To Analyze The Different Types of Multi Storey Buildings With or Without Shear Wall Under Seismic Load

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Abstract- *In the seismic design of buildings, reinforced concrete structural walls, or shear walls, act as major earthquake resisting members. Structural walls provide an efficient way to resist lateral load. Shear wall systems are one of the most commonly used lateral load resisting systems in high-rise building. It have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. Dynamic analysis should be performed for regular and irregular buildings in zone IV. Dynamic analysis can take the form of a full nonlinear dynamic time history analysis or of a linear response spectrum analysis. An earthquake load is calculated by dynamic method using is 1893 (part–I):2016. These analyses were performed by using staad pro. For G+19 story. Dynamic responses under prominent earthquake, six different cases of shear wall position for a g+19 storey building have been analyzed. Model is based on bare frame structural system and dual type structural system. Parameters like lateral displacement, story drift and drift reduction factor and base shear.*

Keywords*:* staad.pro v8i, shear wall, seismic analysis, IS 1893 (part-1)-2016, Storey drift, base shear.

I. INTRODUCTION

An earthquake might be characterized as the release of elastic energy by a sudden slip on a fault and coming about ground shaking and transmitted caused by slip. It is a standout amongst the most devastating natural hazards normal perils that reason extraordinary death toll and livelihood. The greater part of the misfortunes is because of building collapse or damages. An Earthquake can cause harm not just by virtue of vibrations which comes about because of them yet in addition because of other chain impacts like landslides, surges, fires, and so on. An extensive structural analysis of a multi-storied building is dependably a mind boggling undertaking, particularly for a high rise building having plan irregularities.For an irregular building having plan irregularities, it is important to use the dynamic method of analysis to get the reaction parameters. For sure, the reaction of any building under the action of seismic forces is exceptionally complex and Response spectrum method of analysis ends up being a superior choice to acquire the reaction of the structure under the activity of seismic forces. The important earthquake resistant ability in a multi-storied building can be accomplished by giving sufficient stiffness, strength and ductility in the building and shear wall gives an ideal mean for accomplishing the fundamental criteria of design. Shear wall is an element which acts as a vertical cantilever used generally in multi storied building to resist lateral forces like wind, storm, and earthquake. These walls are in general continuous element starting from the foundation and go up to the highest point of the building. However, it may also be curtailed at intermediate height. Shear wall is able to resist the combination of shear, moment and axial load induced by lateral load and gravity load transferred to it through other structural members. For buildings over 30 stories, shear wall has been an essential element to ensure economy and minimize the lateral deflection. When shear wall is used along with moment resisting frame in a structure, it is called dual structural system and in this system the loads are resisted by both frame & Shear wall. The Contribution of Shear wall in resisting overturning moments, storey shear and storey shear forces depends upon the geometric configuration, materials used, orientation and location within the plane of the building.

1.1 SHEAR WALL

Shear wall is an assistant part used to contradict parallel powers for instance parallel to the plane of the wall. For thin walls where the bowing contorting is more, Shear wall restricts the stacks as a result of Cantilever Action. All things considered, Shear walls are vertical parts of the level power contradicting system.

In structure improvement, an inflexible vertical stomach fit for moving even controls from outside walls, floors, and housetops to the ground foundation toward a way parallel to their planes. Models are the braced strong wall. Sidelong powers realized by wind, seismic tremor, and uneven settlement loads, despite the largeness of structure and occupants; make stunning twisting (torsional) powers. This prompts the mistake of the structures by shear.

Shear walls are especially critical in tall structures subject to sidelong wind and seismic forces. All things considered, shear walls are either plane or flanged in region, while focus walls involve channel portions. They similarly give tasteful quality and immovability to control sidelong migrations.

1.1.1 Earthquake load Resisting Mechanism of shear wall

Utilization of shear walls gives an effective solution to stiffen a structural system of a building as it increasses the rigidity against horizontal load acting up on the building. Shear wall essentially increases the stiffness and strength of the building toward its orientation. This outcomes in checked decrease in lateral sway of the building. By and large the Shear wall transfers the load to the next component beneath it in the load path. It helps in reducing the side sway of the above individuals like roof or floor. It also keeps the floor and roof framing individuals from moving off their supports when they are stiffened enough and furthermore diminishes the non structural damages.

PERFORMANCE OF RC FRAMES WITH AND WITHOUT SHEAR WALLS DURING WENCHUAN EARTHQUAKE

1.3.1 Weak-beam and Strong-column

Little damage to second-body beams within the Wenchuan earthquake epicentre location turned into found with the aid of the reconnaissance crew because columns were generally weaker than beams. However, one of the necessities in designing ductile frames is powerful-column and weak-beam, in step with the current code for seismic layout, this is, most structures are designed to have sufficient ductility to survive an earthquake. This manner that elements will yield and deform, but they will be study in shear and retain to assist their load all through and after the earthquake. The reconnaissance team toured a number of body buildings and found that many frame homes collapsed due to weak-column and strong-beam in the epicentre vicinity. It became concluded that the RC slabs that had been solid monolithically with the beams performed a critical role to make a contribution to the stiffness of the beams whilst the structure was shaken under the earthquake movement.

1.3.2 Soft Storey Due to Effect

Many residential and industrial buildings inside the epicentre location skilled excessive harm to the primary storey generally, the ground storeys of these homes had been used for industrial area or as parking area and the top testimonies had been used as residential residences. Hollow clay tiles and gasoline-concrete masonry infill partitions are extensively used in the epicenter vicinity of Wenchuan earthquake. In Dujiangyan region, some of these homes had less, even no infill partitions (or different strong and stiff lateral load resisting elements, e.g. (Shear walls or robust columns) inside the first storey to increase the parking or industrial spaces. However, such buildings had many infill walls in two orthogonal directions as partitions in the upper tales to define residential areas. Such an arrangement of tiles infill partitions created stiffness discontinuities in these buildings, which may additionally have contributed to their crumble via concentrating the go with the flow demands in the first storey. The excessive in-plane stiffness of the masonry infill walls, which is advanced by diagonal compression strut motion, can drastically affect the reaction of the greater bending moment-resisting RC or metallic bounding frames. It was observed that damage to masonry infill walls was concentrated in the lower storeys of buildings.

1.2 OBJECTIVE OF STUDY

Main objective of the present work is to evaluate the performance of an RC building having plan irregularities using response spectrum method of analysis to study the effect of providing shear wall on the performance of the building under seismic loading in seismic zone IV. The specific aims and objectives of the project can thus be summarised as:-

- Structural analysis of six different cases of a G+19 building with and without shear wall in seismic zone IV of India, having different configurations viz. (i) Regular building having rectangular configuration. (ii) Irregular building having L shape configuration and (iii) Irregular building having irregular grid formation of beams and columns.
- Working out the Inter-storey drift, Drift Reduction factor and Base shear.
- Comparing the response parameters to study the effect of irregular configuration on the performance of building under the action of earthquake load and also the effect of providing shear wall in seismic zone IV.

1.3 SOFTWARE USED

Analysis of all the models is carried out with the help of STAAD-Pro software. STAAD is a powerful Building information modeling and design software licensed by Bentley. STAAD stands for structural technique for analysis and design which addresses all aspects of structural engineering i.e. model development, analysis, design, verification and visualization. This is based on the principles of concurrent engineering. One can build his model, verify it graphically, perform analysis and design, review the results, sort and search the data and can create a report within the same graphics based environment. Following are the main options available from the concurrent graphics environment.

1. STAAD-Pro Analysis and design.
2. STAAD-Pre Graphics Input Generation.
3. STAAD-Post Graphical Post processing.

II. LITERATURE SURVEY

R.S. Malik et al [2011] studied the seismic response of the framed form with curtailment of shear walls (furnished at the outermost frame panels) & impact of top on such curtailments taken into consideration three houses having everyday plan with diverse amount of storeys viz. 10, 20 & 30. The assessment turned into done with 3-d models in STAAD for shear wall as lots as 50% constructing top to shear wall as tons as full peak, developing the height in steps of 10% of widespread building top respectively.

N Sivakumar et al [2014] referred to the opportunities of modelling reinforcement detailing of strengthened concrete shear wall fashions in sensible use to explain the behaviour of composite bolstered concrete material. Shear wall have become modelled on ANSYS the use of strong 65 factors (eight nodded solid elements able to cracking and crushing) in methods. (1) Shear wall with discrete reinforcement assets and (2) Shear wall with smeared reinforcement property, every subjected to in plane static loading.

Zheng Ping Wu [2014] placed out in his research that using superior modal reaction spectrum techniques, the contemporary workout of the brand new Zealand standards and the hints/regulations of the national and local authorities, this paper present the investigations at the homes subjected to seismic damages and proposes respective strengthening methodologies. Engineering cases have been investigated.

Venkatesh S.V & H. Sharada Bai [2015] considered unique system for a ten storey constructing viz. (1) easy 2nd resisting framed shape and (2) framed structure furnished with unique forms of shear wall (internal and out of doors) to have a look at the effect of shear wall and its orientation thru numerous parameters like most joint displacement, support response, column forces, beam forces, precept stresses and shear stress.

Sumit Singh Bhadauria & Rashmi Singh[2016] In this study we have considered shear wall system for the stability of structure against lateral forces. Shear wall is a vertical member which can resist moment, shear and axial load arising due to gravity and lateral loads. In this study we have placed shear wall at different orientation or position and identified the best position of shear wall in the building by analyzing the results in terms of storey drift, lateral displacement and base shear. For the analysis we have prepared 4 models of building with G+12 storey height with different position of shear walls. We have analyzed all the models by response spectrum method of seismic analysis in STAAD.Pro v8i software. The comparison of all four models with different location of shear wall has been done with respect to story drift, base shear and lateral displacement. Maximum storey drift in X direction is 21.351 mm in model 1(Shear wall in longitudinal direction at outer periphery). Minimum storey drift in X direction is 0.841 mm in model 2 (Shear wall in transverse direction at middle of outer periphery).

III. METHODOLOGY

A building is said to be irregular if it posses plan irregularities (if structural elements cannot be arranged in proper grid) or vertical irregularities, which is due to the presence of soft storey in high rise buildings [as per clause 7.1, IS 1893 Part (I)]. This work aims to study the seismic performance of the dual structural system of multi-storeys buildings having plan irregularities, which essentially comprises of analysis and comparison of response parameters of the building having regular configuration of rectangular shape without shear wall, with shear wall, irregular building having L shape configuration without shear wall and with shear wall subjected to earthquake loading.

Following major works will be accomplished:-

1) An extensive survey of the literature on shear wall is carried out.
2) Considering six different cases of building having regular and irregular configuration with shear wall and without shear wall.
3) Deciding the design parameters such as size of columns, beams, shear wall, etc. as per the guidelines of IS 1893:2016 (Part 1).

4) Carrying out detailed analysis of bare frame models and dual structural system with shear wall.
5) Plotting curves between storey height and storey drift, base shear, etc.

3.1. DESCRIPTION OF THE STRUCTURE

A building having regular configuration of rectangular shape, a building having irregular configuration of L shape and an irregular building having irregular grid formation of columns and beams are considered to prepare various three dimensional bare frame model and shear wall-frame model of the building. The building is a having a typical floor height of 3 meters. The structure will be analyzed for seismic loads using STAAD.PRO software package.

The following assumptions are considered for the dynamic analysis.

1. All supports are assumed to be fixed.
2. Un-cracked sections for beams and columns are used in the analysis.
3. Shear deformation effects are neglected.
4. The floor diaphragms are rigid enough to distribute uniformly the lateral loads on the vertical elements.
5. The out of the plane deformations are absorbed by rigid horizontal diaphragms.
6. Dead load on all the floors- 4 KN/m2
7. Live load on typical floor- 4 KN/m2
8. Zone factor = 0.24 (for zone iv)
9. Importance factor = 1
10. Response reduction factor = 5
11. Damping = 5 %
12. Medium soil site

3.2. MODELLING APPROACH

The modelling approach includes the preparation of a centreline plan of the irregular building to obtain the coordinates of various joints followed by specifying the nodal co-ordinates data for the development of model using STAAD.PRO. V8i.

3.3. ANALYSIS PROCEDURE

IS 1893(Part I): 2016 recommends the method of dynamic analysis for the following:-

a) Regular buildings- those higher than 40 meters in height in seismic zone IV and V, and those higher than 90 meters in Zone II and III.
b) Irregular buildings- all framed buildings higher than 12 meters in zone IV and V, and those higher than 40 meters in zone II and III.

3.4. RESPONSE SPECTRUM METHOD

The main purpose of the response spectrum method is obtain the design seismic forces, with its distribution to consider one of a type storey ranges alongside the height of the constructing and to the various lateral load resisting element. This technique is based totally on the concept that the dynamic response of the shape may be determined then considering the independent response reaction of every natural mode of vibration after which combining inside the equal manner to compute the complete reaction. For analysis, the mass of the shape is believed to be lumped at the ground ranges and first-class sway displacement is allowed at every storey. Therefore for planer systems, most effective one degree of freedom in keeping with ground and for 3 degree of dimensional assessment three levels of freedom in line with ground i.e. translation and one angle of twist throughout the vertical axis have to be considered.

Step one in the analysis with the aid of using the response spectrum technique is figuring out the lumped hundreds at the floor level due to dead load and suitable quantity of live load. Then the loose vibration assessment of whole constructing will be finished as in step with mounted strategies of mechanics using the appropriate loads and elastic stiffness of the structural system, to obtain natural time period (T) and mode shapes (Ø). The CL. 7.8.4.2 of IS 1893:2002 offers a guiding principle for the wide type of modes to be taken into consideration. As consistent with the clause the wide type of modes to be considered in the method must be such that the sum of model masses of all modes taken into consideration is as a minimum ninety percent of the overall seismic mass. If modes with herbal frequency 33 Hz are to be considered, model mixture ought to be done satisfactory for modes as a whole lot as 33 Hz. The impact of modes with herbal frequency beyond 33 Hz might be covered with the resource of thinking about the missing mass correction. As in step with CL. 7.8.4.5 buildings with everyday and nominal irregular plan configuration can be modelled as a device of hundreds lumped on the ground ranges with every mass having one degree of freedom, which is the lateral displacement within the route underneath attention. After appealing the above circumstance the model mass is calculated using the expression given within the code.

IV. RESULTS

1) Regular building having rectangular configuration without shear wall, termed here as B1(W)
2) Regular building having rectangular configuration with shear wall, termed here as B1(S).
3) Irregular building having L shape configuration without shear wall, termed here as B2 (W).
4) Irregular building having L shape configuration with shear wall, termed here as B2 (S).
5) Irregular building having irregularity in grid formation of column and beams without shear wall, termed here as B3 (W).
6) Irregular building having irregularity in grid formation of column and beams with shear wall, termed here as B3 (W).

EFFECT ON DESIGN BASE SHEAR

Graphical representation showing variation of Base shear and the comparisons made between different cases of the buildings B1, B2 and B2 i.e. without shear wall.

EFFECT ON DRIFT REDUCTION FACTOR ALONG THE HEIGHT

Graphical representation along both the horizontal axis showing variation of drift reduction factor along the building height and the comparisons made between different cases of the buildings B1 and B2 i.e. without shear wall, with shear wall

Building frame without shear walls Considering the importance of storey drift in a building it has been observed from the figures 5.2.1 to 5.2.8, that the storey drift remains well within the permissible limit for B1(W) and B2 (W) for twenty storeys building. It is also observed that the drift in the special moment resisting frame without any shear wall increases with height up to a certain level and then it decreases for both the buildings B1 and B2. The variation of storey drift with storey height in these cases for both the horizontal directions has been observed as follows:

Table 1: Variation of Storey Drift in case of Regular building without shear wall, B1 (W)

B1 (W)	Along X Axis	Along Y Axis
Up to 2nd Storey	2.285 mm to 2.882 mm	0 mm
From 3rd to 20th Storey	2.875 mm to 0.457 mm	0 mm

It has been observed from Table 1, that in case of B1 (W) of twenty storeys, the Storey drift along the horizontal X axis increases with height up to 2nd storey than from 3rd storey onwards it starts decreasing up to 20th storey. Curve along the storey height is parabolic in nature.

It has been observed from Table 1, that in case of B1 (W) of twenty storeys, the Storey drift along the horizontal Y axis is found to negligible. There is no Curve along the storey height.

Table 2: Variation of Storey Drift in case of Irregular building without shear wall B2 (W)

B2 (W)	Along X Axis	Along Y Axis
Up to 2nd Storey	2.207 mm to 2.804 mm	0.013 mm to 0.026
From 3rd to 20th Storey	2.802 mm to 0.483 mm	0.024 mm to 0.022

It has been observed from Table 2, that in case of B2 (W) of twenty storeys, the Storey drift along the horizontal X axis increases with height up to 2nd storey than from 3rd storey onwards it starts decreasing up to 20th storey. Curve along the storey height is parabolic in nature.

It is interesting to observe from Table 2, that in case of B2 (W) of twenty storeys which is an irregular building of L shape, we found some amount of Inter-storey drift along the horizontal Y axis and it increases with height up to 2nd storey than from 3rd storey onwards it starts decreasing up to 20th storey. So, it is evident from above that the Irregular configuration of a building can put impact upon the response parameter.

Table 3: Variation of Storey Drift in case of Irregular building without shear wall B3 (W)

B3 (W)	Along X Axis	Along Y Axis
Up to 6th Storey	3.095 mm to 10.329 mm	0.694 mm to 1.477
From 7th to 20th Storey	10.181 mm to 3.226 mm	1.439 mm to 0.495

It has been observed from Table 3, that in case of B3 (W) of twenty storeys, the Storey drift along the horizontal X axis increases with height up to 6th storey than from 7th storey onwards it starts decreasing up to 20th storey. Curve along the storey height is parabolic in nature.

It is interesting to observe from Table 3, that in case of B3 (W) of twenty storeys which is an irregular building in terms of grid formation of column and beams, we found some amount of Inter-storey drift along the horizontal Y axis and it increases with height up to6th storey than from 7th storey onwards it starts decreasing up to 20th storey. So, it is evident from above that the Irregular configuration of a building can put impact upon the response parameter.

Building frame with shear walls

It has been observed from the figures 5.2.1 to 5.2.6 that the storey drift remains well within the permissible limit for B1 (S) and B2 (S) for twenty storeys building. It is also observed that the drift in the special moment resisting frame with shear wall up to full height increases with height up to a certain level and then it decreases or remains constant for the buildings B1 and B2. The variation of storey drift with storey height in these cases for both the horizontal directions has been observed as follows

Table 4: Variation of Storey Drift in case of Regular building with shear wall B1 (S)

B1 (S)	Along X Axis	Along Z Axis
Up to 14th Storey	0.46 mm to 1.466 mm	0 mm
From 15th to 20th Storey	1.465 mm to 1.377 mm	0 mm

It has been observed from Table 3, that in case of B1 (S) of twenty storeys, the Storey drift along the horizontal X axis increases with height up to 14th storey than from 15th storey onwards it starts decreasing up to 20th storey. Curve along the storey height is parabolic in nature.

It has been observed from Table 1, that in case of B1 (S) of twenty storeys, the Storey drift along the horizontal Y axis is found to negligible. There is no Curve along the storey height

Table 5: Variation of Storey Drift in case of Irregular building with shear wall B2 (S)

B2 (S)	Along X Axis	Along Z Axis
Up to 14th Storey	0.39 mm to 1.308 mm	0.07 mm to 0.203
From 15th to 20th Storey	1.304 mm to 1.23 mm	0.195 mm to 0.167

It has been observed from Table 4, that in case of B2 (S) of twenty storeys, the Storey drift along the horizontal X axis increases with height up to 14th storey than from 15th storey onwards it starts decreasing up to 20th storey. Curve along the storey height is parabolic in nature.

Table 6: Variation of Storey Drift in case of Irregular building with shear wall B3 (S)

B3 (S)	Along X Axis	Along Y Axis
Up to 19th Storey	0.675 mm to 7.073 mm	0.027 mm to 3.725
20th Storey	6.197 mm	3.427 mm

It has been observed from the Table 6 that in case of B3 (S) of twenty storeys, the storey drift along the X axis increases gradually with height up to 18th storey then remains constant up to the 19th storey and then decreases at the 20th storey. Storey drift along the Y axis increases gradually up to the full height of the building.

It can been observed from above Table, that the utilization of shear wall for both the configuration i.e., Regular as well as Irregular configuration helps in Reducing the storey drift up to a greater extent.

It can also been observed from tables above, that for buildings without shear wall the values of inter storey drift for Irregular building B2 (W) is greater than the inter storey drift for Regular building B1 (W) along X axis, hence it can be interpreted that the configuration of a building effects the response parameters, so a regular configuration of a building is better option for greater performance of a building.

For building with shear wall the values of inter storey drift for Regular building B1 (S) is found to be greater than the inter storey drift for Irregular building B2 (S) along X axis, which clearly signify that the if shear wall is placed at a perfect location, it can help in giving strength to a building having Irregular configuration.

Values of Inter-storey drift along Y axis is also observed for building B2 of L shape and B3 having irregular configuration for both the cases i.e. with shear wall and without shear wall, although values of Inter-storey drift is well within permissible limit and also very negligible as compared to values along X axis but it is evident that the irregular configuration of building impacts the response parameters along the Y axis also.

V. CONCLUSION

In view of the study carried out on one building, it is difficult or not fair to give generalized conclusions. However, following are some conclusions made from the study:-

It is observed that the storey drift is well within the permissible limits for all the cases.

Provision of shear wall has helped in reducing the storey drift for Regular building having rectangular shape as well as for irregular building having L shape configuration.

Buildings having shear wall has shown lesser values of storey drift as compared to buildings without any shear wall.

It is observed that the drift in the special moment resisting frame with shear wall up to full height increases with height up to a certain level and then it decreases or remains constant for the both the buildings B1 and B2.

It is evident from above that the Irregular configuration of a building can get inter-storey drift along both the horizontal axis, so it is a better option to provide shear wall along both the axis, and also position of shear wall in a building has greater impact on various parameters It has been observed that the design base shear for building having shear wall is greater that the building without shear wall for both the buildings, it may be due to the fact that the shear wall adds to the model weight of the structure which increases the stiffness of the structure, so it is evident that the shear wall helps in resisting earthquake load.

Hit and trial method based on several parameters like location, cross section, orientation etc is a good practical approach to understand the behaviour and performance of the structure under seismic loads.

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