International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

Seismic Vertical Irregularity and Its Correlation With Regularity Index

M.Tech. Scholar Aakash Verma **Asst. Prof. Suhail Qureshi**
Dept. of Civil Engg.
Prashanti Institute of Technology and Science
Ujjain, M. P., India
aakash555555@gmail.com

Abstract **- As there is an economic boom there is an increasing demand for infrastructure in order to accommodate the requirement. As this will lead to high demand for tall structures with multiple housing units that is not only spacious but also visually appealing. This leads to the various kinds of irregularity that has been prescribed in IS 1893 and these various irregularities forces the building to deviate from their expected behavior. The aim of this paper is to review the previous works on the irregularity of structure and the various indexes that can be helpful to the standardization of the behavior the structure because of seismic activity.**

Key Words- **Seismic irregularity, ductility, shear wall, regularity index**

I. INTRODUCTION

Irregular buildings represent an oversized portion of the trendy urban infrastructure. The cluster of individuals concerned in constructing the building facilities, together with owner, architect, structural engineer, contractor and native authorities, contribute to the general coming up with, choice of structural system, and to its configuration. This might cause building structures with irregular distributions in their mass, stiffness and strength on the peak of building. Once such buildings square measure placed in an exceedingly high seismic zone, the structural engineer's role becomes more difficult. Therefore, the structural engineer must have a radical understanding of the seismic response of irregular structures. In recent past, many studies are administrated to judge the response of irregular buildings.

This report is an effort to summarize the work that has been already done concerning the seismic response of vertically irregular building frames. The primary purpose of every kind of structural systems utilized in the building kind of structures is to support gravity hundreds. The foremost common hundreds ensuing from the result of gravity are load, loading and snow load. Besides these vertical hundreds, buildings also are subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads will develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. In India, a considerable number of buildings have reinforced concrete structural systems. This is due to economic reasons. Reinforced concrete building structures can be classified as :

1. **Structural Frame Systems-** The structural system consist of frames. Floor slabs, beams and columns are the basic elements of the structural system. Such frames can carry gravity loads while providing adequate stiffness.
2. **Structural Wall Systems-** In this type of structures, all the vertical members are made of structural walls, which may or may not be reinforced or have any ductile detailing.
3. **Structural Wall** -Frame Systems (Dual Systems): The system consists of reinforced concrete frames interacting with reinforced concrete structural walls.
4. **Flat slab-** Structural Wall Systems-The system consist of RC walls resisting the lateral forces. In India most of the building are not engineered buildings and the one which are does not have adequate ductility or stiffness to overcome a design earthquake. It is only after tragedy of Bhuj earthquake that the concern towards the earthquake resistant buildings had been risen. As a result we had a revised code of IS 1893 in 2016 which covers a great variety of structural system to give guideline on how to design them.

4. Types of Irregularity

4.1 Mass irregularity -This situation happens in case one floor heavy than the floor that are above and below.

4.2 Stiffness irregularity -This situation occurs when a column length is different than the other floors or non-availability of walls around the columns. The most common case is that of parking which has lower stiffness than the floors above.

4.3 Geometric irregularity -This situation occurs when structure is symmetric about any one axis and hence it can arise to tensional irregularity.

International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

II. CRITERIA FOR VERTICAL IRREGULARITIES IN BUILDING CODES

In the previous versions of IS 1893 which deals with the seismic load calculation of building there were no mention of irregularity upto 1984 , but the recent two revision (IS 1893-2002 and IS 1893-2016) has defined irregularity in great detail. In all five types of vertical irregularity have been listed as shown in figure below. They are: stiffness irregularity (soft story), mass irregularity, vertical geometric irregularity (set-back), in-plane discontinuity in lateral-force-resisting vertical elements, and discontinuity in capacity (weak story).

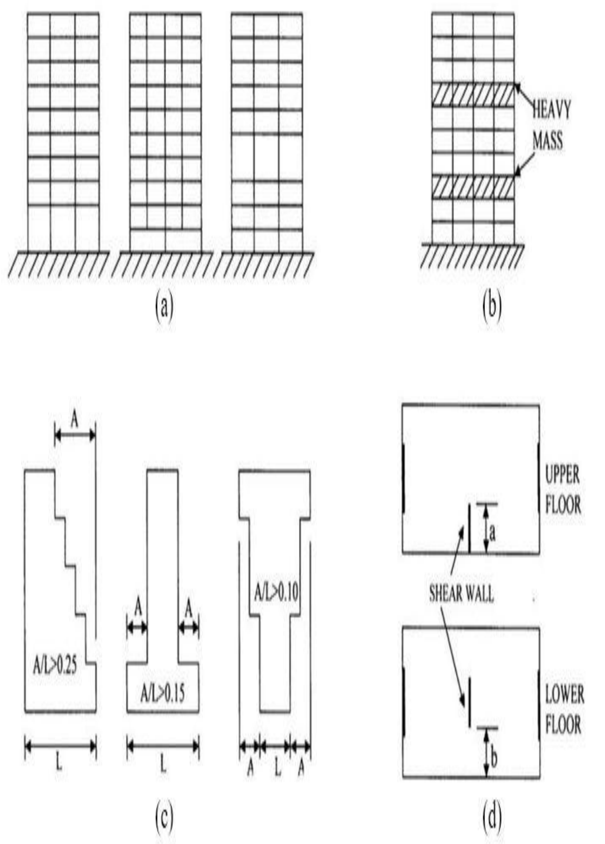


Fig. 1 (a) Stiffness/strength irregularity; (b) Mass irregularity; (c) Vertical geometric irregularity or set-back; (d) In -plane discontinuity in lateral-force-resisting vertical elements when *b* > *a*: plan view.

Table 1 Ratio and density.

Concrete		
Density	Modulus of Elasticity	Poisson ratio
24.2kN/m^3	21.72 GPa	0.3

HEHRP code (BSSC, 2003) has classifications of vertical irregularities similar to those described in IS 1893 (Part 1)-2016. As per this code, a building can be said to be irregular if the ratio of of any one parameter is more than the prescribed value which are defined below:-

Soft storey – 70-80%

Stiffness -Weak storey 80%

Vertical irregularity – Set –back structures 150%

After the classification, the appropriate method of analysis for calculation of lateral forces (Response spectrum, Time history analysis) is used rather than conventional method of Equivalent Static load.

III. OBJECTIVES OF PRESENT STUDY

The broad objective of the study are stated herein:-

- To evaluate the mode and their participation factor of a regular framed building.
- To evaluate the mode and their participation factor of an irregular stepped framed building.
- To study the variation for different storeys.
- To summarize the structural response for all the structure.

IV. METHODOLOGY

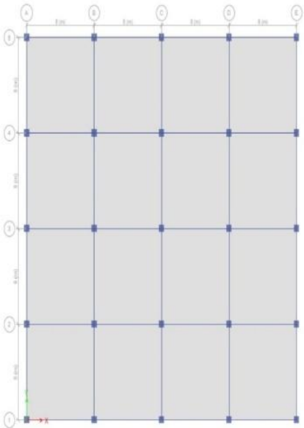
- The methodology followed to accomplish the above mentioned objectives are given below.
- A broad literature review on the vertical irregularity of building.
- Identification of RCC structure. In our case a regular building and three stepped building is considered.
- Model creation of a known dimension in Etabs.
- Execution of Modal analysis according to specification of I.S.1893 Part-1 2002.
- Extraction of modal participation factor and other included data.
- Calculation of regularity index as mentioned in by Sarkar et. al.
- Comparison of regularity index for building of various heights.
- Frame Structure
- Beams 300mm x 450mm and Column 600 x 600 mm
- Slab thickness is 150 mm
- Plan layout is 24m x 24m with 8 m c/c distance between columns
- Floor to floor height is 3m
- Live load 2 kN/m^2 (according to IS 875 Part2-1987[Reaffirmed 2008])
- Seismic Loads are taken according to IS 1893 Part1-2016
- The infill masonry modulus of elasticity is given by E_m=550 f_m according to clause 7.9.2 from IS 1893
- where $f_m=0.433 f_{brick}^{0.64} f_{motar}^{0.36}$ according to IS 1905

International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

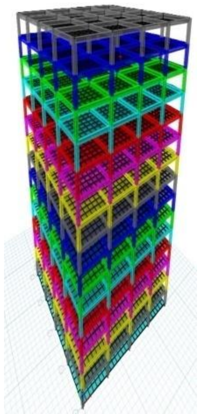
1. Level of Vertical Iregularity

- Regular building no irregularity and is designated as REG.
- One storey at each bay in a stepped manner is removed and is designated as S1.
- Two storey at each bay in a stepped manner is removed and is designated as S2.
- Three storey at each bay in a stepped manner is removed and is designated as S3.

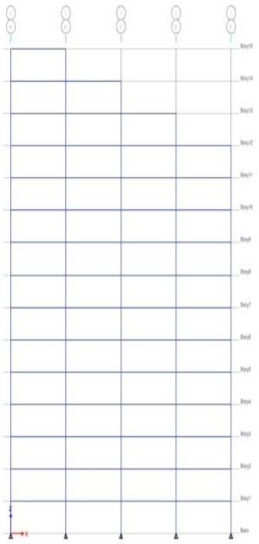
Some of the images of the models are below:-



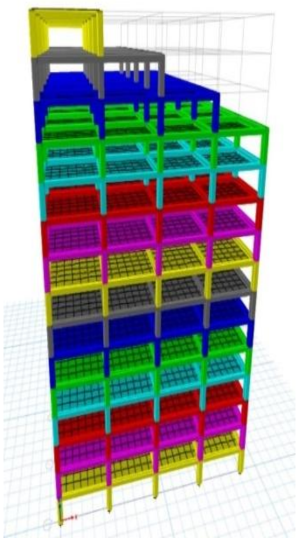
Plan Reg



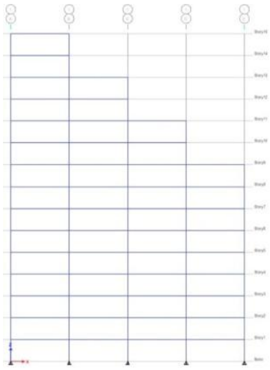
3D Reg



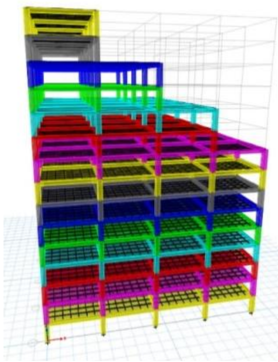
Plan S1



3D S1



Plan2



3DS2

V. CALCULATION OF REGULARITY INDEX REGULARITY INDEX

Table 2 mathematically speaking it is defined a different value for different kind of structure.

References	Building type	Regularity index proposed
Karavasilis et al. (2008)	Steel setback frame	$\phi_s = \frac{1}{n_s-1}\sum_{i=1}^{n_s-1}\frac{L_i}{L_{i+1}}, \phi_b = \frac{1}{n_b-1}\sum_{i=1}^{n_b-1}\frac{H_i}{H_{i+1}}$
Sarkar et al. (2010)	RC stepped frame	$\eta = \frac{\Gamma_1}{\Gamma_{1,ref}}$
Varadharajan et al. (2013)	RC setback frame	$\lambda_r = \sum_{i=1}^{N}\frac{\omega_{k,ir}}{\omega_{k,r}}$

In our case the building is stepped and hence the regularity index is taken as defined by Sarkar.

$$\eta = \Gamma_i / \Gamma ref$$

VI. RESULT

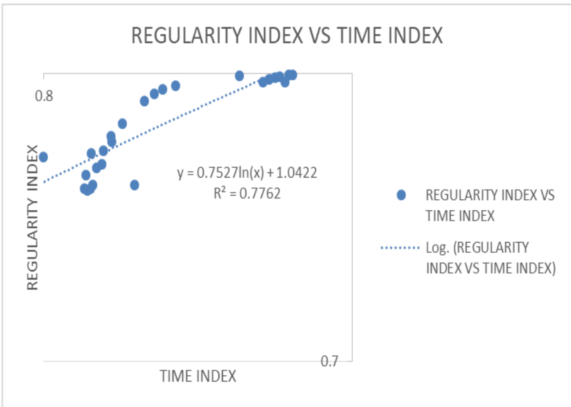


Fig. 2 Regularity index vs time index for G+12

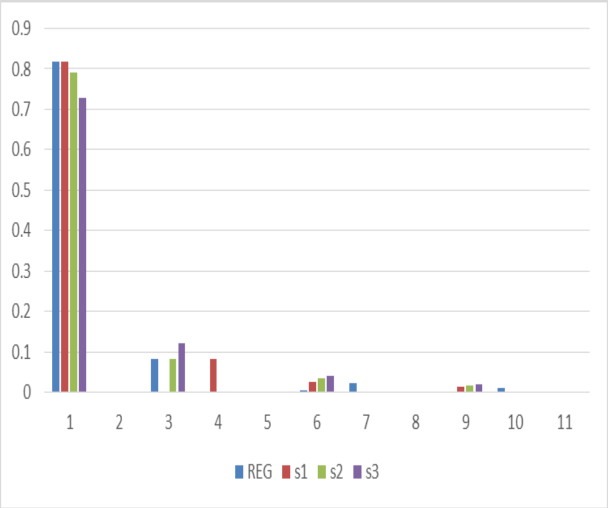


Fig. 3 G+12

VII. CONCLUSIONS

This summary is that the irregularities is likely the cause of failure in the most of the structure during seismic action which forces to instability of structure even before its actual capacity is achieved, hence it is highly advisable by many findings to avoid them. In case it is not possible to remove them adequate methods such as dampeners, base isolation etc. should be implemented in order to reduce the deterioration of the structure during lateral loading. The inference from the graph is as follows:-

- The logarithm scale regularity index is linearly variable to time index within the same base plan and variable storey irregularity.
- As we start to increase the irregularity of building by removing the storey in stepped manner. The regularity index on normal scale first increases and then remains nearly constant.
- The maximum regularity index was 0.9985 at time index 0.95804 for S1 configuration of G+12 building.
- The maximum modes were found to be the first modes which contributes the most.

REFERENCES

[1]. Stafford Smith, B., And Coull A., Tall Building Structures: Analysis And Design, John Wiley And Sons, 1991
[2]. Taranath, B. S., Structural Analysis And Design Of Tall Buildings, Mcgraw-Hill Company, 1988.
[3]. Öztorun, N. K., Computer Analysis Of Multi-Storey Building Structures", Ph.D. Thesis, Middle East Technical University, 1994.
[4]. Cvr Murty, Rupen Goswami, Ar Vijaya narayanan, And Vipul V Mehta. Some Concepts In Earthquake Behaviour Of Buildings. Gujarat State Disaster Management Authority, Government Of Gujarat, 2012.
[5]. Cvr Murty And Sudhir K Jain. Benecial Inuence Of Masonry Infill Walls On Seismic Performance Of Rc Frame Buildings. In 12th World Conference On Earthquake Engineering (Auckland, New Zealand, January 30), 2000.
[6]. Is 13920 – 2016 "Ductile Design And Detailing Of Reinforced Concrete Structure Subjected To Seismic Forces-Code Of Practice"
[7]. Is 1893 2016 Part 1 Criteria For Earthquake Resistant Design Of Structure"
[8]. Vinay Sanjeevkumar Damam "Comparative Study On Multistoried Rcc Structure With And Without Shear Wall By Using Sap2000 V17" In International Research Journal Of Engineering And Technology (Irjet) E-Issn: 2395 -0056 Volume: 02 Issue: 07 | Oct-2015
[9]. Pravin D. Deore, Prof. Dr. Rajashekhar Talikoti"Comparative Study Of Behavior Of Shear Wall With Different Percentage Of Opening" Ijsrd - International Journal For Scientific Research & Development| Vol. 3, Issue 03, 2015 | Issn (Online): 2321-0613.
[10]. Firooz Emamy Farvashany," Parametric Studies On Reinforced Concrete Shear Walls " Aci Structural Journal, V. 114, No. 5, September-October 2017.
[11]. Ugaldea, Diego Lopez-Garciaa "Behavior Of Reinforced Concrete Shear Wall Buildings Subjected To Large Earthquakes" X International Conference On Structural Dynamics, Eurodyn 2017 (10.1016/J.Proeng.2017.09.524)
[12]. Yu Zhang, Caitlin Mueller" Shear Wall Layout Optimization For Conceptual Design Of Tall Buildings" Engineering Structures Journal 140 (2017) 225–240
[13]. Haijuan Duan A, Mary Beth D. Hueste ," Seismic Performance Of A Reinforced Concrete Frame Building In China" Engineering Structures Journal 41 (2012) 77–89.
[14]. Narayanan S P, Sirajuddin M, "Properties Of Brick Masonry For Fe Modeling" American Journal Of Engineering Research (Ajer) E-Issn : 2320-0847 P-Issn : 2320-0936 Volume-1 Pp-06-11
[15]. Rahul P. Rathi , Dr. P.S. Pajgade "Study Of Masonary Infilled R.C. Frame With & Without Opening" International Journal Of Scientific & Engineering Research Volume 3, Issue 6, June-2012 1 Issn 2229-5518.
[16]. P. G. Asteris, M.Asce ,"Lateral Stiffness Of Brick Masonry Infilled Plane Frames" Journal Of Structural Engineering, Asce / August 2003.
[17]. Nikhil Agrawal , Prof.P.B Kulkarni , Pooja Raut"Analysis Of Masonry Infilled R.C.Frame With & Without Opening Including Soft Storey By Using Equivalent Diagonal Strut Method" International Journal Of Scientific And Research Publications,

Volume 3, Issue 9, September 2013 1 Issn 2250-3153.

[18]. Narayanan S P, Sirajuddin M, “Properties Of Brick Masonry For Fe Modeling” American Journal Of Engineering Research (Ajer) E-Issn : 2320-0847 P-Issn : 2320-0936 Volume-1 Pp-06-11.