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Non-linear Time History Analysis of Irregular Shaped Building

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Abstract:

An earthquake occurs when energy is released suddenly owing to movement of rock beds in the earth's crust, resulting in seismic waves. The most common effects of earthquakes are ground shaking and ground rupture. It has social and economic ramifications, such as causing death and injury to living creatures, including humans, as well as structural and environmental damage. So understanding the characteristics of the ground motion is critical for taking safeguards against the loss of lives and damage to structures caused by earthquakes. Peak Ground Acceleration (PGA) frequency and time period, or simply duration, are two highly essential earthquake characteristics. These qualities are crucial in understanding how structures respond to earthquake loads. The PGA, frequency content, and duration of the shaking are used to determine the strength of ground motion. Ground motion can be classified as low, middle, or high frequency. Earthquake resistance is an important factor to consider while planning any structure. Many researchers have reported on their studies into the effects of structures with various abnormalities. The current research focuses on the behaviour of buildings with irregular floor plans. Buildings of various shapes and heights are explored, including normal, L-shaped, and C-shaped structures.

In this research, I looked at G+30 models of each shape. The time history approach of analysis is applied in this project. All of the structures are believed to be in Zone V, with medium soil. The ground motion data from the El-centro earthquake of 1940 was used. Etabs software was used to conduct this research. Building response to ground vibrations is measured in terms of story displacement, story drift, and base shear. Each shape's responses to each form of building are investigated and contrasted. Low-frequency content ground vibrations have a substantial effect on both regular and irregular RC buildings, according to the findings.

Keywords — **Geometric Irregularities, Base shear, Storey Drift.**

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I. INTRODUCTION

Earthquake is a term used to describe the sudden disturbance of the earth caused by moving tectonic plates in the crust. Different kinds of abnormalities in buildings are known to be utilised in modern infrastructure. Because of the high forces applied to structures during earthquakes, structures are frequently constructed to give. During an earthquake, the building is more likely to collapse. This is mostly owing to discontinuities in geometry, mass, and stiffness, as well as a variety of other considerations. Irregular structures describe this discontinuity. Building rules require structures to be designed to resist a specific level of ground acceleration, with the magnitude of the ground motion varying based on the seismic risk. The primary purpose of earthquake engineering is to reduce the number of people killed or injured when a structure collapses. Nowadays, it is fairly normal for anyone to request shape variation when planning a project. As a result, a designer may offer any shape to meet their needs. When a building's shape is altered, it may experience irregularities.

According to IS 1893:2002 clause 7.1, a building must have four essential characteristics to perform effectively in an earthquake: basic and regular configuration, enough lateral strength, stiffness, and ductility. Buildings with basic regular geometry and evenly distributed mass and stiffness in plan and elevation sustain far less damage than those with irregular designs. For the purposes of this standard, a structure is considered irregular if at least one of the characteristics is met. Because irregularities might be of any sort (as per IS 1893:2002, table no. 4 & 5, page no. 18), the designer must take extra precautions. The following are the several types of irregularity.

II. Overview of Study

Many studies have been conducted to investigate the behaviour of structures influenced by ground motion.

There is no research on the seismic behaviour of RC buildings of various shapes. The current research focuses on the seismic behaviour of reinforced concrete structures of various shapes that are subjected to ground vibrations. This research aims to determine how different designed structures with varied heights respond during an earthquake. All structures are considered in Zone V for this study, with medium soil type. The earthquake data from the Elcentro earthquake of 1940 is used for time history analysis. We shall gain a thorough understanding of the response of various shaped structures of various heights as a result of this research. The study uses time history analysis in Etabs 2018 software to understand the variation in base shear, tale displacement, and story drifts.

III. METHODOLOGY

L-shaped building of G+30 height is one of the models selected for investigation. The ground motion data for the Imperial Valley (Elcentro) earthquake was chosen from the N Generation Attenuation (NGA) database of the Pacific Earthquake Engineering Research Center (PEER). IS 1893:2002 was used as the foundation for the analysis. The same height and shape of structure are used in the software for the above model earthquake data (Etabs 2018). Ground motion is then introduced, followed by a non linear time history analysis.

The purpose of this research is to investigate the behaviour of reinforced concrete structures of various shapes and heights. This research shows how different reinforced concrete building forms and heights react to the Elcentro earthquake.

The ground vibrations cause story displacement and base shear in low, mid, and high-rise regular and irregular reinforced concrete buildings. The following is a brief description of the methods used:

1. Data on ground motion is obtained and then standardised.
2. Etabs 2018 does a linear time history analysis.
3. Ground motion causes structural responses such as story displacement, story drifts, and foundation shear.
4. The findings of all regular and irregular RC buildings of various heights are compared to one another.

IV. PERFORMANCE ANALYSIS

In E Tabs 2018, I investigated the base shear and storey displacement of these models. By comparing the data, one may quickly grasp the structure's response and forecast the good shape structure that will withstand earthquake forces. Further investigation of the aforementioned aspects is shown. Models are shaped by taking into account plan imperfections, which means that the plan area of this building is the same. The total number of stories in this construction is 30.

The following are the models that were utilised in the analysis:

TABLE I
DETAILS OF STRUCTURE

SHAPE OF BUILDING	**L-SHAPED**
Storey	G+30
Height of Each Storey	3.00 m.
Plinth Height	1.50 m.
Thickness of External Wall	0.230 m.
Grade of Concrete	M25
Grade of steel	HYSD 500
Live load	3.00 kN/M
Size of Beams	300 mm x 450 mm
Size of columns	300 mm x 500 mm
Thickness of Slab	150 mm

TABLE II
LOAD CASE SUMMARY

Dead	Linear Static
Live	Linear Static
EQ x	Linear Static
EQ y	Linear Static
Wall	Linear Static
THA x	Linear Static
THA y	Linear Static

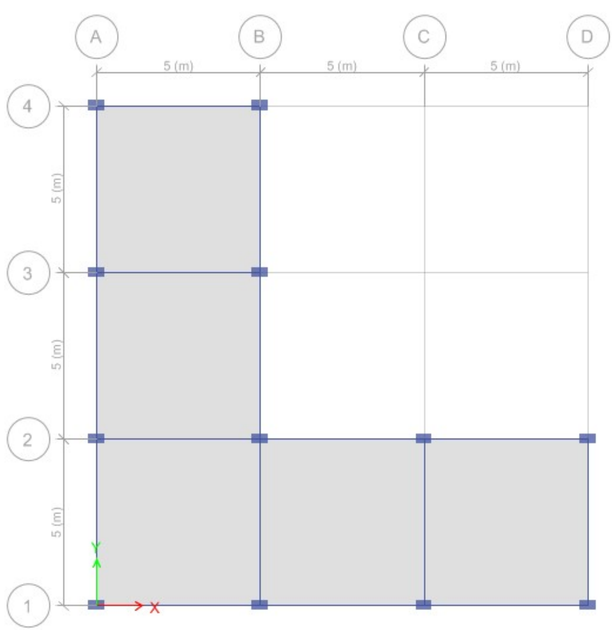

Figure 1 Plan view of G+30 L-Shaped building

A. Figures and Tables

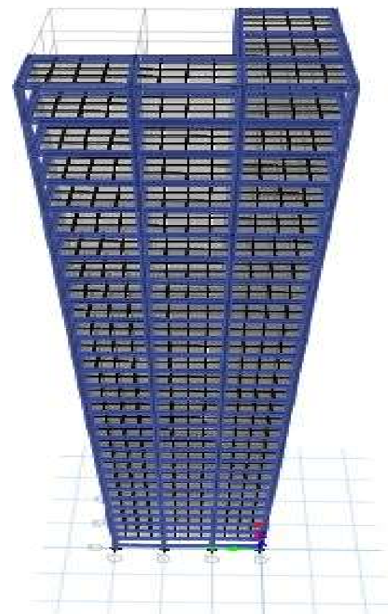

Figure 2 3D view of G+30 L-shaped building

V. RESULTS

Base Shear: In both directions, the weight of the building and the base shear are compared.

TABLE III
BASE SHEAR IN X & Y DIRECTION

Direction	**L-shaped building**
X direction	365.93 kN
Y direction	381.344 kN

Storey displacement occurs in both the X and Y directions. They are as follows:

Storey	**L-shaped building**	**C-shaped building**
Storey30	104.95	82.69
Storey29	102.69	78.45
Storey28	99.58	77.06
Storey27	97.03667	76.98
Storey26	94.35167	75.69
Storey25	91.66667	73.99
Storey24	88.98167	72.58
Storey23	86.29667	71.58
Storey22	84.55	70.25

Storey21	81.55	69.55
Storey20	79.65	67.89
Storey19	78.55667	66.58
Storey18	77.87167	65.99
Storey17	76.978	64.09
Storey16	74.639	62.86
Storey15	71.835	61.058
Storey14	68.422	58.633
Storey13	64.428	55.635
Storey12	59.933	52.139
Storey11	55.021	48.221
Storey10	49.773	43.951
Storey9	44.266	39.398
Storey8	38.574	34.622
Storey7	32.765	29.678
Storey6	26.902	24.617
Storey5	21.047	19.488
Storey4	15.271	14.342
Storey3	9.682	9.264
Storey2	4.545	4.471
Storey1	0.674	0.689
Base	0	0

VI. CONCLUSIONS

1. Because of the different sizes of columns, the base shear in both directions is not equal. All columns' dimensions are smaller in the X direction and greater in the Y direction. As a result, the forces in the X direction will have less area to resist, resulting in a larger base shear value. Similarly, forces in the Y direction will have a bigger area to resist, resulting in a lower base shear value.

2. Although the columns opposing the forces in the X direction are smaller, they function effectively against all forces.
3. The X-direction base shear in an L-shaped building is 365.93 KN.
4. The Y-direction base shear in an L-shaped building is 381.34 KN.

5. The topmost level of an L-shaped building has a maximum story displacement of 104.95 mm.

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