Analysis of an Irregular RC Multi-storeyed Building Subjected to Dynamic Loading

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Abstract. Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. So it is necessary to analyze the structure. The present paper is made to study three type of irregularity wiz vertical, mass and plan irregularity as per clause 7.1 of IS 1893 (part1)2002 code. The paper discusses the analysis of RC (Reinforced Concrete) Buildings with vertical irregularity. The study as a whole makes an effort to evaluate the effect of vertical irregularity on RC buildings for which comparison of three parameters namely shear force, bending moment and deflection are taken into account.

1. Introduction

An earthquake is shaking of the surface of earth, caused by sudden movement in the earth crust. This creates seismic waves which is very hazardous for engineering properties, thus resulting in failure or collapse of structure and can cause harm to many lives, The behavior of the structures depends on many factors like stiffness, mass irregularities etc. The irregular structures suffers more damage as compared to the regular structures so it's a huge challenge for engineer's to analyze and design structures which can withstand against such event of earthquake. The IS1893 (part1):2002 codes has recommended building configuration system for the better performance of RC building during earthquakes. The building configuration has been described as regular or irregular in terms of the size and shape of the building, arrangement of structural the elements and mass. 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. Asymmetrical arrangements cause a large torsion force. The two types irregularities are 1. Horizontal irregularities refers to asymmetrical plan shapes or discontinuities in horizontal resisting elements such as re-entrant corners, large openings, cut outs and other changes like torsion, deformations and other stress concentrations. 2. Vertical irregularities referring to sudden change of strength, stiffness, geometry and mass of a structure in vertical direction. The main objective of the present work is to study the response of the irregular structures under dynamic loads. In this present study it is proposed to consider the RC building frame that are irregular in plan. In this paper four cases are taken into consideration **case I:-**Two (G+5) buildings regular and irregular are modeled and dynamic analysis is performed, **case II:-** Four (G+5) buildings namely box, L, U and T shape are modeled and dynamic analysis is performed **case III :-** Same four (G+5) buildings as in case II are taken and mass irregularity is performed on 2nd and 4th floor of each shape model **case IV :-**Now we had eight models in which four models from case II and four models from case III, so in this case those four models from case II are compared with four models of case III and results are compared.

1.1 Types of irregularity

1) **Plan irregularities**
2) **Vertical irregularities**

Vertical irregularities are mainly of five types –

i)   **Stiffness irregularity-**A soft storey in which the lateral stiffness is less than 70 percent of the storey above or less than 80 percent of the average lateral stiffness of the tree storey above

ii)   **Mass irregularity-**Mass irregularity shall be considered to exist where the seismic weight is more than 200 percent of that of its adjacent storey. The irregularity need not be considered in case of roofs.

iii)   **Vertical geometric irregularity-**A structure is considered to be vertical geometric irregular when the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey.

iv)   **In-plane discontinuity in verticalelements resisting lateral force-**An in-plane offset of the lateral force resisting element greater than the length of those element.

v)   **Discontinuity in capacity – Weak storey-**A Weak storey is one which the storey lateral strength is less than 80 percent of that in the storey above.

(1) box shape   (2) L-shape   (3) Inverted U-shape   (4) T-shape
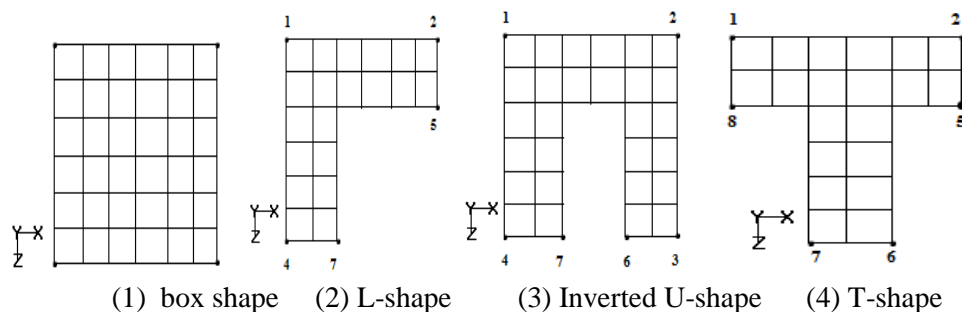
Figure.1 Different shapes of buildings

2. Methodology
1. Review of the existing literatures by different researchers.
2. Selection of type of structures.
3. Modeling of the selected structures.
4. Performing dynamic analyze on selected building models and compare the results.

Problem statement

Seismic co-efficient method was performed on regular and various irregular structures and is modeled by using STAAD PRO software. All the models are modeled for zone II, having Importance factor -1, soil condition- medium, zone factor 0.1.Load combination As per IS 1893(Part1):2002, Cl. 6.3.1.2, pg 13

3. Results and Discussion
Case I:- vertical irregularity

1. Considering a 3 bayed 6-storied 3D Model having bay spacing 3m on each direction and story spacing also 3m.
2. The same model is considered under the Building without Irregularity.
3. For considering Irregular building, the model is modified by eliminating all corner columns of Top story.
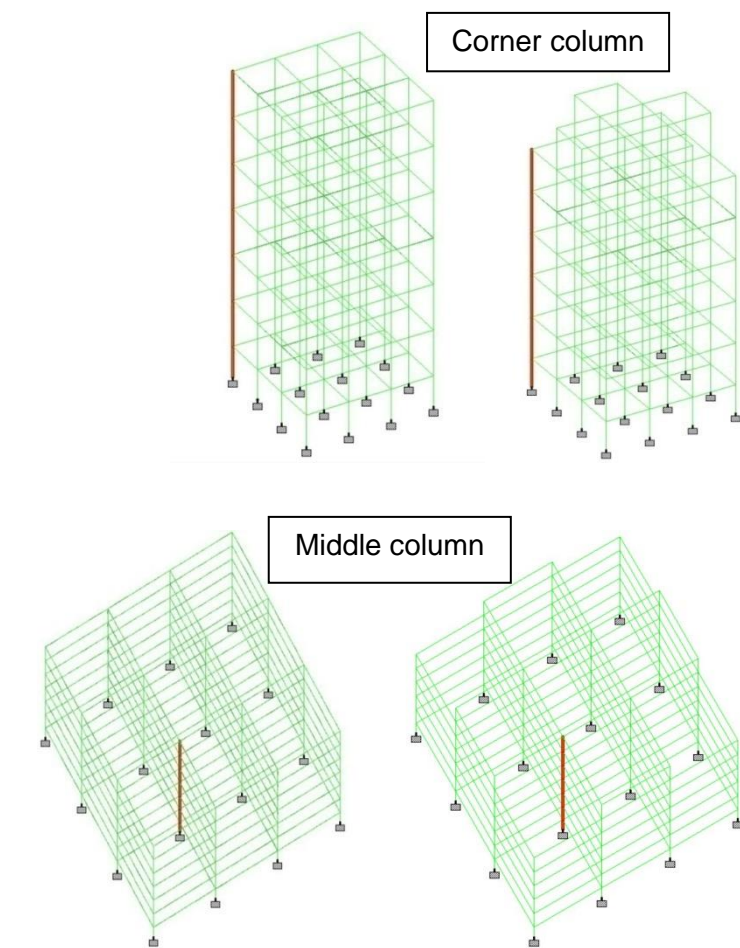
MODE WITHOUT IRREGULARITY   MODEL WITH IRREGULARITY

Figure 2.

Table 1. Specification.

Live load(IS 875-1987 (part 2), p.n.7 Table 1)	2 kN/m^2
Periphery wall thickness(230mm)	13.8 kN/m
Inner wall thickness (115mm)	9 kN/m
Slab thickness (150mm)	3.75 kN/m^2
Floor finish	1kN/m^2

Table 2. Comparison of axial force, shear force, bending moment and deflection of corner and middle

column.

Column position	Axial force (KN)	
	Regular	**Irregular**
corner	755.03	617.89
middle	**1193.99**	1169.32

Column position	Shear force(KN)	
	Regular	**Irregular**
corner	15.81	**-18.15**
middle	-5.39	6.10

Column position	Bending moment(KN m)	
	Regular	**Irregular**
corner	18.15	**21.87**
middle	5.39	6.10

Column position	Deflection(mm)	
	Regular	**Irregular**
corner	3.41	2.90
middle	5.80	**6.19**

Case III:-Shape Irregularity

1) Considering a 6 bayed 5-storied Box shaped 3D Model having bay spacing 3.5 m on each direction and story spacing also 3 m.
2) The same model is then reshaped as L, inverted T and U Shaped.
3) For considering Irregular building, the model is modified by eliminating some members to make the shapes as mentioned above.

Column position 1:-
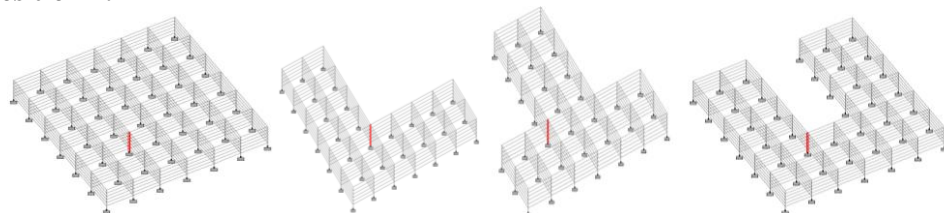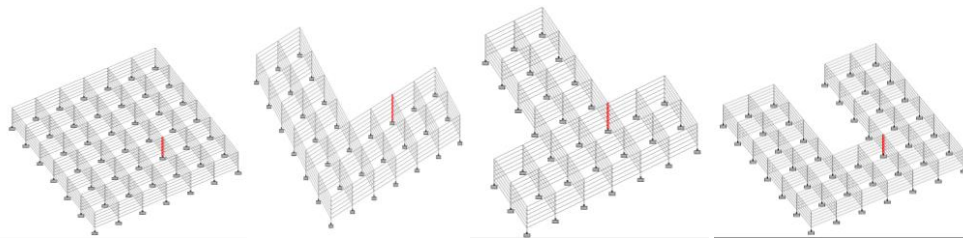

Column position 2:-S

Figure 3.

Table 3. Comparison of max Axial force, shear force, bending moment and deflection for column position 1 and 2.

Column position	Axial force(KN)			
	Box shape	L shape	U shape	T shape
1	1234.75	1250.21	1250.29	**1250.76**
2	1234.75	1250.21	1250.29	**1250.76**

Column position	Shear force(KN)			
	Box shape	**L shape**	**T shape**	**U shape**
1	1.50	5.26	5.56	6.36
2	**1.55**	5.26	9.16	6.36

Column position	Bending moment(KN m)			
	Box shape	**L shape**	**T shape**	**U shape**
1	**2.46**	9.53	10.26	11.34
2	2.45	9.53	10.26	11.34

Column position	Deflection(mm)			
	Box shape	**L shape**	**T shape**	**U shape**
1	**4.420**	4.333	4.328	4.331
2	4.225	4.333	4.328	4.331

Case III:- MASS Irregularity

1) The same four model from case 2 are taken for mass irregularity with same specification.
2) The only change in these four model is according to the definition of mass irregularity i.e. seismic weight of any storey is 200 % of the adjacent storey as per IS 1893:(part1)2002 code.
3) Seismic weight is the total dead load plus imposed load
4) So the mass irregularity is done on the 2nd and 4th floor as shown in fig 3 below
5) For comparison of results same column position are taken in mass irregular models.

Specification on 2nd and 4TH FLOOR

Live load	4KN/m2
Slab thickness (150mm)	7.5 KN/m2
Floor finish	2 KN/m^2

Without mass irregularity
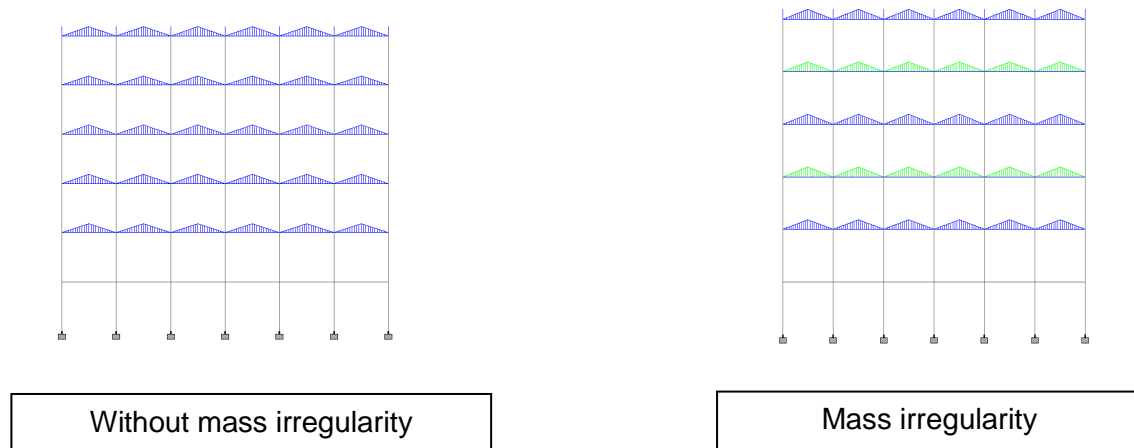
Mass irregularity

Figure4. (G+5) building with mass irregularity on 2nd and 4th floor for all models.

Table 4. Comparison of result for max axial force, shear force, bending moment and deflection for column position 1 and 2.

Column position	Axial force(KN)			
	Box shape	**L shape**	**U shape**	**T shape**
1	**1483.29**	1438.43	1438.14	1438.72
2	1483.29	1110.69	1438.15	1438.72

Column position	Shear force(KN)			
	Box shape	**L shape**	**U shape**	**T shape**
1	**1.65**	8.82	9.16	10.17
2	1.65	1.82	9.16	10.17

Column position	Bending moment(KN m)			
	Box shape	**L shape**	**U shape**	**T shape**
1	**2.20**	13.5	14.31	15.74
2	2.73	2.84	14.32	15.73

Column position	Deflection(mm)			
	Box shape	**L shape**	**U shape**	**T shape**
1	**5.417**	5.082	5.082	5.083
2	5.417	3.901	5.082	5.083

Case IV:- With and without mass irregularity

1) All models from case 2 and case 3 are taken into picture with same specification.
2) In this box model without mass irregularity is compared with box model with mass irregularity, similarly for other models i.e L-shape with L-shape, U with U shape, and inverted T-shape with inverted-T shape.
3) The column position selected for comparison is same as in case 2 and case 3.

Table 5. Comparison of result of with and without mass Irregularity for column position 1 and 2.

Column position	Axial force(KN)							
	box		L shape		T shape		U shape	
	With	Without	With	Without	With	Without	With	Without
1	**1483.29**	1234.74	1438.43	1250.21	1438.14	1250.29	1438.72	1250.76
2	1483.29	1234.75	1110.69	984.22	1438.15	1250.28	1438.72	1250.78

Column position	Shear force (KN)							
	box		L shape		T shape		U shape	
	With	Without	With	Without	With	Without	With	Without
1	1.65	1.59	8.82	5.26	9.16	5.59	10.17	6.36
2	1.65	1.55	1.82	**1.49**	9.16	5.56	-10.17	-6.37

Column position	Bending moment(KN m)							
	box		L shape		T shape		U shape	
	With	Without	With	Without	With	Without	With	Without
1	**2.20**	2.46	13.51	9.53	14.31	10.26	14.31	10.26
2	2.73	2.45	2.84	2.35	14.32	10.27	15.73	11.34

Column position	Deflection(mm)							
	box		L shape		T shape		U shape	
	With	Without	With	Without	With	Without	With	Without
1	**5.417**	4.420	5.082	4.333	5.082	4.328	5.083	4.331
2	5.417	4.425	3.901	3.391	5.083	4.331	5.083	4.331

4. Conclusions

Case I :-
From current study, it states that the shear bond capacity of composite slab increases with increase in thickness of cold formed deck profiled sheet as,

- Axial force is found maximum in regular building middle column which is 2.07% more than irregular building axial force.
- Shear and bending moment is found maximum at corner column irregular building which is 17% more than BM of corner column regular building.
- Deflection is found maximum at middle column of irregular structure which is 6.3% more than deflection of middle column regular building.
- Thus from above 3 points it is observe that SF, BM is found more in irregular building. While axial force is found more in regular building.

Case II :-
- Max axial force is found in T shape model which is 1.28% more than axial force of box model. While the other shape models L, T and U shape model experience almost same amount of axial force.
- The minimum shear force is found in box model, which is 71.48%, 73.02% and 76.41% less than L, T and U shape models.

- Bending moment is found in box model which is 74.18%, 76.02% and 78.30% less than L T and U shape models.
- Max deflection is found in box model which is 1.96% more than L, T and U shape model deflection.
- From the above points it is observe that minimum SF, BM and maximum deflection is found in box shape model.

Case III :-
- Max axial force is found in box shape model which is 3.02 % more than axial force of L, T and U shape model. L, T and U shape model experience almost same amount of axial force.
- Minimum SF, BM with less average % variation of 82.34%, 84.65% and maximum deflection with average % variation of 6.18% found in box shape model compared to L, T and U shape model.

Case IV) :-
- Axial force is found maximum in box shape model with mass irregularity which is 3% more than axial force of without mass irregularity model.
- Minimum SF is found in L shape model without mass irregularity
- Minimum bending is found is box shape model.
- Maximum deflection which is almost same for all models with mass iregularity and 20% more deflection than models without mass irregularity is found in box shape model.

5. References
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