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# Seismic Analysis of Multistory Building by Using the is 1893:2016 Having Stiffness Irregularity in RCC Structure and Composite Structure

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**ABSTRACT**: Earthquake is one of the vital viewpoints to be thought of while planning each construction. Part of exploration works has been accounted for by numerous scientists who attempted to consider the impact of constructions with various anomalies. Current work manages study conduct of working with inconsistency. In this investigation I have considered G+20 models of regular and irregularity structure. For this reaction range technique for examination is utilized. All the structures are thought to be in Zone V and having medium soil type. The ground movement information of El-centro seismic tremor 1940 has been thought of. This investigation is finished by utilizing Etabs programming.

**KEYWORDS**: Structural Irregularities, Stiffness irregularities, I.S 1893:2016 (Part1) Provisions, Base Shear, Storey Drift, Storey displacement.

## I. INTRODUCTION

An earthquake is a sudden tremor of the earth, caused by the displacement of tectonic plates in the earth's crust. It is known that various types of irregularities in buildings are used in modern infrastructure. In the event of an earthquake, high forces are applied to the structure; the structure is usually designed to experience settlement. When an earthquake occurs, buildings tend to collapse. This is mainly due to discontinuity in geometry, mass and stiffness or several different factors. This discontinuity is defined as an irregular structure. According to building regulations, structures must be designed to withstand a certain intensity of ground acceleration, with the intensity of ground motion depending on the seismic hazard. The main objective of earthquake engineering is to minimize the loss of life due to structural collapse.

The behaviour of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns having stiffness irregularity or hang or float on beams at an intermediate storey and do not go all the way to the foundations have discontinuous in the load transfer path.

A regular structure can be investigated to have uniformly distributed mass, stiffness, strength and structural form. When one or more of these properties is non-uniformly distributed, either individually or in combination with other properties in any direction, the structure is referred to as being irregular.

There are various types of irregularities in the buildings depending upon their location and scope is given in the IS 1893:2002 (Part-I), but mainly, they are divided into two groups—plan irregularities and vertical irregularities which are listed in Table-1. . Major failures occurred due to irregularities like soft storey Failure, Mass Irregularity Failure, stiffness irregularity failure, vertical geometry irregularity failure, Plan Irregularity Failure, Shear Failure, etc

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Table 1: Types of Irregularity

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

## II. RELATED WORK

The Current work is centred around the investigation of Seismic requests of various unpredictable R.C structures involving different logical methods for the seismic zone V and on medium soil of India. Vertical inconsistencies, for example, mathematical anomaly, mass irregularity and solidness abnormality structures laying on slanting ground or plain ground. The presentation will be going to contemplating as far as time span, base shear, parallel removals, story floats and eccentricity in straight investigation utilizing a code – IS1893 (Part 1):2002 .The whole displaying, examination and configuration will be completed by utilizing business programming resembles ETABS.

Stiffness Irregularity: This irregularity manages the adjustment of the stature of the floor in the base model that is considered as upward mathematical unpredictable structures with the difference in floor tallness in two unique models. In model-1 the height of fourth floor is changed & in model-2 ground floor height is changed.

- It is accepted in the current review that infill boards are having no window and entryway openings while demonstrating the infill walls.
- In the current review building models are investigated just utilizing linear static, dynamic.

The ground motion data for the Elcentro della Valle Imperiale (El centro) earthquake data were selected from the Pacific Earthquake Engineering Research Center (PEER) Next Generation Attenuation (NGA) database. The basic reference IS 1893:2002 was taken for analysis.

For all six models above, the seismic data remains unchanged introduced in the software (Etabs) only the height and shape of the structure. Then ground motion was introduced and a nonlinear time history analysis was performed.

The basis of this work is the study of the behaviour of reinforced concrete buildings under various shapes and heights. This study shows how the different shapes and heights of reinforced concrete buildings behave in the Elcentro earthquake.

Here, we get the displacement of the plan, the deviation of the plan and the section on the base of the regular and irregular reinforced concrete building with low, medium and high floors due to ground motion. The methodology carried out is briefly described as follows:

1. Records of ground movement are collected and then normalized.
2. Linear time history analysis is performed in Etabs 2016.
3. Building response such as story displacement, story drifts and base shear are found due to the ground motion.
4. The results of the all regular and irregular RC buildings with varying heights are compared with respect each other.

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## III. METHODOLOGY

The methodology worked out to achieve the above-mentioned objectives is as follows:

- **Response Spectrum Method**

The word spectrum in seismic engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. For a given earthquake motion and a percentage of critical damping, a typical response spectrum gives a plot of earthquake-related responses such as acceleration, velocity, and deflection for a complete range, or spectrum, of building periods. Thus, a response spectrum may be visualized as a graphical representation of the dynamic response of a series of progressively longer cantilever pendulums with increasing natural periods subjected to a common lateral seismic motion of the base.

**Seismic Base Shear**: The seismic base shear VB in a given direction shall be determined in accordance with the following equation:

$$VB = Ah\ W \tag{1.1}$$

Where,

Ah = the seismic response coefficient

W = seismic weight of building

The design horizontal seismic coefficient for a structure Ah is given by:

$$A_h = \frac{ZISa}{2Rg} \tag{1.2}$$

Where,

Z = Zone factor given in Table 2 of IS 1893:2002 (part 1).

I = Importance factor, depending upon the functional use of the structure, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical or economic importance. The minimum values of importance factor are given in table 6 of IS 1893:2016.

R = Response reduction factor, depending on the perceived seismic damage performance of the structure given in Table 7 of IS 1893:2016 (part 1).

Sa/g = Average response acceleration coefficient for rock and soil sites as given in figure 2 of IS 1893:2016 (part 1). The values are given for 5 % of damping of the structure.

**Period Determination**: The fundamental period of the building, T, in the direction under consideration shall be established using the structural properties and deformational characteristics of the resisting elements in a properly substantiated analysis or, alternatively, it is permitted to be taken as the approximate fundamental period, T, determined in accordance with the requirements of Sec. The fundamental period, T, shall not exceed the product of the coefficient for upper limit on calculated period from and the approximate fundamental period T.

$Ta=0.075h^{0.75}$ for R.C. frame building (1.3)

$Ta=0.085\ h^{0.75}$ for STEEL frame building (1.4)

Where,

h = Height of building in meter

The approximate Fundamental Natural Period of vibration T a in seconds of moment-resisting frame building with brick infill panels may be estimated by the empirical expression

$$\mathrm{Ta} = \frac{0.009h}{\sqrt{d}} \tag{1.5}$$

Where,

h = Height of building in meter

d = dimension of building at the plinth level in meter along the considered direction of lateral force

**Vertical Distribution of Seismic Forces**: The lateral force, F (KN), induced at any level shall be determined from the following equations:

$$\mathrm{Qi} = \mathrm{V_B}\ \frac{\mathrm{W_i h_i^2}}{\sum_{i=1} \mathrm{W_i h_i^2}} \tag{1.6}$$

Where,

**Qi** = Design lateral force at i,

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**Wi** = seismic weight of floor i,
**hi** = Height of floor I measured from base and
**n** = No. of stories in the building is the no. of level at which masses are located

- Review the existing literature and Indian design code provision for analysis of irregular building.
- Select the vertically irregular (shape irregular) building model for the analysis.
- Linear analysis of the selected building model and a comparative study on the results obtained from the analyses.
- Observations of results and discussions.

## IV. EXPERIMENTAL RESULTS

- **Building Description**

The problem considered for the current review is taken from IS 1893-section 1: 2016 is the vertical geometric irregular structure model is considered for displaying reason and the area is considered in India having severer seismic zone (Seismic Zone V) is chosen for the current review. This structure model is a G+20 story building (67.5M) high is made of Supported cement (RC) Unique second opposing edge (SMRF). The section thickness is 150 mm at each floor. The definite depiction is as displayed in the Table 3.1.

Frame is considered with three different irregularity as taken from IS 1893-part1: 2016. Thus, we have four frames including the base frame. These four frames have been analysed using equivalent static method and response spectrum method of IS 1893-part 1: 2016 while assuming seismic zone V, and importance factor 1.0. Analysis has been carried out using commercial software ETABS program.

- **Seismic Data Used**

Table no. 2 Seismic data

| | |
|---|---|
| **Earthquake Zone** | V |
| **Damping Ratio** | 5 % |
| **Importance Factor** | 1 |
| **Type of Soil** | Medium |
| **Response Reduction Factor** | 5 |
| **Time Period** | Program calculated |
| **Poisons Ratio** | 0.15 |

Table no. 3 Structural composition of regular shaped G+20 building

| **Specification** | **Details** |
|---|---|
| **1 Type of structure** | Composite Structure (Beam and column are composite in nature) |
| **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+20 |
| **8 Dimension of building** | 36 m x 36 m |
| **9 Floor Height (Typical)** | 3.0 m |
| **10 Base floor height** | 3.0 m |
| **11 Infill wall** | 230 mm thick wall |
| **12 Impose load** | 5 KN/m2 |
| **13 Materials** | Concrete (M40) and Reinforcement (Fe500) |
| **14 Specific weight of infill** | 20 KN/m3 |
| **15 Size of Column** | 500 mm × 300 mm with ISMB500 |
| **16 Size of Beam** | ISMB250 |

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| | |
|---|---|
| **17 Depth of slab** | 200 mm |
| **18 Specific weight of RCC** | 25 KN/m3 |

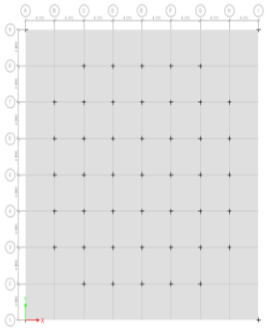

*Figure 1: Plan view of G+20 regular shaped building*

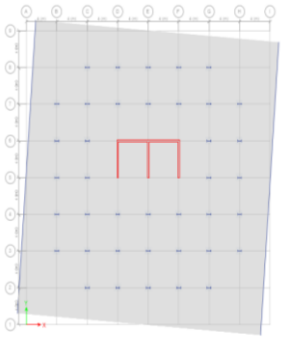

*Figure 2: Plan view of G+20*

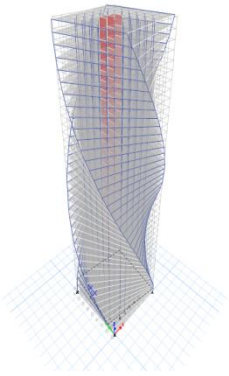

*Figure 3:* 3D view of G+20 building

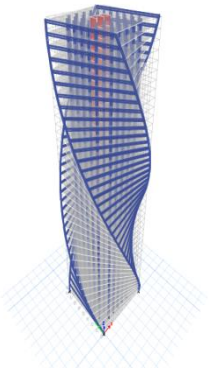

*Figure 4:* 3D solid view of G+20 building

The two frames have been analysed and their lateral storey-displacements, storey drifts and base Shears have been computed to study the effects of irregularities on the vertically irregular frames. The results are presented and discussed hereafter. Below Table shows displacement of storeys of various frames in X-direction which is horizontal. These have been plotted and shown in graph.

Table 4 Story Displacement (Ux) in X-Direction (MM)

| | **MODEL-1** | **MODEL-2** |
|---|---|---|
| **STORY** | **Ux** | **Ux** |
| Story21 | 3.2140 | 3.9460 |
| Story20 | 1.9430 | 1.8940 |
| Story19 | 1.6160 | 1.5630 |
| Story18 | 1.4820 | 1.4610 |
| Story17 | 1.2920 | 1.3610 |
| Story16 | 1.4860 | 1.5590 |
| Story15 | 1.6550 | 1.7190 |
| Story14 | 1.8370 | 1.8890 |
| Story13 | 1.8960 | 1.9430 |
| Story12 | 1.9840 | 2.0270 |
| Story11 | 1.9850 | 2.0180 |
| Story10 | 1.9540 | 1.9840 |

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| | | |
|---|---|---|
| Story9 | 1.8910 | 1.9140 |
| Story8 | 1.7950 | 1.8250 |
| Story7 | 1.5510 | 1.5780 |
| Story6 | 1.3910 | 1.4000 |
| Story5 | 1.0780 | 1.0920 |
| Story4 | 0.8280 | 0.8540 |
| Story3 | 0.5800 | 0.5850 |
| Story2 | 0.4900 | 0.5000 |
| Story1 | 0.3140 | 0.2650 |
| Base | 0 | 0 |

It has been seen that Model-2 gets displaced the most since the lateral stiffness at its bottom two Storeys are quite less than other storeys.

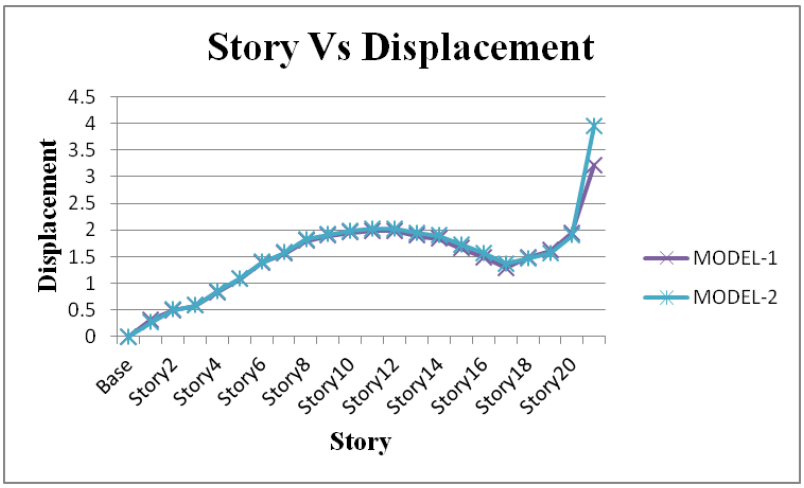


*Figure 5: Story and Displacement graph*

Table 5 : Story Drift In X-Direction (MM)

| STORY | MODEL-1 | MODEL-2 |
|---|---|---|
| Story21 | 0.000524 | 0.003291 |
| Story20 | 0.000150 | 0.001605 |
| Story19 | 0.000115 | 0.001739 |
| Story18 | 0.000113 | 0.001958 |
| Story17 | 0.000109 | 0.002149 |
| Story16 | 0.000107 | 0.002341 |
| Story15 | 0.000084 | 0.002558 |
| Story14 | 0.000087 | 0.002835 |
| Story13 | 0.000077 | 0.002764 |
| Story12 | 0.000059 | 0.002734 |
| Story11 | 0.000048 | 0.002748 |
| Story10 | 0.000042 | 0.002781 |
| Story9 | 0.000035 | 0.002833 |
| Story8 | 0.000082 | 0.002943 |
| Story7 | 0.000062 | 0.003113 |
| Story6 | 0.000104 | 0.002850 |
| Story5 | 0.000083 | 0.002664 |
| Story4 | 0.000083 | 0.002509 |

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| | | |
|---|---|---|
| Story3 | 0.000118 | 0.002318 |
| Story2 | 0.000203 | 0.002022 |
| Story1 | 0.000070 | 0.001137 |
| Base | 0 | 0 |

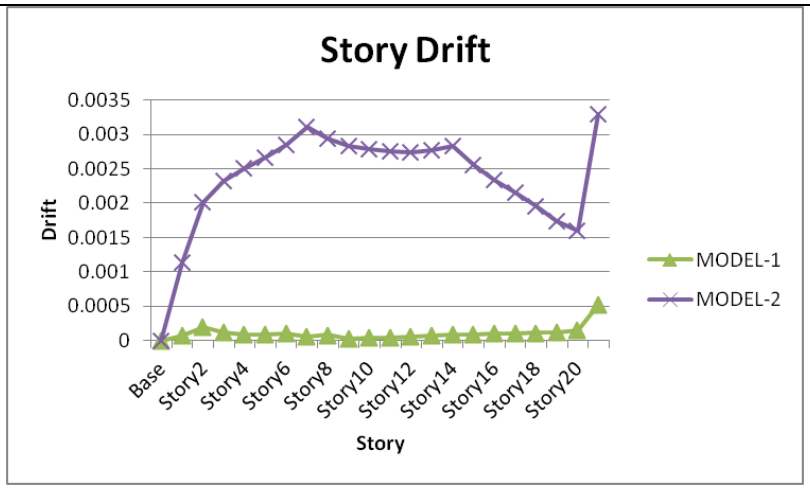


*Figure 6: Story and Drift graph*

Table 6 : Storey Shear Vx In X-Direction (KN) ETABS

| STORY | MODEL-3 ( Vx ) | MODEL-4 (Vx) |
|---|---|---|
| Story21 | -157.8853 | -157.4369 |
| Story20 | -263.6788 | -262.5138 |
| Story19 | -359.1574 | -357.3457 |
| Story18 | -444.8502 | -442.458 |
| Story17 | -521.286 | -518.376 |
| Story16 | -588.9938 | -585.6253 |
| Story15 | -648.5026 | -644.731 |
| Story14 | -701.0252 | -696.8274 |
| Story13 | -742.8959 | -738.3583 |
| Story12 | -777.8738 | -773.0994 |
| Story11 | -807.0332 | -802.0612 |
| Story10 | -830.9028 | -825.7692 |
| Story9 | -850.0118 | -844.7487 |
| Story8 | -864.889 | -859.5251 |
| Story7 | -876.2108 | -870.7551 |
| Story6 | -882.9101 | -877.4000 |
| Story5 | -887.1419 | -881.6031 |
| Story4 | -889.5222 | -883.9673 |
| Story3 | -890.5801 | -885.0181 |
| Story2 | -890.8447 | -885.2809 |
| Story1 | -890.8447 | -885.2809 |
| Base | 0 | 0 |

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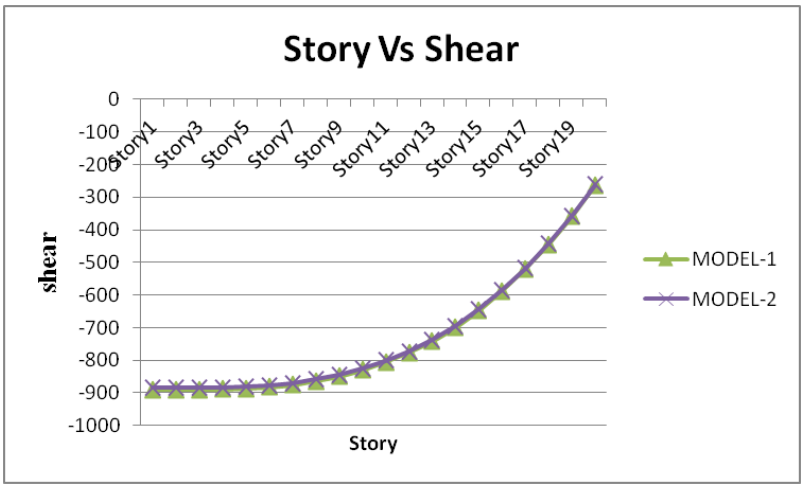


*Figure 7: Story and Shear graph*

## VI. CONCLUSION

The conduct of G+20 in upward direction irregular structures (Geometric irregular) is considered with utilization of mass irregularity on third and seventh floor, Stiffness irregularity on fourth floor and Stiffness irregularity at ground floor on similar in an upward direction unpredictable structure with various models. The results of this examination is as per the following,

- As the stiffness irregularity is towards base, then, at that point, seriousness in the earthquake is more, and assuming it is towards top, then, at that point, seriousness is less in the earthquake.

The investigation demonstrates that irregularities are unsafe for the designs and it is critical to have easier and normal states of edges just as uniform burden appropriation around the structure. Thusly, beyond what many would consider possible irregularities in a structure should be kept away from. Be that as it may, assuming irregularities must be presented under any circumstance, they should be planned appropriately following the states of IS 1893-section 1: 2016 and IS456: 2000, and joints ought to be made ductile according to IS 13920:1993. Complex shaped structures are getting famous, however they have more danger of harms during earthquakes. Subsequently in the complex geometry of the structure, stiffness irregularity should be avoided.

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