Int. J. Struct. & Civil Engg. Res. 2014

International Journal of Structural and Civil Engineering Research

ISSN 2319 – 6009 www.ijscer.com
Vol. 3, No. 4, November 2014

Research Paper

SEISMIC BEHAVIOR OF BUILDINGS HAVING HORIZONTAL IRREGULARITIES

Rakesh Sakale[1], R K Arora[1] and Jitendra Chouhan[1*]

Corresponding author: Jitendra Chouhan** ✉jitendrachouhan550@gmail.com*

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. The object of the present work is to compare the seismic behavior of regular building with horizontally irregular buildings. For this purpose four multi-storey buildings are considered and provided with and without shear walls. Building 1 is regular plan, building 2 is of L shape, building 3 is of T shape and building 3 is of C shape in plan. To study the behavior the response parameters selected are lateral displacement and storey drift. All the buildings are assumed to be located in zone II, zone III, zone IV and zone V. For analysis STAAD. Pro software is used. Observation shows that for all the buildings considered, drift values follow a similar path along storey height with maximum value lying somewhere near the second to tenth storey. From drift point of view, in zone II, zone III and zone IV all the frames are within permissible limit, hence there is no requirement of shear wall in these zones. In zone V only building 4, i.e., C shape building exceeds permissible limits and requires shear wall throughout the height. And from displacement view point, only in zone II all the buildings are within permissible limit. In zone III building 1 slightly exceeds permissible value on 20th floor, but building 2, 3 and 4 requires shear wall to control the limit. In zone IV all the buildings exceeds limits largely. And in zone V all the buildings exceeds largely and requires shear wall throughout the height to control displacement limits. Present work provides a good source of information on the parameters lateral displacement and storey drift.

Keywords: Horizontal irregularity, Seismic behavior, Lateral displacement, Storey drift, Shear wall

INTRODUCTION

Major structural collapses occur when a building is under the action of dynamic loads which includes both earthquake and wind loads. In these modern days, most of the structures are involved with architectural importance and it is highly impossible to plan with regular shapes. These irregularities are

[1] Patel Institute of Engineering & Science, Bhopal (MP).

responsible for structural collapse of buildings under the action of dynamic loads. Hence, extensive research is required for achieving ultimate performance even with a poor configuration.

A building is said to be a regular when the building configurations are almost symmetrical about the axis and it is said to be the irregular when it lacks symmetry and discontinuity in geometry, mass or load resisting elements.

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure.

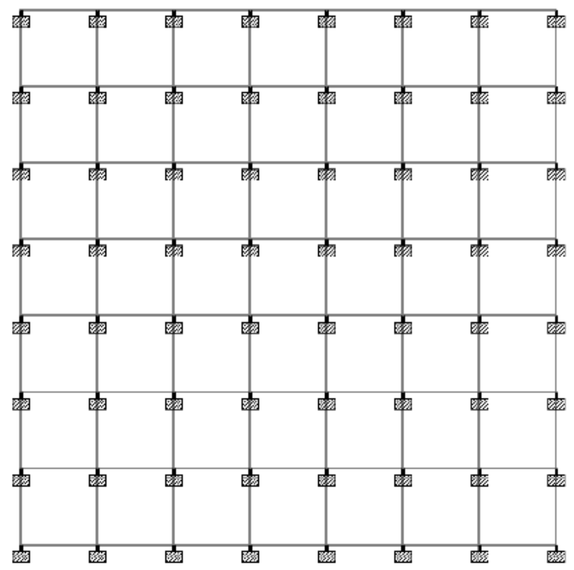
Problem Formulation and Analysis

The object of the present work is to compare the seismic behavior of multi-storey buildings having horizontal irregularity with that to regular building of similar properties. For this purpose four multi-storey building plans are considered that are symmetric plan, L shape, T shape, and C shape. For the comparison, parameters taken are lateral displacement and storey drift. All the four buildings are analyzed for zone II, III, IV and V.

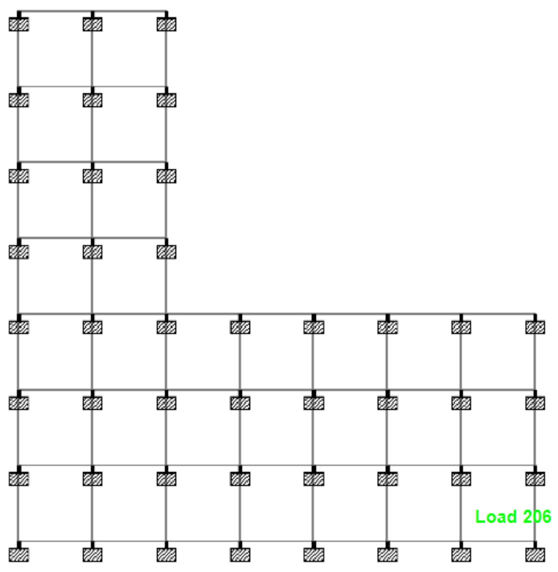
Details of the four frames are as follows:

Building-I is a regular building of twenty stories with a symmetrical plan configuration of square shape provided with 7 x 7 bays and is considered whose centre of mass coincides with centre of rigidity. Building-II, building-III and building-IV are irregular buildings of 20 stories having L shape plan, T shape plan and C shape plan, respectively, within that 7 x 7 bays regular

Building 1



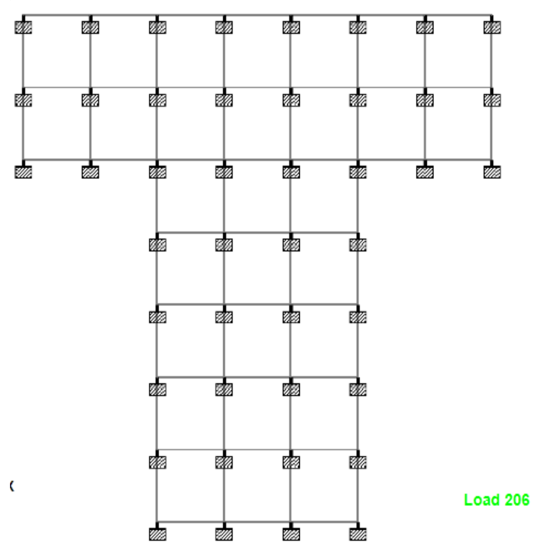
Building 2 (L shape)



building plan. All these are 20 storied building frames with floor heights of 3.6 m each. The total height of all the building frames is 72 m.

As per IS code 1893-2002, the natural time period is 2.025 s. Number of nodes, beams and plates of all four buildings are given in the

Building 3 (T shape)



Building 4 (C shape)

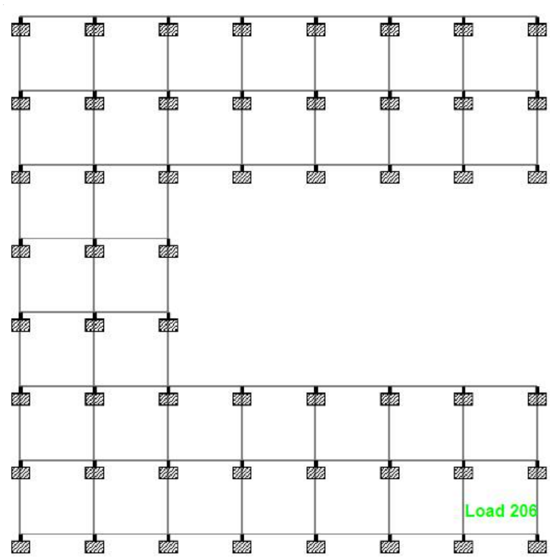


Table 1. Material properties considered for the analysis using STAAD are given in the Table 2. Physical properties of members selected for the analysis are given in the Table 3. Dead load and Live loads considered for the analysis are given in Table 4. Earthquake loads considered for the calculation of seismic weights are as per the IS 1893(Part 1): 2002 and are given in the Table 5.

For the analysis purpose, these structures are assumed to be located in zone-II, zone-III, zone-IV and zone-V on site with medium soil and Sa/g value taken from the Figure 2 of IS-1893: 2002, i.e., Response spectra for rock

Table 1: Nodes, Beams and Plates for All Buildings

Building Frames	Regularity	Number of nodes	Number of beams	Number of plates
Building-1	Regular in horizontal	1408	3696	84
Building-2	Irregular in horizontal	968	2436	42
Building-3	Irregular in horizontal	968	2436	84
Building-4	Irregular in horizontal	1188	2961	63

Table 2: Material Properties Considered for the Analysis

Modulus of Elasticity (E)kN/m^2	Poisson's Ratio	Unit Weight kN/m^3	Coefficient of Thermal Expansion@ / ^{0}K	Damping Ratio
2.17185E+007	170 E-3	23.561	1E-005	0.05

Table 3: Physical properties of the columns and beams

Member	Size
Columns for all floors	450mm x 450mm
Beams for all floors	300mm x 450mm

Table 4: Dead load and Live loads considered for the analysis

Type of load	Load value
DEAD LOAD	
On floor slabs	
Self weight	3.75 kN/m2
partition wall (assumed)	2.00 kN/m2
floor finish (assumed)	1.00 kN/m2
Total dead load on floors	6.75 kN/m2
On roof slab	
Self weight	3.75 kN/m2
weathering course (assumed)	2.00 kN/m2
Total dead load on roof	5.75 kN/m2
LIVE LOAD	
On floor slabs	
Live load on floors	2.50 kN/m2
On roof slab	
Live load on floors	1.50 kN/m2

Table 5: Loads considered for the calculation of seismic weights

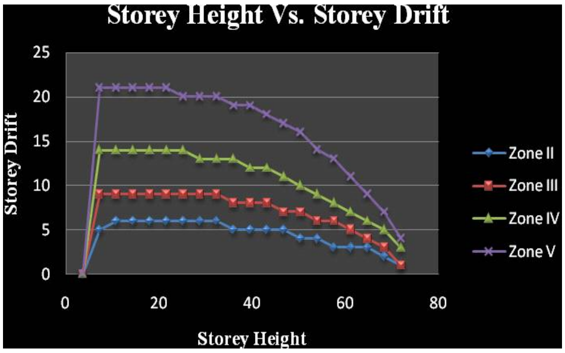
Loads on the floors Full dead load acting on the floor plus 25 percent of live load (since, as per clause 7.3.1 Table 8 of IS 1893(Part 1):2002, for imposed uniformly distributed floor loads of 3 kN/m2 or below, the percentage of imposed load is 25 percent) = 6.75+((25/100)x2.5) = 7.375 kN/m2
Loads on the roof slab Full dead load acting on the roof (since, as per clause 7.3.2, for calculating the design seismic forces of the structure, the imposed load on roof need not be considered.) hence take the load as 5.75 KN/m 2

and soil sites for 5% damping. These structures are taken as general building and hence Importance factor is taken as 1 and the frames are proposed to have ordinary RC moment resisting frames and hence the Reduction factor is taken as 3. Response of the building frame structures is studied mainly for the dominated load combination i.e. 1.5DL ± 1.5EL in X-direction for the selected columns at different levels including roof displacement.

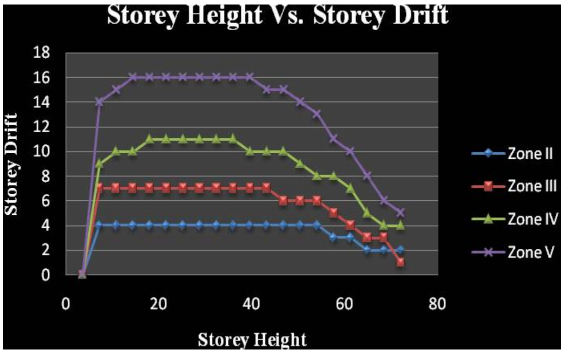
RESULTS

The performance of multi-storey buildings is assessed for four buildings in which one is regular and other three are irregular horizontally at different conditions for zone II, zone III, zone IV and zone V. The results obtained from analysis are given in various figures as follows:

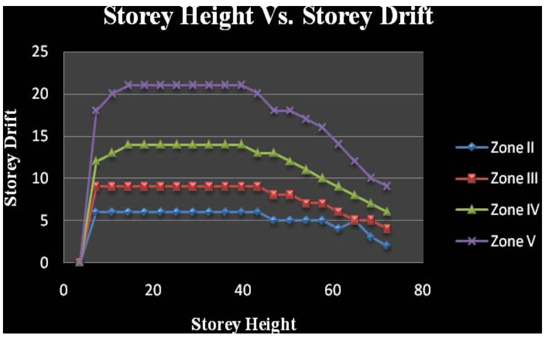
Figure 1: Analysis Results



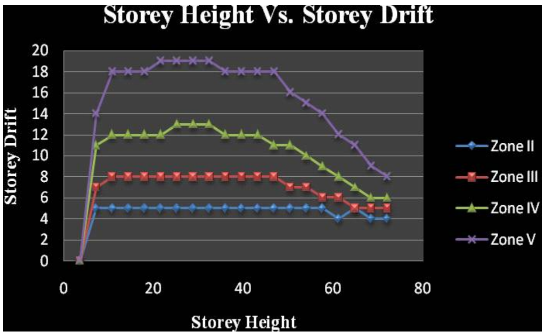
Frame 1 Without Shear Wall



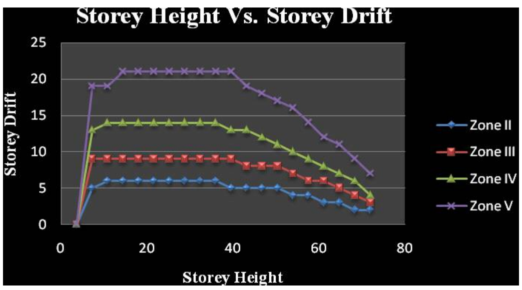
Frame 1 With Shear Wall



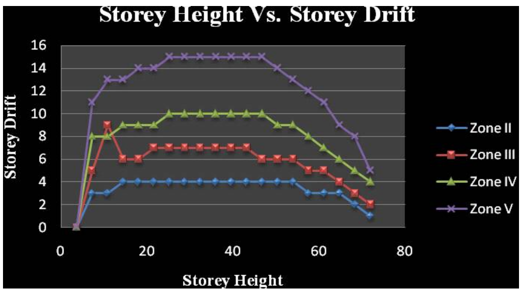
Frame 2 Without Shear Wall



Frame 2 With Shear Wall

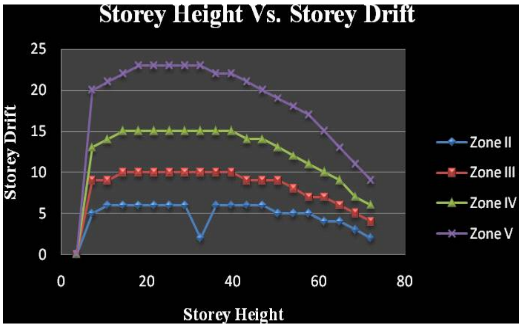


Frame 3 Without Shear Wall

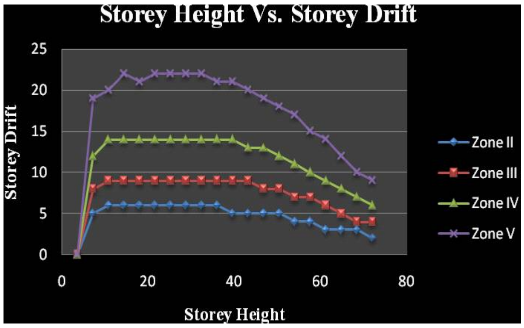


Frame 3 With Shear Wall

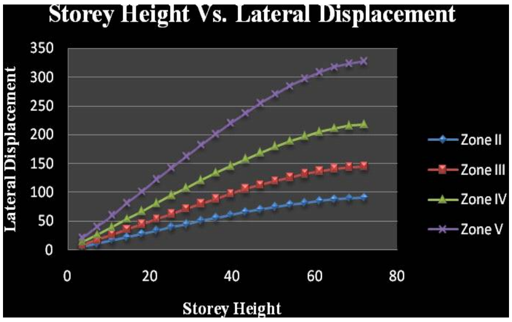
Figure 1 (Cont.)



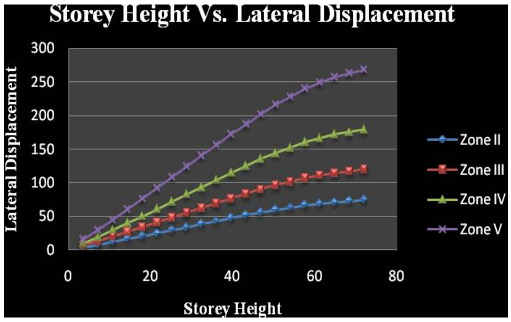
Frame 4 Without Shear Wall



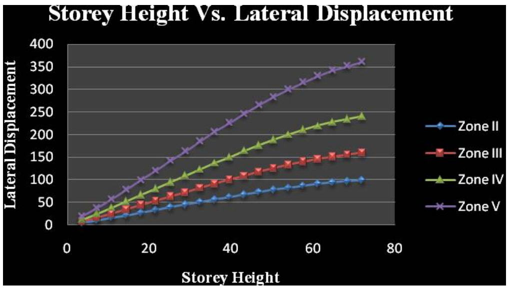
Frame 4 With Shear Wall



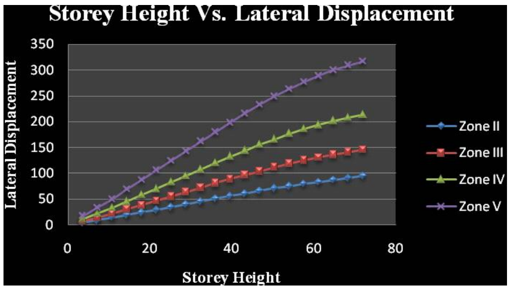
Frame 1 Without Shear Wall



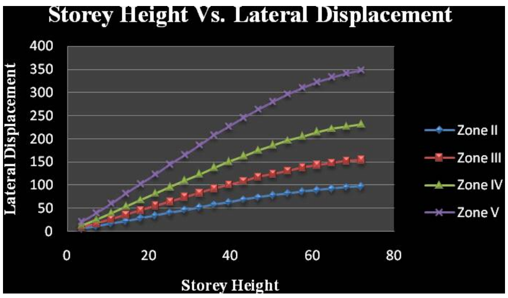
Frame 1 With Shear Wall



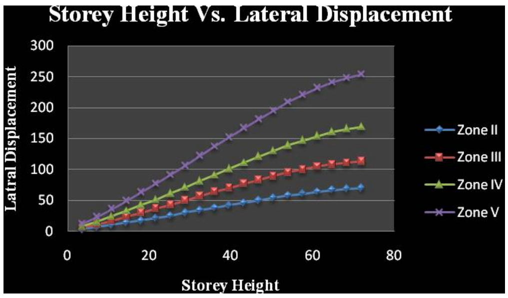
Frame 2 Without Shear Wall



Frame 2 With Shear Wall

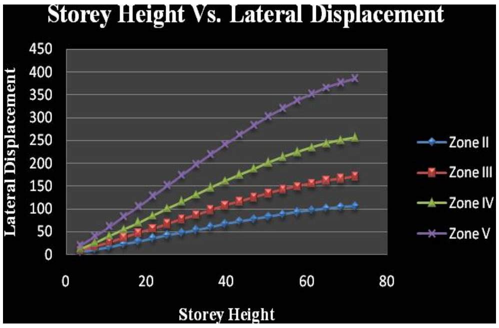


Frame 3 Without Shear Wall

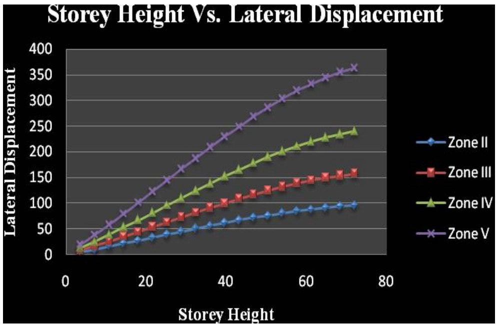


Frame 3 With Shear Wall

Figure 1 (Cont.)



Frame 4 Without Shear Wall



Frame 4 With Shear Wall

DISCUSSION

The study examines the seismic performance of multi-storey buildings having horizontal irregularities with different plan shapes. Four buildings are analyzed for zone II, zone III, zone IV and zone V. To study the effectiveness of all these buildings, the storey drift and lateral displacement are worked out and are presented in tables and figures.

The results organized in various figures are discussed in detail.

Effect of parameters studied on storey drift:

1. According to IS:1893:2002 (part I), maximum limit for storey drift with partial load factor 1.0 is 0.004 times of storey height. Here, for 3.6 m height and load factor of 1.5, though maximum drift will be 21.6 mm.
2. It is observed from result tables and figures that for all the buildings considered drift values follow a similar path along storey height with maximum value lying somewhere near the second to tenth storey.
3. In zone II zone III and zone IV it is observed that for all the buildings storey drift is safe under its permissible limit and hence there is no need to provide shear wall.
4. In zone V in case of without shear wall and with shear wall it is observed that building 1, 2 and 3 are well within permissible limits. Building 4 exceeds permissible values from fourth to eleventh storey so in case of building 4 shear wall should be provided throughout the building height.

Effect of parameters studied on lateral displacement:

1. According to IS:456:2000, maximum limit for lateral displacement is H/500, where H is building height. Here for building height 72 m maximum limit for displacement is 144 mm. Results for lateral displacement are tabulated in the result tables.
2. In zone II it is observed that all the buildings are safe within permissible limit in case of without shear wall also hence there is no need to provide shear wall.
3. In zone III it is observed that building 1 slightly exceeds in the 20th floor but with can

be permissible. Building 2 exceeds permissible limit from 17th to 20th floors in case of without shear wall but is safe in case of shear wall. Building 3 exceeds only on 18th, 19th and 20th floors. Building 4 exceeds permissible limits largely from 16th to 20th floors, so in case of this type of building shear wall is necessary to provide.

4. In zone IV it is observed that all the buildings exceeds permissible limits largely in case of without shear wall, but when shear wall is provided values exceeds slightly.

5. In zone V it is observed that all the buildings exceeds badly to maximum permissible limits of displacement, hence to reduce displacements shear wall must be provided throughout the building height.

CONCLUSION

Within the scope of present work following conclusions are drawn:

1. For all the frames considered, drift values follow a similar path along storey height with maximum value lying somewhere near the second to tenth storey.

2. From drift point of view, in zone II, zone III and zone IV all the frames are within permissible limit, hence there is no requirement of shear wall in these zones. In zone V only building 4, i.e., C shape building exceeds permissible limits and requires shear wall throughout the height.

3. From displacement view point, only in zone II all the buildings are within permissible limit. In zone III building 1 slightly exceeds permissible value on 20th floor, but building 2, 3 and 4 requires shear wall to control the limit. In zone IV all the buildings exceeds limits largely. And in zone V all the buildings exceeds largely and requires shear wall throughout the height to control displacement limits.

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