ix. Total Dead Load for Parapet walls
= 4.6 +1.04 = 5.64 kN/m

3. Seismic Weight Calculation: As per Table 8 in Clause 7.3.1 of IS 1893 (Part 1):2002 “Percentage of Imposed Load to be considered in Seismic Weight calculation” (As per the norms given in the IS 1893 (Part 1):2002 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).

i. Total Seismic weight floors = 3.75 + (0.25 x3)
= 4.5 kN/m2

ii. Total Seismic weight roof floors = 3.75 kN/m2

iii. STAAD Pro V8i SS5 calculates the design base shear by adding some useful parameters during analysis.

The fundamental natural period of vibration (Ta) is calculated by

$T_a = 0.09h/\sqrt{d}$, Where, “h” = height of building and “d” = width of building at plinth height in a particular direction

a) Hence along X- Direction, $T_a = 0.09h/\sqrt{d} = 0.09 \times 30/\sqrt{20} = 0.604$

b) Along Z- Direction, Ta = = $0.09h/\sqrt{d} = 0.09 \times 30/\sqrt{20} = 0.604$

Model I

Model II

Model III

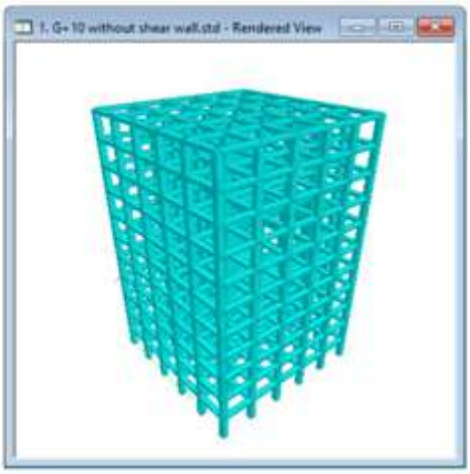


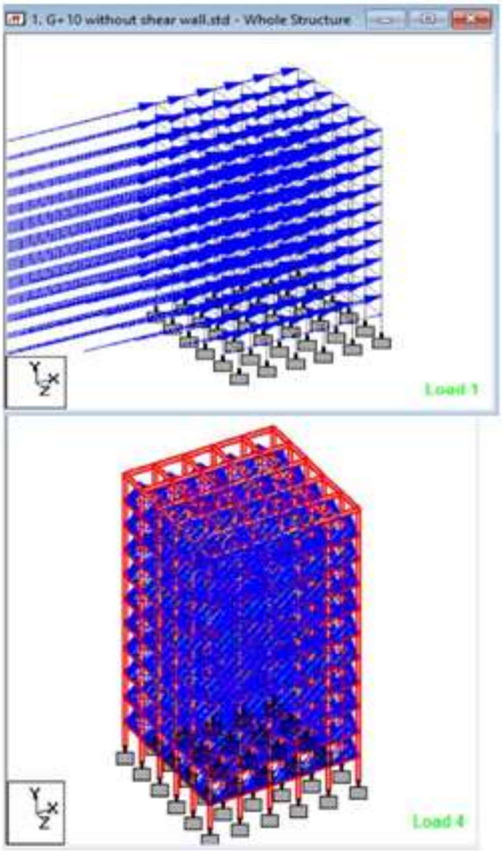
Figure 2: - Models generated in STAAD Pro V8i SS5 for the Problem Statement.

4. Loadings and Analysis Loads as mentioned above are added and generated in STAAD Pro V8i SS5 for earthquake analysis and applied to the prepared models as shown in figure 2.

Dead Load

Live Load

Roof Live Load
Earthquake Load in +ve X- Direction



Earthquake Load in +ve X- Direction

Figure 3: - Load distribution for Model I (STAAD Pro V8i SS5 model)

Loads as mentioned above are added and generated in STAAD Pro V8i SS5 for earthquake analysis and applied to the prepared models as shown in figure 2. The wall loads (Member loads) are same for all the floors except roof floor.

Load Combination along -ve X- direction for Model I
Load Combination along +ve X- direction for Model I
Earthquake load on Model II along +ve
X- direction
Earthquake load on Model II along +ve
X- direction
Figure 3.1: - Dead load, live load and seismic load (STAAD Pro V8i SS5 model).

A plan generated in STAAD Pro V8i SS5 and the floor loads distributed on the respective beams on each floor as per the guidelines of IS 456: 2000 shown in figure 4. All the models are same in size and height except the introduction of shear wall and column flange in model II and model III respectively.

Plan of building without loading
Plan of building with load distribution

Figure 4: - Plan of building with and without loading distribution generated in STAAD Pro V8i SS5.

IV. 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 IV is modelled using STAAD Pro V8i SS5 software and the results are computed. The configurations of all the models are discussed in previous chapter. Three models were prepared based on different configuration, Model I for non-shear wall type of multistoried building, Model II for same building with Shear wall type and model III for same building with Column flange type. These models are analyzed and designed as per the specifications of Indian Standard codes IS1893, IS 13920, IS 875 and IS 456: 2000.

1. Lateral Force and Base Shear

Elements or members of building should be designed and constructed to resist the effects of design lateral force. STAAD Pro V8i SS5 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 STAAD Pro V8i SS5. 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 II and model III, when compared with model I, shows that there is approximate decrease of 60% for both the models.

Table 3: Lateral Force At Different Floor Level Along X-Direction

Fl. Ht.	Lateral Force			% force decrease from model I	
	Model I	Model II	Model III	Model II	Model III
33	75.81	33.35	38.08	56.01	49.77
30	73.43	30.74	36.26	58.13	50.62
27	69.50	27.83	33.77	59.95	51.40
24	64.00	24.66	30.67	61.49	52.12
21	57.18	21.25	27.03	62.82	52.73
18	49.31	17.66	22.95	64.19	53.44
15	40.69	13.97	18.58	65.65	54.32
12	31.56	10.33	14.03	67.25	55.52
9	22.19	6.909	9.461	68.86	57.36
6	12.91	3.887	5.029	69.91	61.07
3	4.583	1.463	1.279	68.07	72.09
Average Percentage (%)				63.86	55.49

Figure 5: - Lateral force or storey shear along X-direction throughout the height.

Figure 5 shows a graph of storey height versus Lateral force in X-Direction and it is evident that the lateral force for Model I, Model II, and Model III differs from each other storey wise. Lateral force or storey shear for model I, model II and model III are different and approximately 60% decrease in lateral force for model II and model III is seen at each storey level when compared with model I.

Table 4 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 60% reduction in the base shear for model II and model III when compared with model I. The values for each storey is cumulative of top storey thus it differs from storey to storey.

Table 4 Base Shear At Different Floor Level Along X Direction

Fl. Ht.	Base Shear			% force decrease from model I	
	Model I	Model II	Model III	Model II	Model III
33	75.81	33.35	38.08	56.01	49.77
30	149.2	64.09	74.34	57.05	50.2
27	218.7	91.93	108.1	57.98	50.57
24	282.7	116.6	138.7	58.76	50.91
21	339.9	137.8	165.8	59.45	51.22
18	389.2	155.5	188.7	60.14	51.50

15	429.9	169.4	207.3	60.58	51.77
12	461.5	179.8	221.4	61.03	52.03
9	483.7	186.7	230.8	61.39	52.27
6	496.6	190.6	235.9	61.61	52.50
3	501.2	192.0	237.1	61.67	52.68
Average Percentage (%)				59.61	51.40

Figure 6: - Base shear along X-direction throughout the height storey wise.

Figure 6 shows base shear along X-Direction storey wise. As tabulated above the values are graphically represented in the figure 6. After introducing shear walls the base shear is reduced by 55%. 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 III).

V. Conclusions

Three different models are studied in this present research. A building with moment resisting frame named as model I, for the same building shear walls are introduced symmetrically concentrically at outer edge and named as model II, third type of model named model III is newly introduced as column flange type providing opening for shear wall. STAAD Pro V8i SS5 software is used for analysis and the results obtained were satisfactory and following are the concluded remarks that can be established from the results.

1. Lateral force or storey shear at each consecutive storey level for model I is more as compared to model II and model III. Model III has least lateral force on consecutive storey as compared to model I and model II.
2. Approximately on an average 60% lateral force or storey shear is decreased by introducing Shear wall for same configuration as of model I. Model II and Model III have 60% less storey shear as compared to Model I.
3. Base shear for model I is higher than model II and model II. Approximately 55% decrease in base shear is calculated after introducing shear wall (Model II) and flange column (model III).
4. Storey shear and base shear in both the directions i.e. along X-direction and along Z-direction for model II and model III are decreased by nearly same amount i.e. approximately 55% when compared to model I.
5. Model II and model III shows 2% - 3% reduction in axial force when compared with Model I.
6. The parameter shear force shows decrease in X-direction and increase in Y-direction for model II and model III as compared to model I.
7. The parameter of bending moment shows increase in Z-Direction and reduction in Y-direction. For model II and model III when compared with model I.
8. There is a pattern of reduction in node displacement for model II and model III when compared with model I. This briefly states that the building is stiff with shear walls and column flanges. Whereas the model III becomes economical as the concrete is reduced being approximate similar stiffness is acquired due to less consumption of concrete.

VI. Scope For Future Work

1. Construction of shear walls gives all time protection for the building not only while the times of earthquakes but also against vibrations created by blasts in quarry’s and also even if the capacity of the building is to be increased shear walls give enough strength and can confidently raise the building to another floor Shear walls are considered to be a gift to the future construction industry.
2. Where the lateral loads are most predominantly wind and earth quake loads. And predominantly earthquake loads are more intense in their effect on the building structures.
3. Therefore, there is lot of scope for future study in flanged concrete column and shear walls. The shear walls can be designed and provided for the existing buildings having more than 3 floors.
4. Further various design methods of shear walls can be studied. The various shapes and thickness of shear walls can be studied. Different locations can be studied. Provision of shear walls with different materials can be studied.

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References

[1]. B. Ramamohana Reddy, M. Visweswara Rao, “Earthquake Resistant Design of a Building Using Shear Wall”, International Journal & Magazine of Engineering, Technology, Management and Research (IJMETMR), ISSN No: 2348-4845, Vol. 2, Issue 10, October 2015, pp.415-421.

[2]. P. P. Chandurkar, Dr. P. S. Pajgade, “Seismic Analysis of RCC Building with and Without Shear Wall”, International Journal of Modern Engineering Research (IJMER), ISSN No: 2249-6645, Vol. 3, Issue. 3, May - June 2013, pp.1805-1810.

[3]. Alokkumar A. Mondal, Miss. Deepa Telang, Mrs. Gitadevi. B. Bhaskar, “Comparing the Effect of Earthquake on High-Rise Building with Shear Wall and Flange Concrete Column”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN No: 2321-9653, Vol. 5, Issue. 7, July 2017, pp.697-711.

[4]. Mr. Alokkumar A. Mondal, Mrs. Gitadevi B. Bhaskar, Miss. Deepa. Telang, “Comparing the Effect of Earthquake on Shear wall building and Non-Shear Wall Building – A Review”, International Research Journal of Engineering & Technology (IRJET), e-ISSN No: 2395-0056, p-ISSN No: 2395-0072, Vol. 4, Issue. 6, June 2017, pp.3286-3289.

[5]. Shyam Bhat M, N. A. Premanand Shenoy, Asha U Rao, “Earthquake Behaviour Of Buildings with And Without Shear Walls”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN No: 2278-1684, p-ISSN No: 2320-334X, 2015, pp.20-25.

[6]. Ali Fathalizadeh, “Introducing two most common types of shear walls and their construction methods”, Journal of Civil Engineering Researchers (JCER), February 2017, pp.7-12.

[7]. Bhruguli H. Gandhi, “Effect of Opening on Behaviour Of Shear Wall”, International Journal for Technological Research in Engineering (IJTRE), ISSN No: 2347 – 4718, Vol. 3, Issue. 4, December 2015, pp.875-878.

[8]. Venkata Sairam Kumar, Surendra Babu, Usha Kranti, “Shear Walls- A Review”, International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), ISSN No: 2319-8753, Vol. 3, Issue. 2, February 2014, pp.9691-9694.

[9]. S.K. Duggal, “Earthquake Resistant Design of Structures”, Second Edition, 2013, Oxford University Press, ISBN- 0-19-808352-1.

[10]. IS 875 (Part-1,2,3 & 4), “Code of Practice for Design Loads (Other Than Earthquake) For Building and Structures”, Dead loads, New Delhi, 1987.

[11]. 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.

[12]. IS 1893:2002 (Part 1), “Criteria for Earthquake Resistant Design of Structures”, Fifth revision, Bureau of Indian Standards, New Delhi.

[13]. IS 456:2000, “Plain and Reinforced Concrete Code of Practice”, Fourth revision, Bureau of Indian Standards, New Delhi.