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Analysis And Design of High Rise Buildings With Vertical Irregularities Located at Seismic Zone-III.

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Abstract - *The primary subjects of this study are the analysis and design of high rise buildings with vertical irregularities. India is a developing country at the moment with a sizable population, and as a result of this large population, there is a lack of available land there. Due to a paucity of land, India has little opportunity to stretch a construction out horizontally. That structure began to spread vertically throughout India. Make the shape of the structure asymmetrical for aesthetic purposes. Consequently, it is crucial to evaluate and create irregular structures. For this purpose, this study analyses and designs an irregular structure. and the goal of this effort is to enhance the understanding and design of vertically uneven structures.*

Key Words: **Irregular Structure, Storey Shear, Storey Shear Force, Storey Displacement, Storey Drift**

1.INTRODUCTION

Damage from earthquake ground motion frequently starts where there are structural vulnerabilities in the lateral load resisting frames in multi-storeyed framed constructions. Occasionally, differences in mass, stiffness, or strength between neighbouring floors may contribute to these issues. The frame geometry across the height frequently undergoes rapid alterations in conjunction with these storey shifts. Several structures have collapsed as a result of such vertical discontinuities during previous earthquakes.

When a building's lateral dimension is decreased along its height, a common sort of vertical discontinuity is generated. In this instance, the "stepped" building type is significant. Due to its attractive and useful design, this specific building type is being employed more and more often in the construction of contemporary multi-story buildings. For instance, in an urban area with closely spaced tall buildings, a tiered design like this one gives the lowest levels ample sunlight and ventilation. Furthermore, this style of building design ensures adherence to "floor area ratio"-related building byelaw restrictions (common in India). New Delhi(fig.1), located in metropolitan India, is a well-known example of a stepped building.

Stepped structures exhibit abrupt, staggered reductions in floor area along the building's height, as well as equivalent reductions in mass, strength, and stiffness (albeit not necessarily at the same rate). In terms of their dynamic properties, these structures' height-wise stiffness and mass fluctuations differ from those of a "typical" building. The stepped building shape has not received much attention from the design codes. This could be as a result of the literature's dearth of published studies on stepped structures.

Seismic disturbances can cause damage to existing structures. The design of structures for seismic susceptibility is of paramount importance since it causes economic loss. Building seismic performance is substantially different from wind loading patterns that cause elastic deformations in structures.

It is believed that perfect uniformity in building is an ideal that seldom comes true. They really combine the two, though. Plan and elevation irregularities are two separate opinions, according to important national and international rules. A paradigm shift has already occurred in the comparison of irregular and regular structures. Plan irregularity indicates that this sort of asymmetric behaviour is caused by a non-uniform mass, stiffness, and strength distribution over the structure, leading to significant floor rotations and displacements, as shown by previous earthquakes. Numerous improvements have been considered in recent decades.

Fig-1: A typical stepped building located in New Delhi, India.[1]

2. LITRETURE REVIEW

1. Sarkar, P., Prasad, A. M., & Menon, D. (2010). Vertical geometric irregularity in stepped building frames. *Engineering Structures*, *32*(8), 2175-2182.

This study provides a new approach for assessing anomalies in these building frames while taking into consideration dynamic properties (mass and stiffness). For assessing the seriousness of abnormalities in a stepped building construction, a "regularity index" is proposed. In order to estimate the fundamental time period of the stepped construction frame, this research also suggests modifying the empirical approach supplied by the code for calculating the fundamental period for regular frames. The regularity index serves as a function in the proposed equation for basic time periods. It has been examined using several distinct stepped irregular frame types. Vertical irregularity, as shown by this study, arises "when the lateral dimension of the greatest offset at the roof level exceeds 25% of the lateral dimension of the structures at the base," as stated by IS:1893-2002. A/L > 0.25." If a building's horizontal dimension at any given level (Li) is larger than 130% of that at an adjacent storey (Li+1), it is said to be vertically irregular, per ASCE:7-2005.

Results:

It is suggested that the name "regularity index" be used to describe a method of measuring vertical irregularity appropriate for stepped buildings that takes into account variations in mass and stiffness throughout the structure's height. Tests have shown that it improves the accuracy of the current measurements and that it makes sense. The fundamental time period of stepped structures is given as a function of regularity index using an empirical formula. A free vibration study conducted on a variety of stepped frames has confirmed this. As shown by an example of a genuine stepped structure in New Delhi, the suggested modification of the empirical formula required by the code yields a valid estimate of the fundamental period, even for three-dimensional building models. The length of time periods grows with structure height. In addition, lateral displacement and inter-story height also rise with the structure's height.

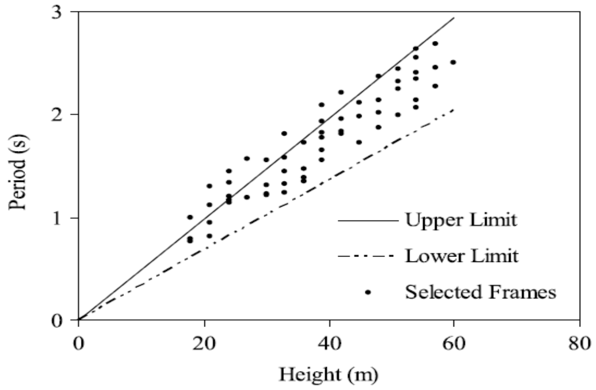

Fig-2: Fundamental period versus height of the structure[1]

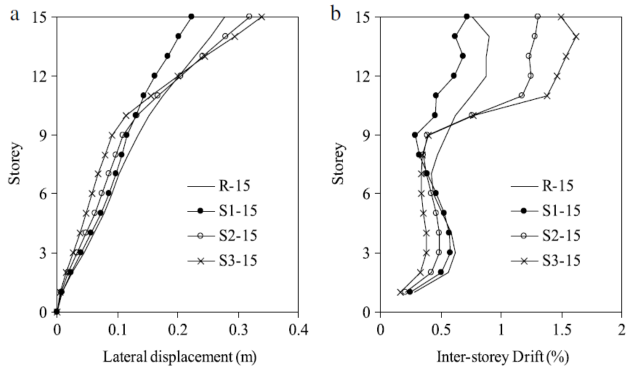

Fig-3: Elastic response of stepped building frames.[1]

2. Satheesh, A. J., Jayalekshmi, B. R., & Venkataramana, K. (2019). Effect of in-plan eccentricity in vertically mass irregular RC framed buildings under seismic loads. *Asian Journal of Civil Engineering*, *20*(5), 713-726.

In this study, three structures are taken into account. 5 storeys, 10 stories, and 15 stories high. In addition, the storey height and bay width are both taken to be 3 metres. 300 x 400 mm for the beam and 400 x 400 mm for the column, respectively. Concrete is thought to be grade M25, while steel is thought to be grade Fe-415. The foundation slab is 500 mm thick, compared to the usual floor slab's thickness of 150 mm. For analysis and design, the IS 456-2000, IS 1893(p-1), and IS 875-1987 codes are employed. An analysis of a building is done using LS DYNA software. The mass ratio is 1.5, 2, 3, 4, and 5 at the lowest, middle, and top floor levels of the building, respectively. The seismic weight of the floor being analysed is compared to the seismic weight of the floor below using a mass ratio. In order to calculate dynamic eccentricity, apply the equations below.

$e_{di} = 1.5e_{si} + 0.05b_i$ or $e_{si} - 0.05b_i$

where,

e_{di} = dynamic eccentricity

e_s = static eccentricity

i = number of the floor

b = floor plan dimension perpendicular to the force

Results:

Natural periods are enhanced by 8 to 44% in frames with vertical mass irregularity at the top level compared to frames with irregularity at the bottom. This impact on the regular structures in the plan is increased by no more than 30.5% because of the in-plan eccentricity in the building frames. Due to in-plan as well as vertical mass irregularity, natural period is elevated by 38% in Group A buildings, 18% in Group B buildings, and 28% in Group C buildings even in structures with a mass ratio of 1.5 at the top level. The location of the masses in relation to those at the lowest levels causes the base shear ratio in each group of structures to rise by 9–29%. When the irregularities are supplied at the top level of the frames, the base shear demand is at its maximum. Due to the substantial in-plan eccentricity at the top compared to regular structures, the base shear ratio rises by 34.6%. When the masses are positioned at the top levels of the frames as opposed to the lower levels, the maximum roof rotation is increased by 16–67%. Roof rotation increases by 138.5% with plan eccentricity compared to frames with normal plans. Even in the case of irregularity with a mass ratio of 150%, the in-plan eccentricity increases the roof rotation by a maximum of 88.8%. When the mass anomalies are at the top level of the frame as compared to the bottom levels, the roof deflection ratio rises by 6.8 to 35.5%. The highest increase in roof deflection is 28.9%.

3. STRUCTURAL AND SECTION DETAILS

TABLE-1: Irregular building's Notation

IT 01	MS (Mass irregularity & Soft Storey)
IT 02	SG (Soft Storey & Vertical Geometric irregularity (Set back))
IT 03	MG (Mass irregularity & Vertical Geometric irregularity)
IT 04	MSG (Mass, Soft Storey, Vertical Geometric irregularity)

Table-2: Structural Details

Dimension of Members	
Building type	Commercial
Average Story Tallness	3.2 m
Story Tallness	3.2 m
Number of Floors	22
Tallness of Cellar	3.2m
Tallness of Cellar	3.2 m
Total dimension of plan in X-direction	28.7 m
Total dimension of plan in Y-direction	19.7 m
Dimension of Members	
Column Size	450mm x 1000mm
Beam Size	300mm x 750mm
Slab Thickness	150mm
Thickness of Wall	115mm
Thickness of Shear Wall	230mm
Thickness of Shear Wall	230mm
Grade of Steel	Fe 550
Loads Taken	
Unit weight of RCC	25 kN/m³
Unit weight of Masonry	20 kN/m³
Floor Finish Load	3.5 kN/m³
Live Load	4 kN/m³
Seismic Parameters	
Seismic Zone Factor	0.16 (III)
Response Reduction Factor	5
Importance Factor	1.2
Type of Soil	Medium (II)
Damping Ratio	5%
Support Condition	Fixed
Frame Type	MRF

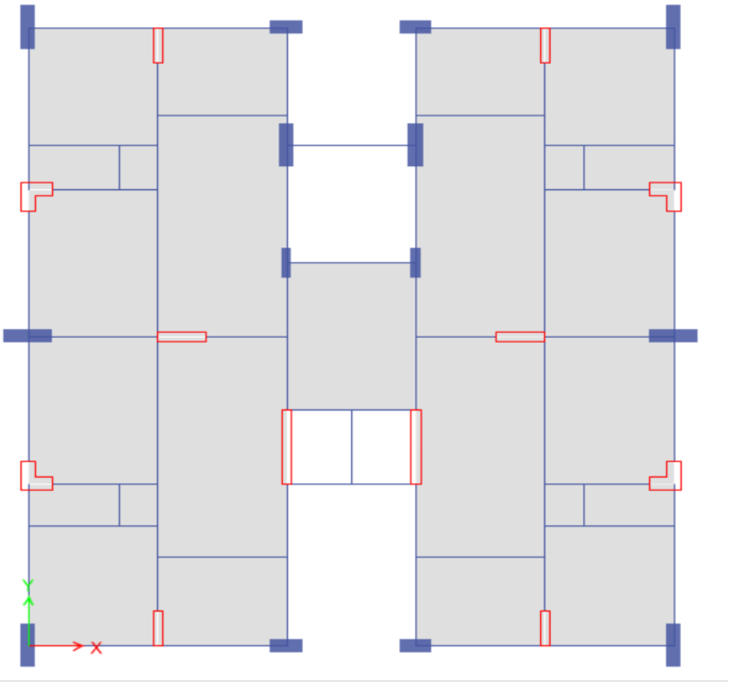

Fig-4: ETABS Basic Model Plan.

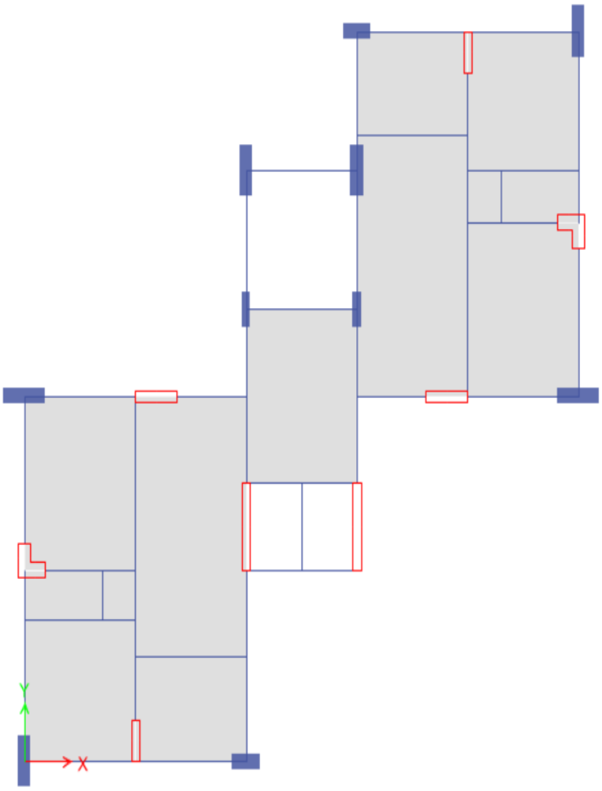

Fig-5: ETABS PLAN IT02,03,04.

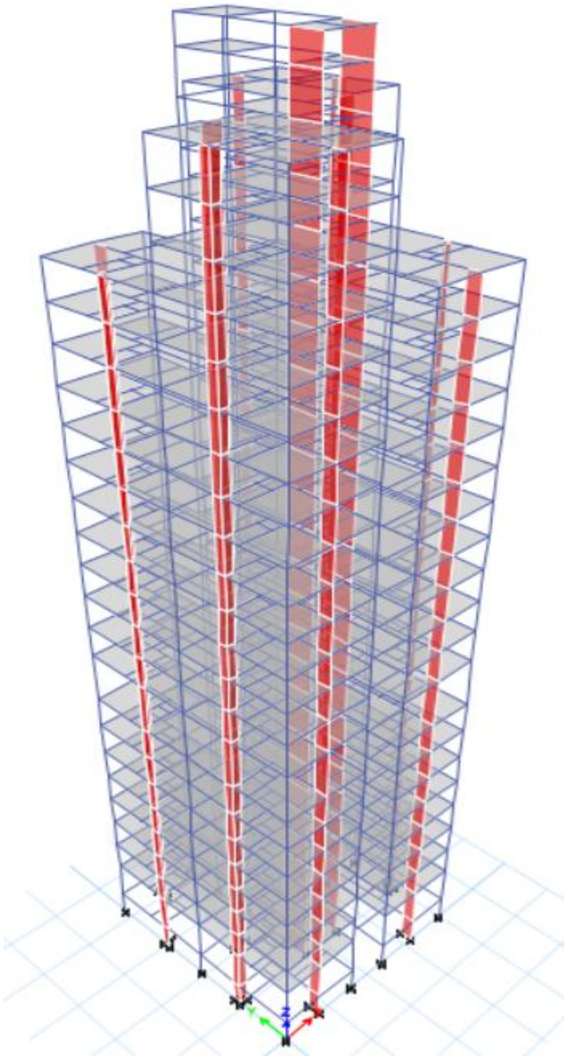

Fig-5: ETABS 3D-PLAN IT02,03,04.

Value of Mass irregularity = 15 KN/m^3 at 8th floor
Soft Storey = 5 m height at 8th floor
Geometric Irregularities = 0.5 setback at floor 20th, 21th, 22th

4. METHODOLOGY

The analysis and design of the following structure with various vertical irregularities has been done in the current work.

Types of irregularities is considered,

i) Vertical Geometric irregularity
ii) mass irregularities
iii) stiffness irregularity
iv) soft storey

Analysis and design is done in ETABS(version17.0.1) software.

5.CONCLUSION

The uneven structure of type IT 01, which combines soft story and mass irregularity, has the largest storey displacement. an illustration of the maximum storey displacement at terrace level. The largest storey drift is observed in irregular constructions of the IT 01 type that combine soft storey with mass irregularity. and slab level eight indicates the maximum storey drift. The greatest storey shear is observed in irregular constructions of the IT 01 type that combine soft storey and mass irregularity. and the biggest straw shear can be seen towards the bottom. In typical constructions, the fourth story slab is where the maximum storey stiffness is seen. The aforementioned data lead us to the conclusion that weak structures are those that have soft storeys and mass abnormalities together, as both features lower a building's performance.

Buildings are at danger during earthquakes because of the interaction of mass anomalies and soft storeys.

IT 01 > IT 04 > BASIC > IT 02 > IT 03 is a weak building.

6.REFERENCES

[1] Sarkar, P., Prasad, A. M., & Menon, D. (2010). Vertical geometric irregularity in stepped building frames. *Engineering Structures*, *32*(8), 2175-2182.

[2] Satheesh, A. J., Jayalekshmi, B. R., & Venkataramana, K. (2019). Effect of in-plan eccentricity in vertically mass irregular RC framed buildings under seismic loads. *Asian Journal of Civil Engineering*, *20*(5), 713-726.

[3] Kiran, K. S., & Suresh, G. Seismic Analysis and Design of Vertically Irregular RC Building Frames. *vol*, *6*, 9017-9019.

[4] Rahman, S. A. A. A., & Deshmukh, G. (2013). Seismic response of vertically irregular RC Frame with stiffness irregularity at fourth floor. *International Journal of Emerging Technology and Advanced Engineering*, *3*(8), 377-385.

[5] Shelke, R. N., & Ansari, U. (2017). Seismic analysis of vertically irregular RC building frames. *Int. J. Civil Eng. Technol*, *8*(1), 155-69.

[6] Sumit Gurjar, Lovish Pamecha, "Seismic Behavior Of Buildings Having Vertical Irregularities", International Journal of Engineering Science Invention Research & Development (April-2017).

[7] Kevin Shah, Prutha Vyas, "Effects Of Vertical Geometric And Mass Irregularities In Structure", International Conference on Research and Innovations in Science, Engineering &Technology (2017).

[8] Pradeep Pujar, Amaresh, "Seismic Analysis Of Plan Irregular Multi-storied Building With And Without Shear Walls", International Research Journal of Engineering and Technology (Aug -2017).

[9] Ravikumar C M, Babu Narayan, Sujith B V, "Effect Of Irregular Configurations On Seismic Vulnerability Of Rc Buildings", Architecture Research, (2012).

CODES:

[10] IS-456 (2000), Indian standard of code and practice for plain and reinforced concrete for general building construction.

[11] IS-1893 2016, Criteria for Earthquake Resistant Design of Structures, [Part1: General Provisions and Buildings, Bureau of Indian Standard].

[12] IS 13920: 2016, Ductile design and detailing of reinforced concrete structures subjected to seismic forces.

[13] IS-875 (Part 1 Dead Loads)-1987, Code of practice for design loads (other than earthquake) for building and structures.

[14] IS-875 (Part 2 Impose Loads)-1987, Code of practice for design loads (other than earthquake) for building and structures.

BOOK:

[15] Reinforced Concrete Vol. I Part II, By DR. H. J. SHAH.