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Effect of Plan and Vertical Irregularities on Seismic Behaviour of RC Framed Buildings.

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Abstract— ***As we all knows most of the building constructed as an irregular configuration both in plan and elevation. The most devastating and unpredictable natural disaster is the earthquake. Earthquake can give very sever effect on irregular configuration of building. For the better behaviour of structure in earthquake, the structure should be simple and regular and also it has adequate lateral strength, stiffness, ductility. It is necessary to design the structure to withstand against earthquake. Irregularity used in models are as per new code of earthquake IS 1893:2016(part1). The paper discussed on behaviour of building having plan and vertical irregularity. For whole study irregularities used are Torsional, Re-entrant corner, floor slabs having excessive cut-outs or opening, Out of plane offset in vertical element, Non-parallel lateral force system, Mass, Vertical geometric irregularity, stiffness irregularity, stub column, In-plane discontinuity in vertical element resisting lateral force.***

Keywords— Parametric study, Plan Irregularity, Vertical Irregularity, Response spectrum Method, Etabs.

I. Introduction

Our world is facing a threat of natural disasters from time to time. Earthquakes are one of the most unpredictable and devastating of all natural disasters. The records based on earthquakes occurrence show that the consequences are loss of human lives and destruction of properties which eventually affects the national economy. However the occurrence of earthquakes cannot be predicted and prevented but we can design the structures to resist such earthquake forces. For a structure to perform well in earthquake, the structure should be simple and regular configuration, adequate lateral strength, stiffness and ductility. Structures with simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation are considered to suffer much lesser damage than structures with irregular configurations. But nowadays, with the advancement in rapid growth of urbanization and for aesthetic purpose buildings with irregular structural configurations are widely constructed. These configurations in buildings leads to non-uniform distributions in their masses, stiffness and strength therefore they are prone to damage during earthquakes, it has also been found that irregular structures exhibit significantly different behaviour than their regular counterparts during seismic activity.

A large portion of modern urban infrastructure is made up of buildings with structural irregularities. While often desired by owners for their unique attributes, these irregular structures have architectural and aesthetic considerations which often require irregularities in mass, strength, stiffness, or structural form. Through the study of these structures' performance during earthquakes, it has also been found that irregular structures exhibit significantly different behaviour than their regular counterparts during seismic activity.

The magnitude of lateral force due to an earthquake depends mainly on inertial mass, ground acceleration and the dynamic characteristics of the building. To characterize the ground motion and structural behaviour, design codes provide a Response spectrum.

II. Aim And Objective

The main objective of the project is to perform a comparative study between Regular building and different types of irregular buildings.

- To analyse and compare plan and vertical irregularities for different storey heights.
- Comparative study of storey displacement, storey drift, Base shear and Fundamental time period of each irregularity model with regular building model.
- The above mentioned structural systems are analysed by Response spectrum method.

III. METHODOLOGY

In this study comparison of Plan and Vertical irregular buildings is compared with regular building in terms of storey displacement, storey drift, base shear and fundamental time period.

Following steps are adopted in this study.

Step 1: Review of existing literatures by different researchers.

Step 2: Selection of building geometry and modelling of all types of plan and vertical irregular buildings models as per IS 1893:2016 (part 1) using ETABS 2016 software.

Step 3: Application of loads and load combination to the structural model according to the standard codes.

Step 4: Comparative study of results in terms of storey displacement, storey drift, base shear and time period by considering different storeys i. e. 10 storey, 14 storey, and 17 storeys.

Step 5: Above structures are analysed by dynamic method by response spectrum method and the results have to be compared.

IV. MODELLING DATA

Table I

Table showing modelling data

Plan dimension	(20X 30) m
Number of storey	10,14,17
Floor to floor height	3.3m
Structure utility	Commercial
Seismic zone	3
Seismic coefficient	0.16
Response reduction factor	5
Importance factor	1.2
Wind speed	44 m/s
Structure type	C
Analysis method	• Dynamic analysis(RSM)
Codes used	• IS 456-2000, • IS 800-2007. • IS 875-2015. • IS 1893 Part 1-2016

The design data as follow:

1. For all the types of Irregular buildings 230x600 mm concrete sections have been used as beam sections.
2. For all the types of Irregular buildings 600x600 mm concrete section have been used as column sections for interior as well as exterior.
3. For Stiffness irregularity model bracing are provided to increase stiffness of particular storey.
4. For all types of irregularity model shear wall of size 230 mm thickness is used.
5. Floor finish of 1.5 kN/m^2 is applied on all the storeys.
6. Live load of 3 kN/m^2 is applied on all storeys.
7. Wall load of 12kN/m and 6kN/m as parapet wall load is applied on the storeys.
8. For plan and vertical irregular models total weight of building kept same as that of regular building model.

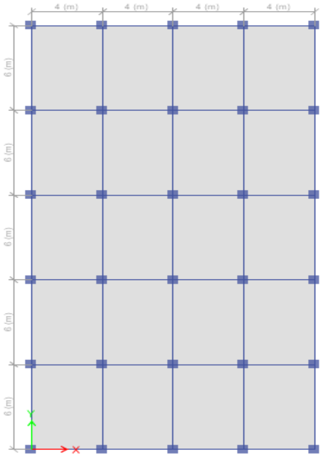

Fig. 1 Plan of regular building.

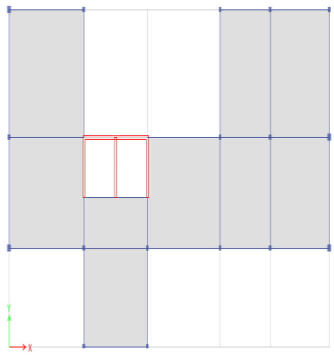

Fig. 2 Plan of torsional irregularity.

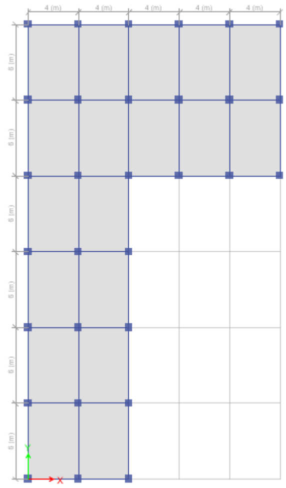

Fig. 3 Plan of re-entrant corner irregularity.

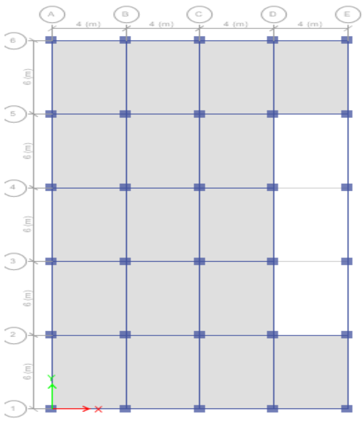

Fig. 4 Plan of floor slabs having excessive cut-outs.

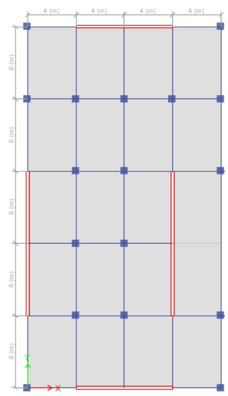

Fig. 5 Plan of out of plane offset in vertical element.

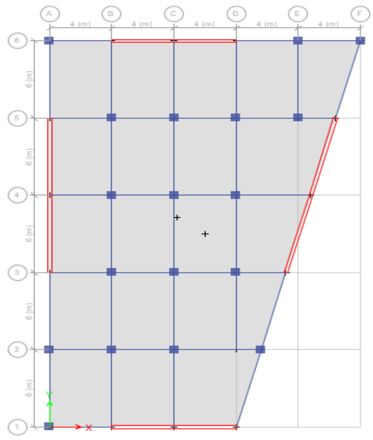

Fig. 6 Plan of non-parallel lateral force system.

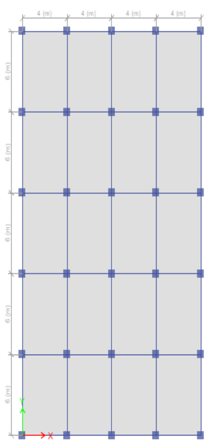

Fig.7 Plan of mass irregularity.

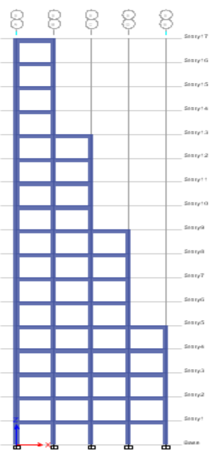

Fig.8 Elevation of vertical geometric irregularity.

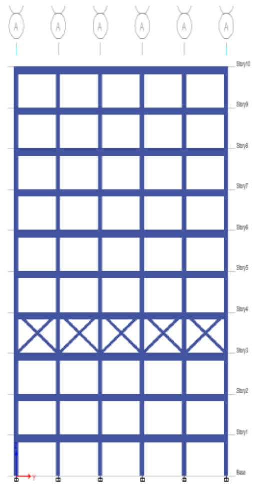

Fig.9 Elevation of stiffness irregularity.

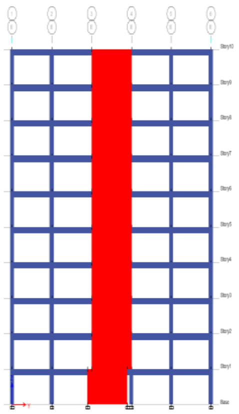

Fig.10 Elevation of In-plane discontinuity in vertical element .

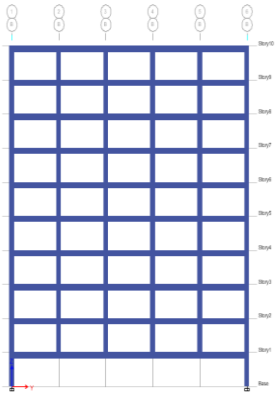

Fig. 11 Elevation of Stub column.

V. Results

- For the above given data the building had been modelled in Etabs.
- The method of analysis are Response spectrum method.
- Storey displacement, Storey drift, Base shear and Fundamental time period parameters are compared for plan and vertical irregularity and comparing all results with regular building results.
- For below tables negative sign indicates percentage increase and positive sign indicates percentage reduction.

Table II

Percentage reduction in Base shear for Plan Irregularity in RSM

STOREY LEVEL	*10*		*14*		*17*	
MODEL NAMES	X	Y	X	Y	X	Y
T	36.94%	59.57%	36.73%	60.07%	36.74%	59.85%
RC	26.68%	43.41%	27.07%	38.05%	27.37%	37.61%
C	7.40%	7.40%	7.36%	7.36%	7.34%	6.75%
O	2.95%	2.95%	3.10%	3.11%	3.21%	2.56%
N	10.83%	37.82%	10.01%	37.69%	25.32%	12.60%

Table III

Percentage increase in Base shear for Vertical Irregularity in RSM

STOREY LEVEL	*10*		*14*		*17*	
MODEL NAMES	X	Y	X	Y	X	Y
M	-0.16%	-4.13%	-0.45%	-2.75%	-2.44%	-3.20%
V	-23.96%	-11.34%	-52.98%	-22.01%	-57.66%	-52.91%
SB	-0.75%	-0.76%	-0.82%	-0.23%	-0.80%	-1.46%
ST	-0.32%	-0.33%	-0.24%	-0.23%	-0.19%	-0.82%
IP	0.55%	0.55%	0.55%	0.55%	0.55%	0.59%

Table IV
Percentage reduction or increase in storey Displacement for Plan Irregularity in RSM

STOREY LEVEL	*10*		*14*		*17*	
MODEL NAMES	X	Y	X	Y	X	Y
T	-59.69%	-80%	-63.86%	-82.6%	-66.32%	-87.13%
RC	-10.15%	-1.36%	-14.33%	-0.86%	-17.50%	-1.42%
C	-0.37%	3.26%	-0.44%	1.74%	-0.72%	1.75%
O	-11.68%	26.78%	-23.33%	9.28%	-28.78%	1.60%
N	30.62%	35.37%	26.57%	27.55%	25.30%	23.99%

Table V
Percentage reduction or increase in storey Displacement for Vertical Irregularity in RSM

STOREY LEVEL	*10*		*14*		*17*	
MODEL NAMES	X	Y	X	Y	X	Y
M	-0.92%	0.65%	-0.47%	-0.48%	-0.67%	-0.70%
V	-12.58%	-2.26%	-13.82%	-4.61%	-10.17%	-2.39%
SB	-3.28%	-1.49%	-2.35%	-2.17%	-2.10%	-1.80%
ST	-56.27%	-48.40%	-59.38%	-56.86%	-63.15%	-60.16%
IP	-72.33%	-31.95%	-70.88%	-43.55%	-69.63%	-46.78%

Table VI
Percentage reduction or increase in storey drift for Plan Irregularity in RSM

STOREY LEVEL	*10*		*14*		*17*	
MODEL NAMES	X	Y	X	Y	X	Y
T	-80.46%	-92.68%	-81.76%	-91.35%	-83.61%	-96.52%
RC	-80.39%	-66.53%	-10.54%	-60.00%	-13.58%	-0.37%
C	-46.21%	1.80%	-29.82%	1.68%	-21.83%	2.00%
O	-8.75%	28.04%	-19.32%	13.21%	-29.46%	5.89%
N	32.97%	39.49%	29.28%	33.78%	27.41%	24.57%

Table VII
Percentage reduction or increase in storey drift for Vertical Irregularity in RSM

STOREY LEVEL	*10*		*14*		*17*	
MODEL NAMES	X	Y	X	Y	X	Y
M	-1.77%	-1.76%	-0.54%	-0.75%	-0.37%	-0.30%
V	-12.84%	-1.53%	-14.47%	-0.63%	-13.66%	-1.11%
SB	-20.34%	-15.40%	-17.77%	-13.96%	-14.98%	-13.49%
ST	-68.62%	-63.35%	-74.70%	-73.12%	-76.20%	-75.28%
IP	-73.71%	-10.65%	-73.32%	-34.68%	-70.41%	-39.55%

Table VIII
Percentage reduction or increase in fundamental period for Plan Irregularity in RSM

STOREY LEVEL / *MODEL NAMES*	*10*	*14*	*17*
T	-68.90%	-70.95%	-73.67%
RC	1.39%	1.19%	1.00%
C	3.74%	3.61%	3.57%
O	52.12%	45.29%	41.16%
N	47.31%	42.96%	40.16%

Table IX
Percentage reduction or increase in fundamental period for vertical Irregularity in RSM

STOREY LEVEL / *MODEL NAMES*	*10*	*14*	*17*
M	-2.47%	-2.29%	-2.22%
V	6.27%	7.22%	10.43%
SB	-7.85%	-5.63%	-4.64%
ST	14.95%	12.46%	9.79%
IP	6.14%	5.19%	4.89%

VI. CONCLUSIONS

- Base shear :-
  i. Reduction in Torsional irregularity is 27% in X-direction and 60% in Y-direction which is maximum among remaining plan irregularities.
  ii. Reduction in In-plane discontinuity is 0.55% in both X & Y direction which is maximum among remaining vertical irregularities.
  iii. Increase in vertical geometric irregularity is 44% in X-direction & 28% in Y-direction which is maximum among remaining vertical irregularities.
- Displacement :-
  i. Increase in Torsional irregularity is 63% in X-direction and 83% in Y-direction which is maximum among remaining plan irregularities.
  ii. Reduction in Non-parallel system resisting lateral force is 27.49% in X-direction and 28.97% in Y-direction which is maximum among remaining plan irregularities.
  iii. Increase in In-plane discontinuity in vertical element is 70.94 % in X-direction and 40.76% in Y-direction which is maximum among remaining vertical irregularities.
- Storey drift : -
  i. Increase in Torsional irregularity is 81% in X-direction and 93.51% in Y-direction which is maximum among remaining plan irregularities.
  ii. Reduction in Non-parallel system resisting lateral force is 30% in X-direction and 32.61% in Y-direction which is maximum among remaining plan irregularities.
  iii. Increase in In-plane discontinuity in vertical element is 72.48 % in X-direction and 28.29% in Y-direction which is maximum among remaining vertical irregularities.

- Fundamental Time period : -
  i. Increase in torsional irregularity is 71.17% which is maximum among remaining plan irregularities.
  ii. Reduction in out of plane offset is 46.19% which is maximum among remaining plan irregularities.
  iii. Increase in stub column irregularity is 71.17% which is maximum among remaining vertical irregularities.
  iv. Reduction in stiffness irregularity is 12.4% which is maximum among remaining vertical irregularities.

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