A Comparative Study on Effects of Regular and Irregular Structures Subjected to Lateral Loading by Equivalent Static Method and Response Spectrum Method

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Abstract— This paper aims in thoroughly examine and have a comparative study of the behavior of regular and irregular R.C building with and without shear wall for seismic and wind load activities in different zones of India through equivalent static method and response spectrum method. For this purpose, regular and irregular R.C structures are taken and analyzed against earthquake and wind forces in different zones of India. Further shear wall is introduced in both regular and irregular structure and again analyzed in different zones. For structural irregularity, vertical irregularity and plan irregularity are taken into account. These irregularities are taken as per Indian standard code, IS 1893 (Part I): 2002. The whole models were analysed with the help of CYPE Software. In current study drifts has been considered in both X and Y directions and are compared with structure shear wall.

Keywords— Irregular Structures, Seismic Load, Wind Load, Shear Wall, CYPE.

I. INTRODUCTION

For the last decade there is a gradual increase of irregular structures due to enhancement in architecture. Irregular structures leads to remarkable eccentricity between center of mass and stiffness. This leads to lateral response due to which damage occurs. During earthquake, surface of the ground will be subjected to six different motion i.e three translations and three rotations. Each of these components are uncorrelated. Due to uncorrelated components the damage of a structure are unconfined. During Nepal Earthquake (2015), the failure due to vertical and horizontal irregularity was encountered. The main problem is the lack of study of irregular structure. Provision of shear wall can stabilize stiffness, mass and increase the strength of a structure. The scope of this study is to compare the shear wall performance for regular and irregular structures in different zones of India by equivalent static method and response spectrum method.

II. METHODOLOGY

Analysis of a structure is done by equivalent static method and response spectrum method. The main difference between this methods lies in the magnitude and distribution of lateral forces over the height of a structure. The analysis of structure is done by using CYPE software. The different configuration position of shear wall in Reinforced Concrete building were analyzed for under seismic and wind analysis. The data used is as per earthquake loading (IS: 1983-2002) and Wind loading (IS: 875 Part 3).

III. SHEAR WALL LOCATION

Location of Shear Wall is an important part which effects the response of a structure. Shear wall is a good mechanism for lateral loads resisting, but the placement of shear walls should be made judiciously. In case of regular structure, shear walls at mid-sides perform better in major number of cases (Anshul Sud et at.,2014). Incorporation of shear walls improves the seismic performance of the building with re-entrant corner i.e plan irregularity buildings and strengthening the inner notch was found to be much efficient compared to strengthening outer notch (Divyashree M et at. (2014)). In case of vertical irregularity, placement of shear wall mainly depends on the location of centre of mass and centre of rigidity.

IV. MODELLING AND ANALYSIS

Six storey structure with regular and irregular configuration with typical floor height of 3m are

considered. Loads are considered with reference to relevant codes of IS 875 part1- 1987, IS 875 part3-1987, IS 1893 part1-2002. The dead and imposed loads of all the reinforced concrete members will be given as self-weights of the members; all the floor loads expressed as load per square area is applied as distributed floor loads onto the supporting beams. Wall loads are taken as line load onto the supporting beams; the wind and earthquake loads are applied as lateral loads at each floor level. Material grades of M25 & Fe 415 is used. Six-storey RC office structure is located in seismic zone-II, zone-III, and zone-IV and V on medium soil. Thickness of slab is 150mm. Ordinary moment-resisting frame (OMRF) is taken for analysis. These frames are subjected to dead load of 1.5 kN/m^2, live load of 2 kN/m^2 on all floors, wall load of 12 kN/m^2, parapet load of 5kN/m^2 on roof (as per IS 875-part-2) earthquake loads as per IS 1893:2002 and wind load as per IS 875 Part 3. More than 45 load combinations are taken for analysis. Importance Factor 'I' equal to 1, Response reduction factor 'R' as 3 and Damping Ratio as 5 is considered for all structures. In case of wind analysis Terrain Category is taken as I (Exposed open terrain with few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5 m) and Land Orography is taken as flat.Six structures have been considered with one regular and two irregular with and without shear wall. For regular structural in x-direction there are 5 bays, each of 5 m width and in z-direction also there are 5 bays, each of 5 m width. For Plan irregular structure it has 64% re-entrant corner in L shape and in case of vertical irregular structure irregularity taken is 80 % as per IS 1893:2002.

Table 1: Structural properties of structures

	Zone Area-	Bangalore
Zone 2:	Beam Dimension-	230X450mm
	Column Dimension-	230X900mm
	Basic Wind Speed-	33 m/s
	Zone Area-	Ahmedabad
Zone 3:	Beam Dimension-	230X650mm
	Column Dimension-	300X900mm
	Basic Wind Speed-	39 m/s
	Zone Area-	Darjeeling
Zone 4:	Beam Dimension-	230X650mm
	Column Dimension-	300X900mm
	Basic Wind Speed-	47 m/s
	Zone Area-	Bhuj
Zone 5:	Beam Dimension-	450X900mm
	Column Dimension-	450X900mm
	Basic Wind Speed-	50 m/s

Frame elements consist of columns and beams of different dimensions for different zones because in different zone load acting on a structure are different. The storey drifts at various floors are determined from response spectrum method and equivalent static method. For different structure different configurations of shear wall have been considered to evaluate the effect of shear wall when subjected to lateral loadings. Configuration of shear walls for different structures is shown table 2.

Table 2: Structural properties of shear walls

	Shape-	Normal
Regular	Number of shear wall provided	4
	Thickness	300mm
	Length	5.3m
Plan Irregular	Shape	L shaped
	Number of shear wall provided	1
	Thickness	300mm
	Dimension	5.5X5.5m
Vertical Irregular	Shape	Normal
	Number of shear wall provided	1
	Thickness	300mm
	Length	15.3m
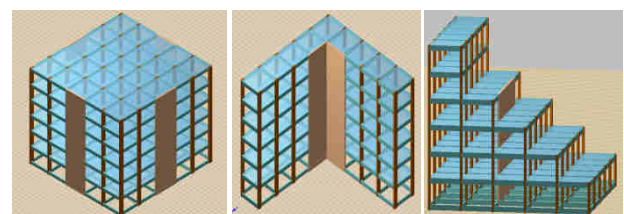
a) Regular   b) Plan Irregular   c) Vertical Irregular
Fig.1:Structures with shear wall

V.   RESULT AND DISCUSSION

Drifts are considered to identify the structural response of regular and irregular structures with and without shear wall by equivalent static method and response spectrum method. Also wind load has been considered to identify the response of a structures. Result obtain from the analysis are graphically represented for the following structures:

Structure 1: Regular Structure
Structure 2: Plan Irregular Structure
Structure 3: Vertical Irregular Structure
Structure 4: Regular Structure with Shear Wall
Structure 5: Plan Irregular Structure with Shear Wall
Structure 6: Vertical Irregular Structure with Shear Wall
Where;

ESM WS-X=Drift from equivalent static method for a structure without shear wall in x direction

ESM SW-X= Drift from equivalent static method for a structure with shear wall in x direction

RSM WS-X= Drift from response spectrum method for a structure without shear wall in x direction

ESM SW-X= Drift from response spectrum method for a structure with shear wall in x direction

ESM WS-Y=Drift from equivalent static method for a structure without shear wall in y direction

ESM SW-Y= Drift from equivalent static method for a structure with shear wall in y direction

RSM WS-Y= Drift from response spectrum method for a structure without shear wall in y direction

ESM SW-Y= Drift from response spectrum method for a structure with shear wall in y direction
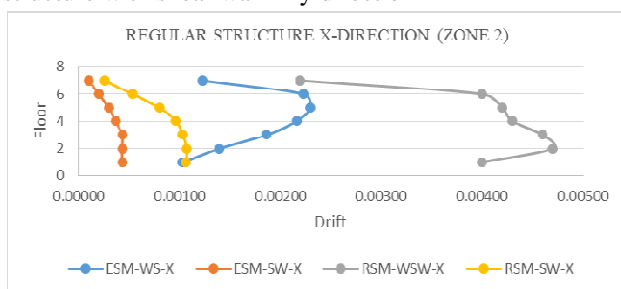
Fig.2: Comparision of drifts for regular structure(X-direction) in zone II.
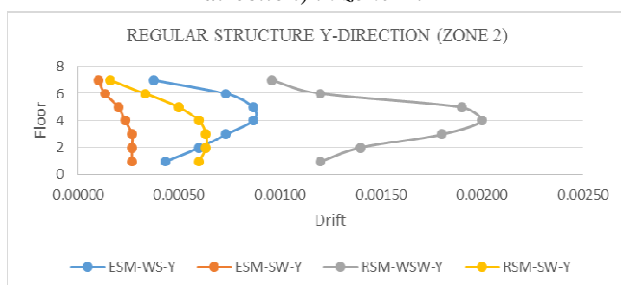
Fig.3: Comparision of drifts for regular structure(Y-direction) in zone II.
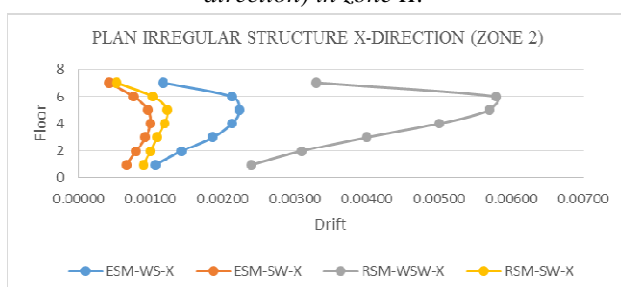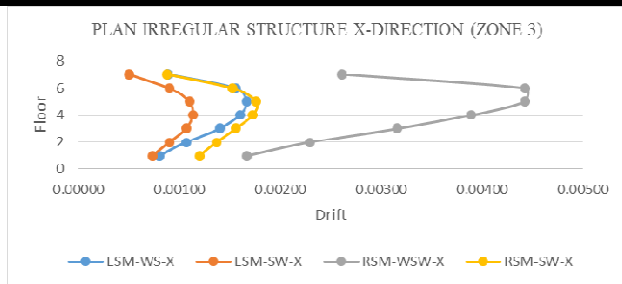

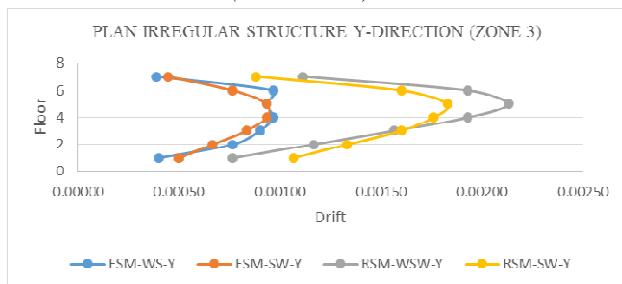*Fig.4: Comparision of drifts for Plan irregular structure(X-direction) in zone II.*
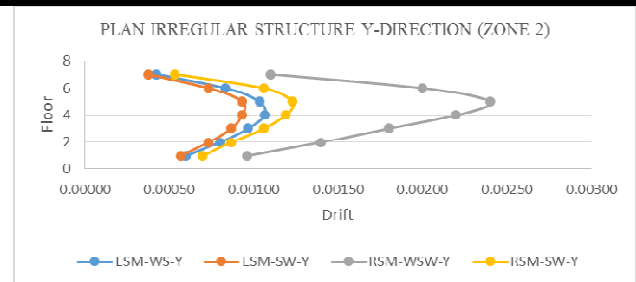
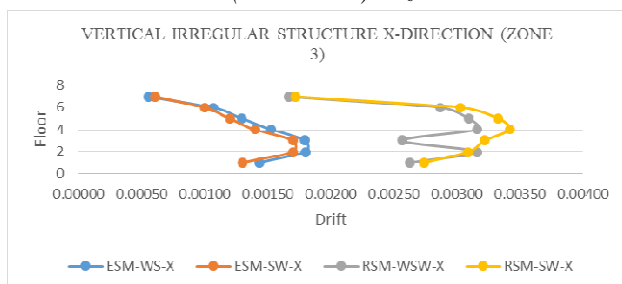*Fig.5: Comparision of drifts for Plan irregular structure(Y-direction) in zone II.*
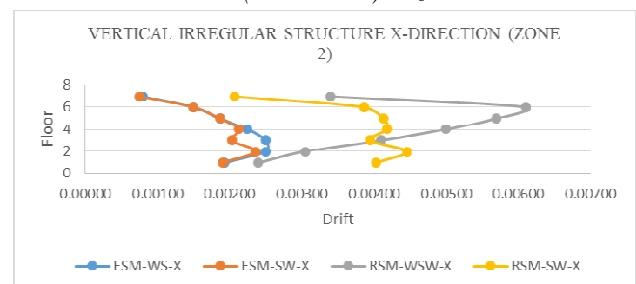
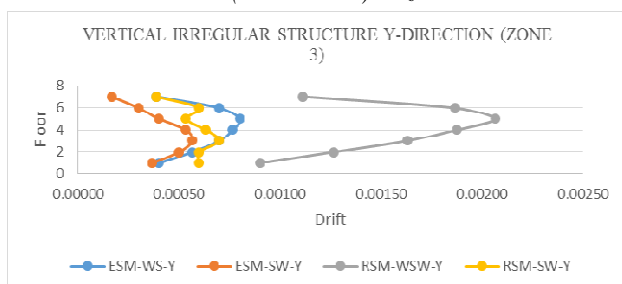*Fig.6: Comparision of drifts for Vertical irregular structure(X-direction) in zone II.*
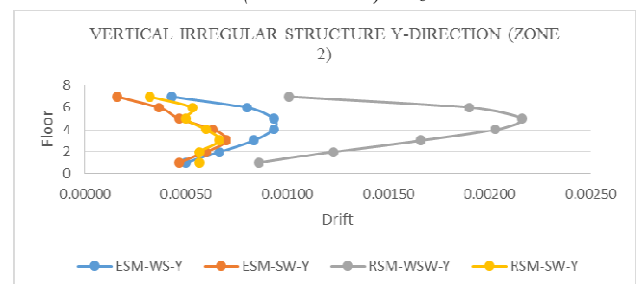
Fig.7: Comparision of drifts for Vertical irregular structure(Y-direction) in zone II.
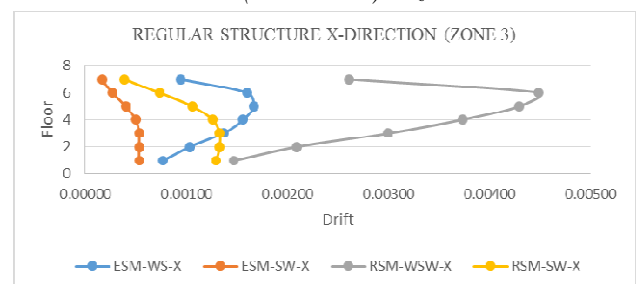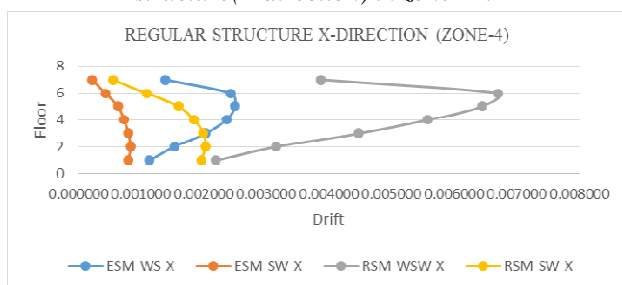

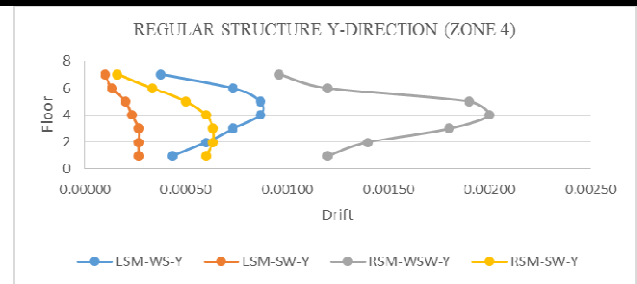*Fig.8: Comparision of drifts for regular structure(X-direction) in zone III.*
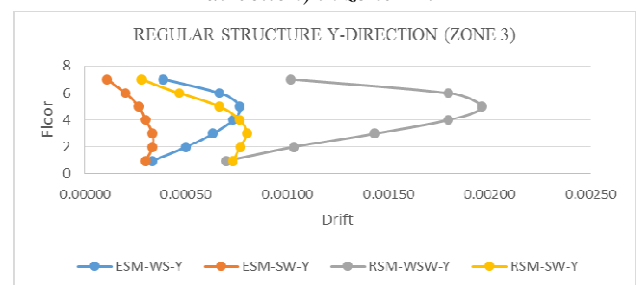
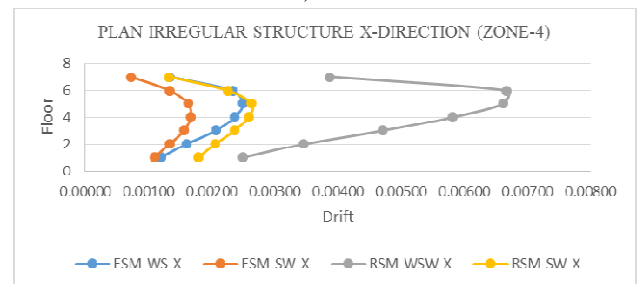*Fig.9: Comparision of drifts for regular structure(Y-direction) in zone III.*

Fig.10: Comparision of drifts for Plan irregular structure(X-direction) in zone III.

Fig.15: Comparision of drifts for regular structure(Y-direction) in zone IV.

Fig.11: Comparision of drifts for Plan irregular structure(Y-direction) in zone III.

Fig.16: Comparision of drifts for Plan irregular structure(X-direction) in zone IV.

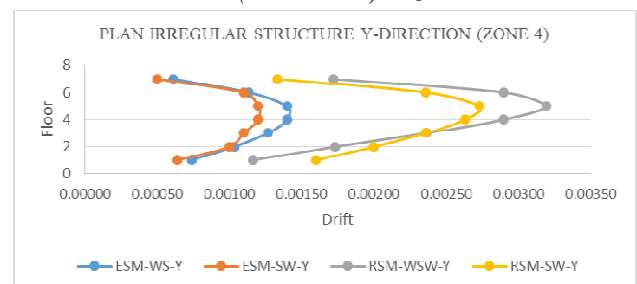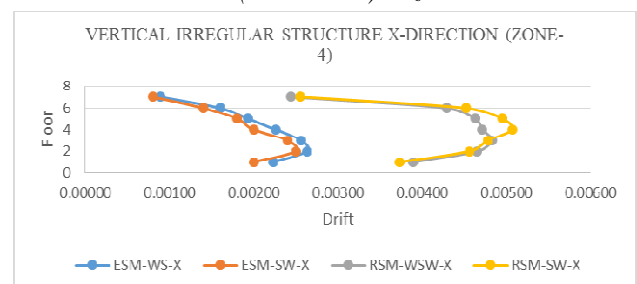*Fig.12: Comparision of drifts for Vertical irregular structure(X-direction) in zone III.*

Fig.17: Comparision of drifts for Plan irregular structure(Y-direction) in zone IV.

Fig.13: Comparision of drifts for Vertical irregular structure(Y-direction) in zone III.

Fig.18: Comparision of drifts for Vertical irregular structure(X-direction) in zone IV.

Fig.14: Comparision of drifts for regular structure(X-direction) in zone IV.
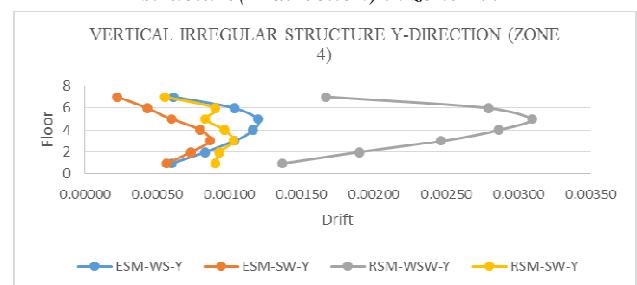

Fig.19: Comparision of drifts for Vertical irregular structure(Y-direction) in zone IV.
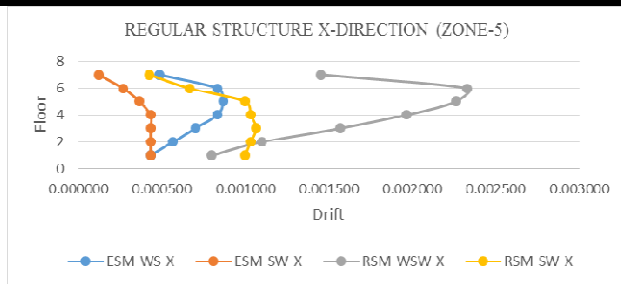
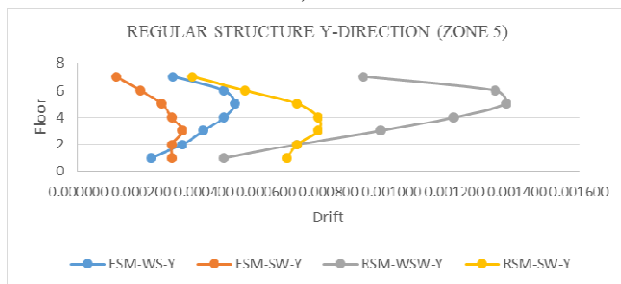*Fig.20: Comparision of drifts for regular structure(X-direction) in zone V.*

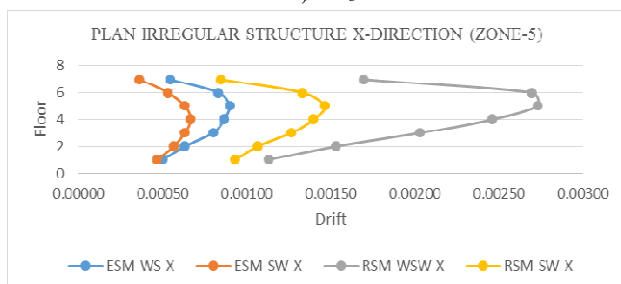*Fig.21: Comparision of drifts for regular structure(Y-direction) in zone V.*

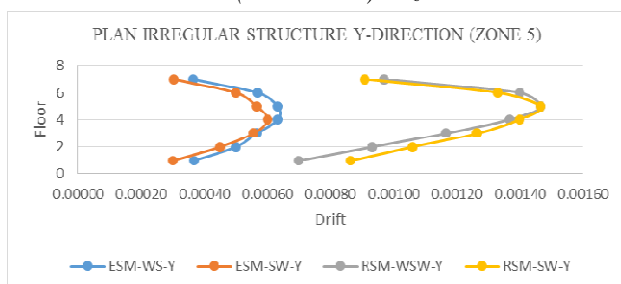*Fig.22: Comparision of drifts for Plan irregular structure(X-direction) in zone V.*

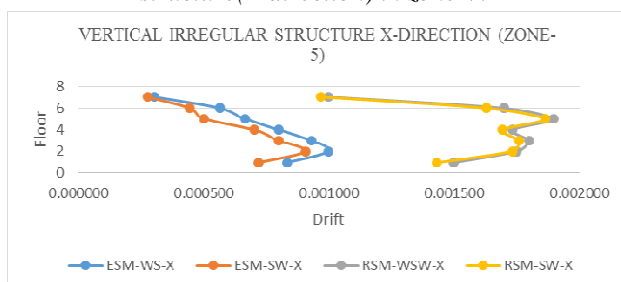*Fig.23: Comparision of drifts for Plan irregular structure(Y-direction) in zone V.*

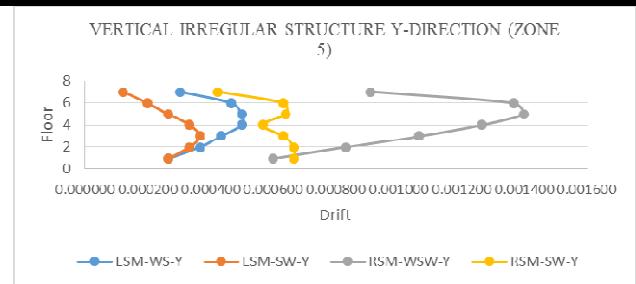*Fig.24: Comparision of drifts for Vertical irregular structure(X-direction) in zone V.*

Fig.25: Comparision of drifts for Vertical irregular structure(Y-direction) in zone V.

VI.   CONCLUSION

To obtain accurate results, comparison has been done with respect to its particular zones. The study of regular and irregular structure with and without shear wall in different zones of India by equivalent static method and response spectrum method leads to the following conclusions:

1. Regular structure shows better performance as compared to irregular structure under earthquake and wind loading and response spectrum methods gives higher value for drifts as compared to equivalent static method.
2. In-case of regular structure shear wall will reduce drift by 70-80% in X-direction and by 55-65% in Y-direction if analysis is done by response spectrum method and if analysis is done by equivalent static method drift is reduced by 50-60% in X-direction and by 40-50 % in Y-direction.
3. In-case of plan irregular structure shear wall will reduce drift by 60-80% in X-direction and by 20-50% in Y-direction if analysis is done by response spectrum method and if analysis is done by equivalent static method drift is reduced by 40-50% in X-direction and by 10-15 % in Y-direction.
4. In-case of plan irregular structure shear wall will reduce drift by 15-25% in X-direction and by 60-80% in Y-direction if analysis is done by response spectrum method and if analysis is done by equivalent static method drift is reduced by 10-15% in X-direction and by 40-50 % in Y-direction.

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