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Research Article

Effect of Column Discontinuity at Top Floor Level on Structure

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Abstract

Structural engineer's greatest challenge in today's scenario is constructing seismic resistant structure. Uncertainties involved and behavior studies are vital for all civil engineering structures. The presence of vertical irregular frame subject to devastating earthquake is matter of concern. A G+3 vertically irregular building is modeled as 3D space frame for the analysis with discontinuous column at top floor. To response parameters like base shear, storey displacement of the structure under seismic force under the linear dynamic & non linear static analysis is studied. This analysis shows focuses on the base shear carrying capacity of a structure and performance level of structure under moderate zone of India. The result remarks the conclusion that, a building structure with irregularity produced due to column discontinuity provides instability and increases storey displacement, and drift at discontinuous level but reduces the base shear. The soft computing tool and commercial software SAP 200 (version 15) is used for modeling and analysis.

Keywords: *Column discontinuity, Response spectrum, Pushover analysis, Storey Displacement, interstorey drift, Base shear*

1. Introduction

In the past, several major earthquakes have exposed the shortcomings in buildings, which lead to damage or collapse. It has been found that regular shaped buildings perform better during earthquakes. The structural irregularities cause non-uniform load distribution in various members of a building.

There have been several past studies on the structural irregularities, viz., (Jack P. Moehle, A. M. ASCE 2002), Seismic Response of Vertically Irregular Structures, seismic response of vertically irregular frames with pushover analysis (Chintanapakdee, Chopra, 2004) and evaluation of mass, strength and stiffness limits for regular buildings specified by UBC (Valmundsson and Nau, 1997), Seismic Response of RC Frame Buildings with Soft First Storeys (Arlekar Jaswant N, Jain Sudhir K. and Murty C.V.R, 1997) etc. In the present paper, response of a four storeyed vertically irregular frame to lateral loads is studied for irregularity at top floor in the elevation. Irregularity is produced by discontinuing on column at the top storey level maintaining aspect ratio for vertically irregular frame Specified in I.S1893:2002(part1) guidelines. Effect of this column discontinuity on storey-shear forces, storey displacement at performance point and interstorey drift is studied

There are various types of irregularities in the buildings depending upon their location and scope, but mainly, they are divided into two groups—plan irregularities and vertical irregularities. In the Study, the vertical irregularities are considered which are described as follows.

Table 1 Types of Irregularity

Plan Irregularity	Vertical irregularity
Torsion irregularity	Stiffness Irregularity
Re-entrant Corners	Mass Irregularity
Diaphragm Discontinuity	Vertical Geometric Irregularity elements resisting lateral force
Out of plane offsets	In Plane discontinuity in vertical
Non parallel Systems	Discontinuity in capacity-weak storey

2. Problem statement

In order to study the column discontinuity, two frames are produced. The first frame is a regular frame in which all the columns are of full height. The second frame is irregular frame in which the middle column discontinuity is assumed to be at a top, as Figure 1 shows.

Linear and nonlinear analyses are carried out to study the effect of the column discontinuity on the behavior of each frame subjected to the vertical and the seismic loads.

For non linear seismic analysis the hinges in the beam and column are auto generated and all the diaphragms are assumed as rigid diaphragms. The beam elements are assigned with plastic hinge As per the guidelines of ATC-40 and FEMA –273, 356; the beam elements are assigned

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with moment (M_3) hinges and the column elements are assigned with axial load, moment in 2 and 3 – directions (P-M_2-M_3) hinges.

Table 2 Structural Data

Number of bays in X direction	2
Number of bays in Y direction	2
Span of each bay	5 m
Length	10 m
Width	10 m
Storey height	3 m
Number of storey	3
Size of column	0.3 m x 0.6 m
Size of beam	0.23 m x 0.6 m
Total number of columns (For regular floor)	9
Total number of columns (For irregular floor)	8
Slab thickness	0.175 m
Wall thickness	0.23 m
Parapet	0.15 m
Concrete Grade	M-25
Steel Grade	Fe-415
Density of Concrete	$25kN/m^3$
Density of Steel	$78.5\ kN/m^3$
Density of wall Masonry	$20kN/m^3$
Floor finish on slab	$1kN/m^2$
Imposed load on slab	$2kN/m^2$

For the base shear calculation and response spectrum analysis the following factors are considered

Table 3 Earthquake analysis Data

Earthquake zone	III
Importance factor	1 (Considering general building)
Response reduction factor	5 (Special moment resisting frame)
Type of soil	II (Medium Soil)
Damping	5%

Figure 1, 2, 3 and 4 shows a base model frame of structure with geometrically vertical irregularities

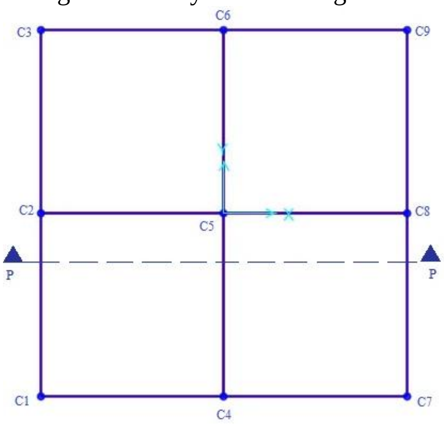

Fig 1 Plan of regular floor

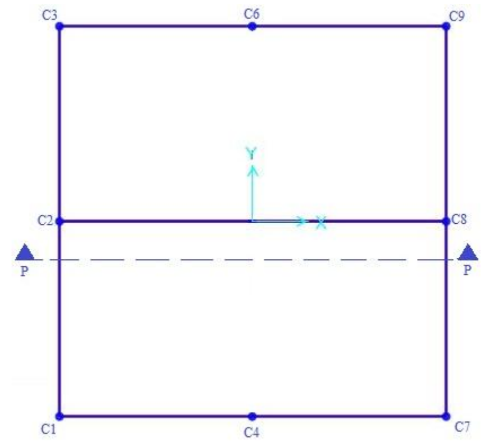

Fig 2 Plan of irregular floor

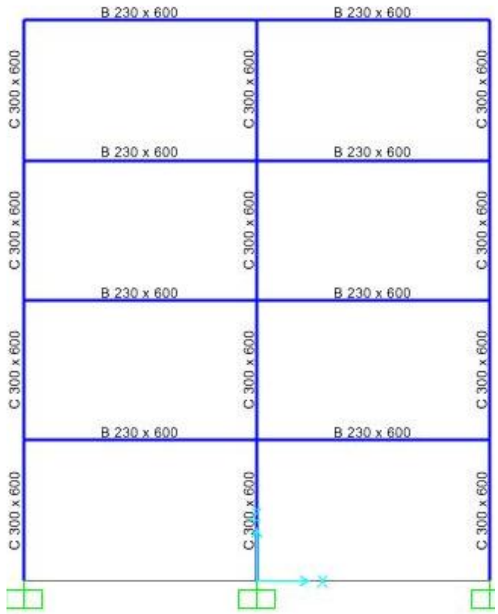

Fig 3 Sectional view (P-P) Regular Frame

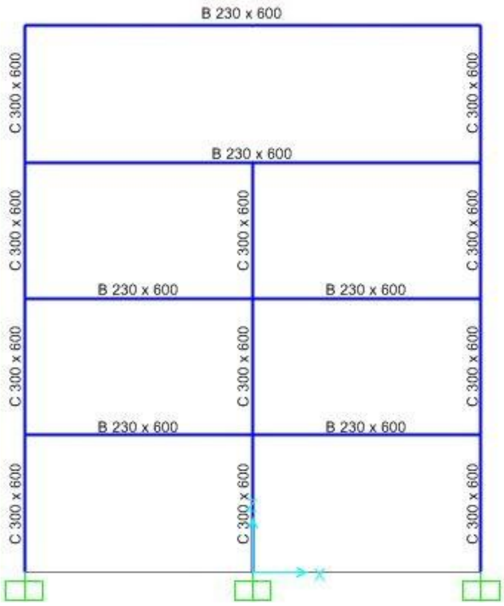

Fig 4 Sectional view (P-P) Irregular Frame having discontinuity at top floor

3. Results and discussion

SAP2000 (V15) is used to compute the response of a four (G+3) storey regular and irregular frames for rigid floor diaphragm Linear Dynamic (response spectrum analysis), Non Linear Static (Pushover analysis)

Pushover curves results have been used to observe and compare the displacement of the buildings at the performance point for parabolic lateral load patterns.

Following figure shows the pushover curves for both the regular and irregular frame for two orthogonal directions.

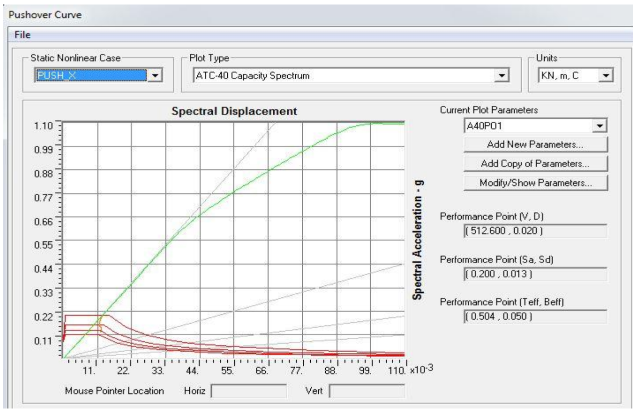

Fig 5 Pushover Curve in X-direction for regular frame

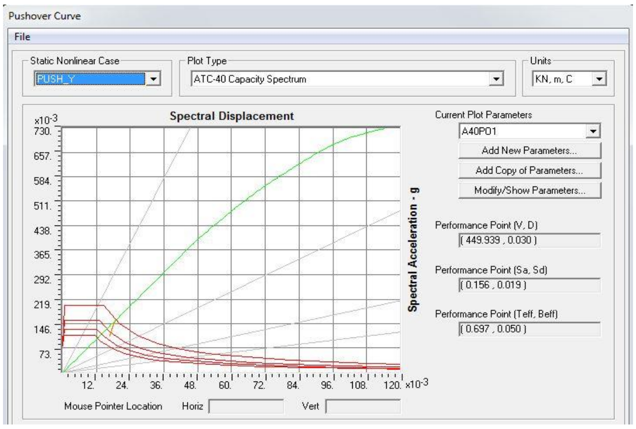

Fig 6 Pushover Curve in Y-direction for regular frame

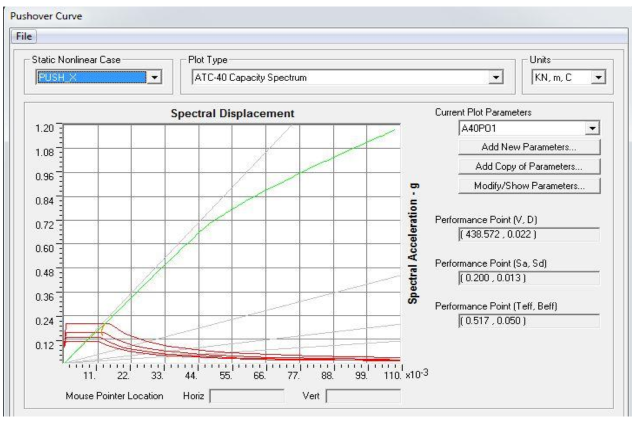

Fig 7 Pushover Curve in X-direction for irregular frame

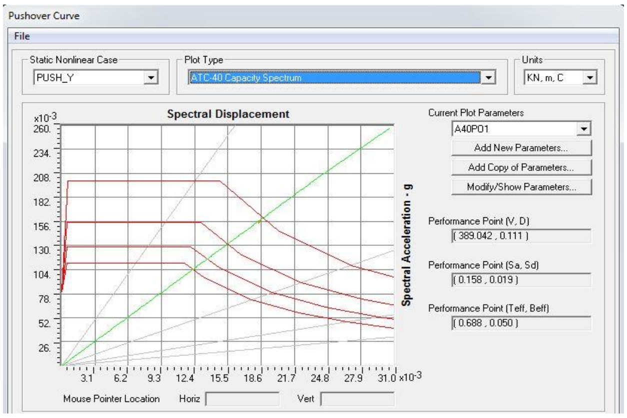

Fig 8 Pushover Curve in Y-direction for irregular frame

Table 4 Drift in X direction (in m)

	REG	IRG3
LEVEL 1	0.01032	0.009826
LEVEL 2	0.019082	0.019365
LEVEL 3	0.017097	0.018546
LEVEL 4	0.01122	0.021136

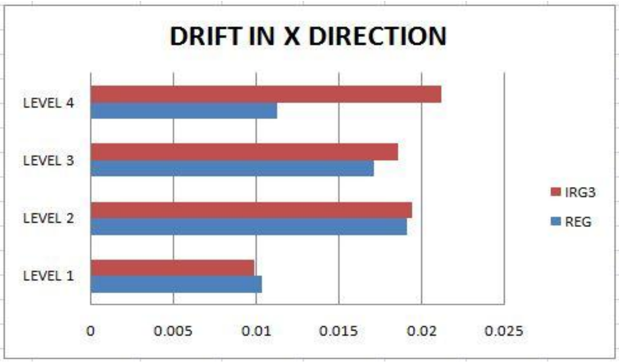

Fig 9 Drift in X-direction

Table 5 Drift in Y direction (in m)

	REG	IRG3
LEVEL 1	0.024404	0.023182
LEVEL 2	0.033359	0.021452
LEVEL 3	0.026507	0.017221
LEVEL 4	0.015871	0.046937

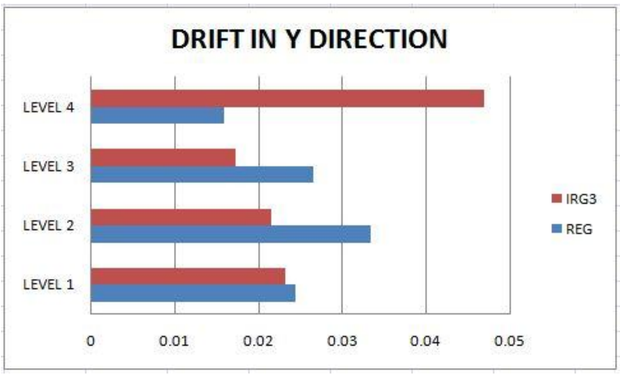

Fig 10 Drift in Y-direction

Conclusions

From the above results we can conclude the following points

- The base shear of regular and irregular frame in both the orthogonal direction is more than the calculated base shear.
- The base shear at performance point for irregular frame in X direction is reduces by 14.45% and that of in Y direction is reduced by 13.5%.
- The displacement in X direction at performance point is 20 mm for regular frame and that of irregular frame is 30 mm.
- The displacement in Y direction at performance point is 22 mm for regular frame and for irregular frame it is 11 mm
- The displacement of irregular frame is increased by 33.33% in X direction and that of in Y direction by 50% than regular frame.
- It is very clear from above values that the structural irregularity produced due to column discontinuity increases displacement but reduces the base shear under seismic loading.
- For irregular buildings, lesser than 40 m in height in Zones II and III, dynamic analysis, even though not mandatory, is recommended. Dynamic analysis may be performed by the Response Spectrum Method. However, in this method, the design base shear (V_B) shall be compared with a base shear (V_B)
- The drift in X direction for regular frame is less than the drift of irregular frame. On the other hand drift in Y direction for regular frame is more than the drift of irregular frame.
- The common observation is that the drift in both the orthogonal direction is suddenly increases at the discontinuous level.
- It is recommended that the irregularity in column is vulnerable condition for the building structure and it creates the soft storey effect.
- It also has effect on overall performance of the building under the seismic loading.

References

Jack P. Moehle, A. M. ASCE (1984), Seismic Response of Vertically Irregular Structures, *ASCE Journal of Structural Engineering*, Vol. 110, No. 9.

Valmundsson and Nau. (1997), Seismic response of buildings frames with vertical structural Irregularities, *ASCE Journal of Structural Engineering*, Vol. 123, No. 1, 30-41.

Arlekar Jaswant N, Jain Sudhir K. and Murty C.V.R, (1997), Seismic Response of RC Frame Buildings with Soft First Storeys. *Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat*, New Delhi.

Chintanapakdee and Chopra. (2004), Seismic response of vertically irregular frames: response history and modal pushover analyses, *ASCE Journal of Structural Engineering*, Vol. 130, No. 8, 1177-1185.

Vinod K. Sadashiva, Gregory A. MacRae & Bruce L. Deam (2009),Determination Of Structural Irregularity Limits – Mass Irregularity Example *Bulletin Of The New Zealand Society For Earthquake Engineering*, Vol. 42, No.4.

Ravikumar C M, Babu Narayan K S, Sujith B V, Venkat Reddy D (2012) , Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings *Architecture Research* 2012, 2(3): 20-26, Surathkal, India.

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