Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 2(H), pp. 24317-24321, February, 2018

ISSN: 0976-3031

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

SEISMIC RESPONSE OF VERTICALLY IRREGULAR RC FRAME WITH MASS IRREGULARITY

Shaikh Abdul Aijaj Abdul Rahman[1] and Ansari Ubaidurrahman Salik[2]

[1]Department of Civil Engineering, Mavin Switchgears & Control Pvt. Ltd. Aurangabad, Maharashtra, India
[2]Department of Civil Engineering, SND College of Engineering and Research Centre, Yeola, Maharashtra, India

DOI: http://dx.doi.org/10.24327/ijrsr.2018.0902.1640

ARTICLE INFO

Article History:
Received 17th November, 2017
Received in revised form 12th December, 2017
Accepted 04th January, 2018
Published online 28th February, 2018

Key Words:
Structural Irregularities, Vertical irregularities, Mass irregularities, IS 1893(Part1):2002Provisions, Base Shear, and Storey Drift.

ABSTRACT

A large number R.C.C. multistoried buildings are heavily damaged and some of them are collapse, due to vertical irregularity of structure in earthquake zone. 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. Points of sudden change of stiffness, mass and strength in building are known as weak points. For design safe irregular building it is necessary to study the effect of irregularity on the response of building for lateral loads. The present thesis research attempts to investigate the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in mass of frame on vertically irregular structures. In this paper effect of mass irregularity of G+10 storey vertical geometric irregular building using finite element method based software ETABS is studied. Two methods of analysis namely linear static and linear dynamic analysis are used to evaluate response of Structure in the form of Storey shear, Storey displacement and storey drift. Response are plotted and compared and final conclusions have been made.

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 must be a continuous path for these inertial forces to be carried from the ground to the building weight locations. A gap in this transmission path results in failure of the structure at that location.

There have been several studies on the irregularities, viz., (Jack P. Moehle, A. M. ASCE 1984), Seismic Response of Vertically Irregular Structures, (Bhattacharya S.P, Chakraborty S.K, 2010) Estimation of storey shear of a building with Mass and Stiffness variation due to Seismic excitation and evaluation of mass, strength and stiffness limits for regular buildings specified by UBC (Valmundsson and Nau, 1997), (Vinod K. Sadashiva, Gregory A. MacRae& Bruce L. Deam 2009) determination Of Structural Irregularity Limits – Mass Irregularity Example etc. In the present paper, response of a G+10-storeyed vertically irregular frame to lateral loads is studied for Stiffness and mass irregularity at different floor with base models. Mass irregularity is introduced at 3rd and 7th floor by increasing mass.

Structural Irregularities

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.

Stiffness Irregularity

1. ***Soft storey:*** A soft storey is one in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average lateral stiffness of the three storeys above.
2. ***Extreme Soft Storey:*** An extreme soft storey is one in which the lateral stiffness is less than 60% of that in

Corresponding author:* **Shaikh Abdul Aijaj Abdul Rahman
Department of Civil Engineering, Mavin Switchgears & Control Pvt. Ltd. Aurangabad, Maharashtra, India

the storey above or less than 70% of the average stiffness of the three storeys above. For example, buildings on stilts will fall under this category.

Mass Irregularity

Mass irregularities are considered to exist where the effective mass of any storey is more than 150% of effective mass of an adjacent storey. The effective mass is the real mass consisting of the dead weight of the floor plus the actual weight of partition and equipment. Excess mass can lead to increase in lateral inertial forces, reduced ductility of vertical load resisting elements, and increased tendency towards collapse due to P-Δ effect. Irregularities of mass distribution in vertical and horizontal planes can result in irregular response and complex dynamics. The central force of gravity is shifted above the base in the case of heavy masses in upper floors resulting in large bending moments.

Vertical Geometric Irregularity

Geometric irregularity exists, when the horizontal dimension of the lateral force resisting system in any storey is more than 150% of that in an adjacent storey. The setback can also be visualized as a vertical re-entrant corner. The general solution of a setback problem is the total seismic separation in plan through separation section, so that the portion of building is free to vibrate independently.

Discontinuity In Capacity - Weak Storey

A weak storey is one in which the storey lateral strength is less than 80% of that in the storey above, the storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction.

Problem Formulation

The problem considered for the current study is taken in reference to IS 1893(Part1):2002 and worked done by Valmundsson and Nau, 1997. This G+10 vertically irregular frame is considered with mass irregularity. Two frames including the base frame is referred. Two frames have been analyzed using equivalent static method of IS 1893(Part1):2002assuming Preliminary data as Location of Structure in seismic zone V, with soil type medium soil, effective damping 5% and importance factor 1.5. Analysis has been carried out using ETABS V 9.7program. Configuration of frames is as given below and typical layout is shown in Fig.1.

Frame-1: This is the base model frame of structure with geometrically vertical irregularities and having ten bays and G+10 storeys, with a storey height of 3.5 m for ground floor and 3.0 m for remaining floor and the bay width of 5 m. The basic specifications of the building are: Dimensions of the beam = 0.3 m × 0.6 m; Column size = 0.70 m × 0.30 m; Beam length = 5 m; Column length = 3.5 m; Load combinations as per clause 6.3.1.2 of IS 1893:2002 (Part-1) are;
a) 1.5 (DL+ LL), b) 1.2 (DL + LL ± EQL), c) 1.5 (DL ± EQL) d) 0.9 DL ± 1.5 EQL.

Frame-2: This frame consists of heavier loading on the third and seventh storey introduced in Frame 1, and the building becomes irregular. It has 10 bays and ten storeys, with a ground storey height of 3.5 m and typical floor height 3.0 m the bay width of 5 m.

The base model having the shape irregular to know the effect of mass irregularity on the shape (vertical geometric) irregular building the excess mass is applied on the 3ed & 7th storey as per the IS 1893(Part1):2002. The structural data is same except of the following with respect to the base model.

1. Impose Load (LL) : 32 KN/m2
2. Depth of Slab : 200 mm

The respective change is incorporated on the 3ed & 7th storey. In reference to this condition following structural& seismic data for modeling the plan, elevation & 3-D view of the base model is included as shown in Table 1.

Table 1 Details of Base Model (All dimensions are in mm.)

	Specification	Details
1.	Type of structure	Multi-storey rigid jointed plane frame(Special RC moment resisting frame)
2.	Seismic zone	V
3.	Zone Factor	0.36
4.	Importance factor	1.00
5.	Response spectra	As per IS 1893 (part 1):2002
6.	Type of soil	Medium soil
7.	Number of storey	G+10
8.	Dimension of building	60 m x 60 m
9.	Floor Height (Typical)	3.0m
10.	Base floor height	3.5m
11.	Infill wall	230 mm thick wall
12.	Impose load	5 KN/m2
13.	Materials	Concrete (M30) and Reinforcement Fe415
14.	Specific weight of infill	20 KN/m3
15.	Size of Column	700 mm x 300 mm
16.	Size of Beam	300 mm x600 mm throughout
17.	Depth of slab	150 mm
18.	Specific weight of RCC	25 KN/m3

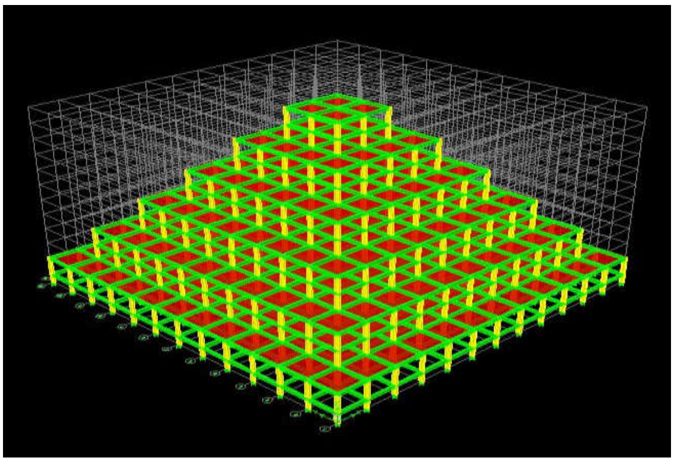


Fig 1 Base Model (Frame-1) showing 3-D view

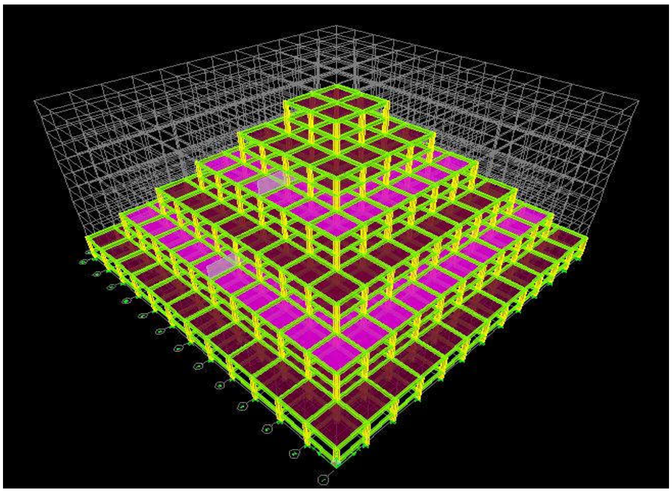
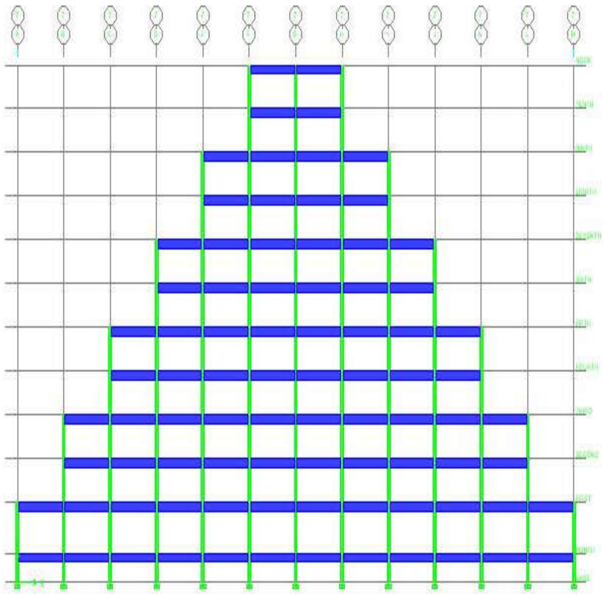
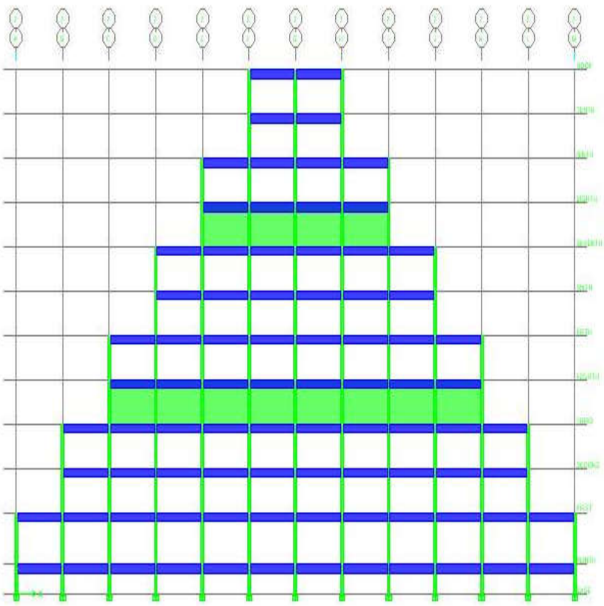


Fig 2 frame-2 3-D view Mass Irregularity at 3ed & 7th floor



(a) Frame-1 Elevation



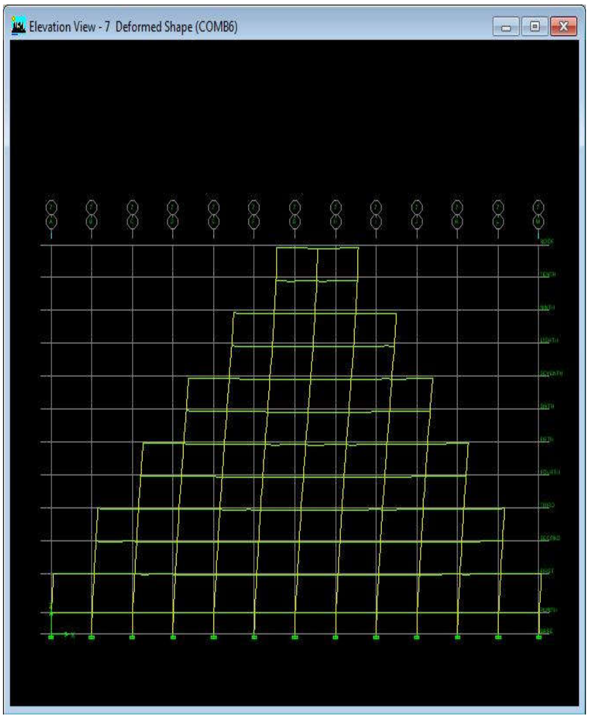
(b) Frame-2 elevation
Fig 3

ANALYSIS RESULTS

Two frames have been analyzed and responses like lateral storey-displacements, storey drifts and base shears have been computed to study the effects of mass irregularity on the vertically irregular frame. The results are presented and discussed hereafter. Table-3 shows displacement of storeys of various frames in X-direction (horizontal) graphically presented in figure It can be seen that from table-3 the frame-2 gets slightly displaced the more since the lateral stiffness with reference to frame-1and the bottom two storeys is quite less than other storeys. Whereas it’s being minimumin the base frame. Typical deflected shapes of two frames in combinations are represented in Fig. 3.

Table 2 Story Displacement (Ux) In X-direction (mm)

STORY	FRAME-1	FRAME-2
	Ux	**Ux**
ROOF	0.092815	0.104726
TENTH	0.089327	0.101178
NINTH	0.082156	0.094116
EIGHTH	0.074495	0.086706
SEVENTH	0.063778	0.076171
SIXTH	0.054715	0.064721
FIFTH	0.043792	0.051499
FOURTH	0.03501	0.041348
THIRD	0.025377	0.030459
SECOND	0.01786	0.021315
FIRST	0.010113	0.012045
PLINTH	0.001783	0.002127
BASE	0	0



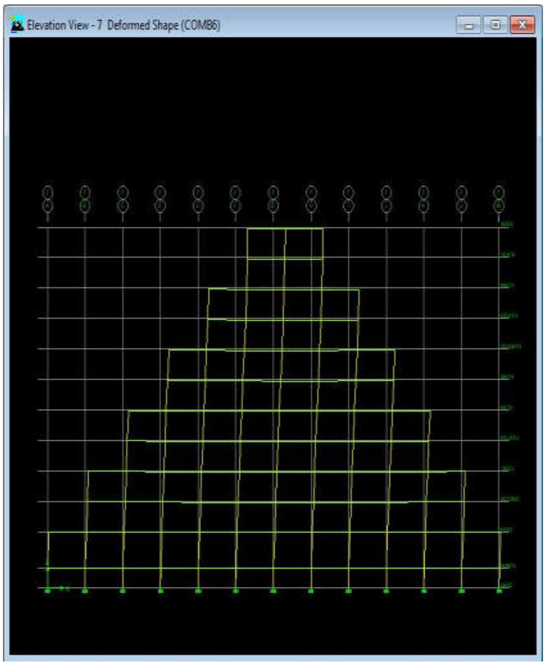


Fig 3 Deflected shapes of frames in their combination

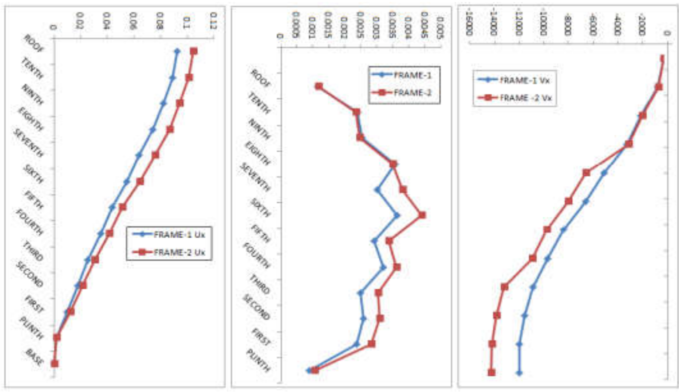
Table 3 Story Drift InX-direction (mm)

STORY	FRAME -1	FRAME-2
ROOF	0.001162	0.001183
TENTH	0.00239	0.002354
NINTH	0.002554	0.00247
EIGHTH	0.003572	0.003512
SEVENTH	0.003021	0.003816
SIXTH	0.003641	0.004408
FIFTH	0.002927	0.003384
FOURTH	0.003211	0.00363
THIRD	0.002505	0.003048
SECOND	0.002582	0.00309
FIRST	0.00238	0.002834
PLINTH	0.000892	0.001063

Storey-drifts for all the frames are tabulated Table-3 while graphically presented in Fig. 4(b). Frame-1 and frame-2 are seen to exhibit abrupt changes in storey drifts at third and seventh storey, which is slightly changed in respective storey.
The storey shears as given by ETABS using IS 1893(Part1):2002, are Tabulated in Table-4 and represented in Fig. 4(c). Frame-2, being the heaviest one, develops maximum amount of shear force in its storey's compare to Frames 1.

Table 4 Story ShearIn X-direction (mm)

	FRAME-1	FRAME -2
STORY	Vx	Vx
ROOF	-279.8094	-288.9388
TENTH	-766.9844	-754.826
NINTH	-2121.592	-2050.242
EIGHTH	-3283.746	-3161.614
SEVENTH	-5146.129	-6596.34
SIXTH	-6625.345	-8010.92
FIFTH	-8427.288	-9734.125
FOURTH	-9705.725	-10956.7
THIRD	-10908.04	-13206.54
SECOND	-11582.64	-13851.66
FIRST	-11981.04	-14232.66
PLINTH	-12016.64	-14266.69



a Displacement (mm) **b Story Drift (mm)** **c Story Shear (mm)**

Fig 4 Response of various frames with irregularities

DISCUSSION AND CONCLUSION

Considering the storey displacement, the frame with heavy mass on 3rd & 7th floor (frame-2) is the weakest than the (frame-1), as it suffers the considerable change in displacement in all the floors. As far as storey drift is concerned, frame-2 is weak than the frame-1, as the frame -2 having the considerable change in story drift. Story shear is maximum in frame-2. From this it is clear that the frame having mass irregularity on vertically irregular frame is susceptible to damage in earthquake lying zone.

In this paper, two frames having different irregularities but with same dimensions have been analyzed to study their behavior when subjected to lateral loads. All the frames were analyzed with the same method as stated in IS 1893(Part1):2002. The frame-1 (vertically irregular) develops least storey drifts while the building with mass irregularity on vertically irregular building (frame-1) shows maximum storey drifts on the respective storey levels. Hence, this is the most vulnerable to damages under this kind of loading and the same frame with heavy loads develops maximum storey shears, which should be accounted for in design of columns suitably.

The analysis proves that vertically irregular structures are harmful and the effect of mass irregularity on the vertically irregular structure is also dangerous in seismic zone. Therefore, as far as possible irregularities in a building must be avoided. But, if irregularities have to be introduced for any reason, they must be designed properly following the conditions of IS 1893(Part1):2002and IS- 456: 2000, and joints should be made ductile as per IS 13920:1993. Now a day, complex shaped buildings are getting popular, but they carry a risk of sustaining damages during earthquakes. Therefore, such buildings should be designed properly taking care of their dynamic behavior.

References

1. Jack P. Moehle, A. M. ASCE (1984), "Seismic Response Of Vertically Irregular Structures", *ASCE Journal of Structural Engineering,* Vol. 110, No. 9.
2. Bhattacharya S.P, Chakraborty S.K, Estimation of storey shear of a building with Mass and Stiffness variation due to Seismic excitation, *International Journal Of Civil And Structural Engineering* Volume 1, No 3, 2010, ISSN 0976 - 4399.

3. Valmundsson and Nau. (1997), "Seismic response of buildings frames with vertical structural Irregularities", *ASCE Journal of Structural Engineering*, Vol. 123, No. 1, 30-41.
4. 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.
5. 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.
6. 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.
7. IS: 456-2000 (Fourth Revision), "Indian standard code for practice for plain reinforced concrete for general building construction", Bureau of Indian Standards, New Delhi.
8. IS 1893:2002 (Part-I), Criteria for earthquake design structures, General provisions on buildings, Bureau of Indian Standards, New Delhi.
9. C.V.R. Murty, "Earth quake tips", Indian Institute of Technology Kanpur, India.
10. Dr. S.K. Dubey, P.D. Sangamnerkar, Seismic Behavior of Asymmetric RC Buildings, *International Journal of Advanced Engineering Technology* E-ISSN 0976-3945.

How to cite this article:

Shaikh Abdul Aijaj Abdul Rahman and Ansari Ubaidurrahman Salik.2018, Seismic Response of Vertically Irregular RC Frame With Mass Irregularity. *Int J Recent Sci Res.* 9(2), pp. 24317-24321. DOI: http://dx.doi.org/10.24327/ijrsr.2018.0902.1640

****