"Seismic Analysis of L-Shape Building Frame Using Linear Dynamic Method"

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Abstract— All over the world, earthquake-resistant building design and analysis are crucial. Hilly areas in Chhattisgarh, such as Ambikapur, Koriya, Dantewada, and Jagdalpur district, have been found to be more susceptible to seismic collapse structures in recent years. As a result, there is an increasing demand for high-rise structures with irregularities, as shown below, due to the high cost of land and infrastructure. The topic of the essay is the analysis of various RCC frames in both regular and atypical building plans, including square, L, C, and T shapes. The purpose of this paper is to examine seismic parameters like storey shear and displacement to assess stability and validate the best shape for a building to avoid before it is destroyed.

Keywords: Asymmetry, Regular, Irregular, Displacement, Storey Shear

I. INTRODUCTION

Analyzing a building's structural response to earthquakes is known as seismic analysis, which is a subset of structural analysis. In areas where earthquakes are common, it is a step in the structural design, earthquake engineering, or structural assessment and retrofit process. Seismic analysis has been the subject of numerous studies, and those studies are still ongoing because we believe that by adjusting certain structural element parameters, we can reduce damage and save lives. Points of weakness are where a structure first fails during an earthquake. This weakness results from a discontinuity in the structure's mass, stiffness, and geometry. These discontinuous structures are known as irregular structures. One of the main causes of quake-related structural failures is irregularities in the plan. A building should have adequate lateral Strength, stiffness, and ductility as well as a simple and regular configuration to perform well in an earthquake. Buildings with straightforward regular geometry, evenly distributed mass, and stiffness in both plan and elevation, sustain significantly less damage than those with irregular configuration. Normal buildings must be able to withstand the following according to the traditional design philosophy for earthquake resistance: a) Minor (and frequent) shaking with no structural or non-structural damage; b) Moderate (and infrequent) shaking with minor structural damage and some non-structural damage; c) Severe (and infrequent) shaking with structural element damage but NO collapse (to protect people and property inside or adjacent to the building)[1] . (Gorle et al.) 2018 [2] has studied that before any structure is built, structural analysis as well as earthquake or seismic analysis is required. The investigation of the member forces, joint displacement, and support reaction of structures in response to earthquake excitation. All of the following are examined: base shear, displacement, axial load, moments in the Y and Z directions in columns, shear forces, maximum bending moments, and maximum torsion in beams. The current work aims to understand that structures need to have appropriate earthquake-resisting features in order to safely withstand large lateral forces applied to them during earthquakes in various seismic zones, as well as construction material, cost, and effectiveness in minimizing earthquake damage to structures.

Patil and Sonawane (2015) [3] found in their paper that effective earthquake-resistant structure design and construction are becoming more and more crucial around the world. In this paper, the symmetric multistory building's earthquake response is examined using both manual calculations and the ETABS 9.7.1 programme. The IS 1893:2016 [4]-recommended seismic coefficient method is used in the method. Both manual analysis and soft computing produce comparable results. This paper offers a thorough manual and software analysis of the seismic coefficient method guideline.

(Imranullahkhan, 2017) [5] [6], [7] used linear dynamic analysis to examine the dynamics of a g+9 storey asymmetrical in plan building under earthquake load. Storey drift and displacements are assessed using the (Response Spectrum Method). The current study is limited to multi-story apartment buildings made of reinforced concrete (RC) that are regular, L-shaped, or T-shaped.

(Patel & Abdulla, 2016) [8] examined the L-shaped high-rise building with various shear wall locations and shear wall shapes being taken into consideration for analysis. The high-rise building is analyzed using the ETABS programme to ascertain a number of parameters, including Time period, Base shear, Storey drift, and Storey displacement. The results of various parameters' analyses are shown in tabular and graphical form, and they are contrasted using various seismic analysis techniques, including ESA RSA and Time history analysis.

(Guleria, 2014)[9] looked into a variety of plan shapes, including rectangular, C, L, and I-shaped. A 15-story R.C.C. framed building is modelled using the ETABS programme for analysis. After conducting a structural analysis, maximum shear forces, bending moments, and storey displacements are calculated for each analysed case and compared.

Harshitha M K and Vasudev M V [10] studied that earthquake is one of the major disasters known to mankind for many years, and structural and architectural engineers has made important aids to the safety of the structure. Assuming steel plate bracing in the structure as one option for minimizing earthquake damage. These members can be used in the building as a horizontal load resisting system to improve the rigidity of the frame for seismic forces. The present study is based on an RC-framed structure analysis having structural steel braces performed with the ETABS software. These studies were conducted for various arrangements in order to learn about the effect of various bracing systems. discovered that many structures have been completely or partially destructed by earthquakes. As a result, the seismic responses of such constructions must be determined. There are various techniques for analyzing structure. This paper investigates the effects of various mass and column stiffness irregularities on a structure's seismic response. The project's goal is to perform Response spectrum analysis (RSA) on vertically mass and section stiffness irregular RC frame structures

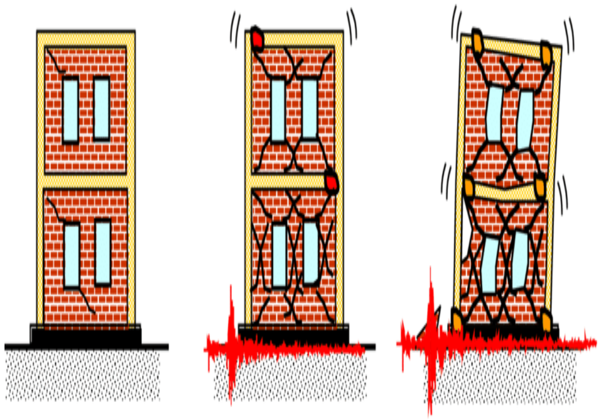


Fig. 1. Earthquake-Resistant Designs

A. Approaches of Seismic Analysis

The external action, the behavior of the structural material, and the type of structural modal chosen all influence the choice of seismic analysis method for the structure. These four types of analysis—linear static analysis, linear dynamic analysis, non-linear static analysis, and non-linear dynamic analysis—are described in the Bureau of Indian Standards.

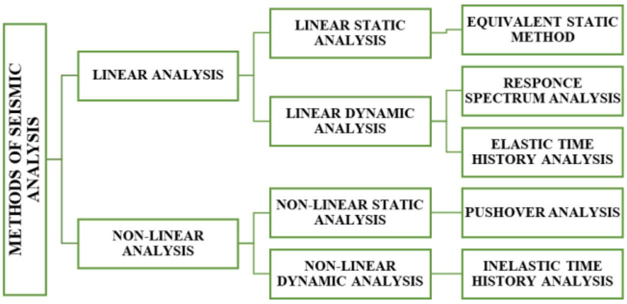


Fig. 2 Earthquake Analysis Classification

II. General Considerations for Planning Methodology of Seismic Analysis -

In this study, using the ETABS software, the equivalent dynamic analysis has been performed on the various cases of regular and irregular shapes of building plan frames. The loads taken into consideration comply with IS-875 (Part 1 and Part 2), IS-1893:2002/2016, and load combinations with IS-875 (Part5). In this paper, Seismic Zone-seismic V's analysis of the asymmetry plan is examined using the ETABS

III. Structural Specifications

For all of the various cases, the built-up area of an asymmetrical building is assumed to be equal. The building is (G+4) Storeys tall and measures 20 m x 20 m, or 400 m2. All structures are assumed to have a floor-to-floor height of three metres, and all case frame structures share the same sectional properties. The Case Study that will be designed and analyzed for this thesis is as follows:

Table 1 Planned Models

Explanation	**Notations**
Regular Square Shape Building	**RS**
L-Shape Building made with 36 % cut-off	**L36**
L-Shape Building made with 48 % cut-off	**L48**
L-Shape Building made with 64 % cut-off	**L64**
L-Shape Building with shear wall along X-direction	**LWX**
L-Shape Building with shear wall along both direction	**LWB**
Regular shape Building with shear wall at Corner	**RSC**

The data of structure used in this thesis is in the form of tabulation considered for design and analysis of frame are given below-

Table 2 Structural Specification for the study

PARTICULARS	**STRUCTURAL PROPERTIES**
Total Built-Up Area	**20 X 20 m**
Number of Stories	**G+4**
Floor to floor Height	**3.0 meter**
Size of Columns	**450X 450 mm**
Beam Size	**230 X 450 mm**
Slab/Plate thickness	**150 mm**
Shear Wall thickness	**250 mm**
Bracing dimension	**230 X 450 mm**

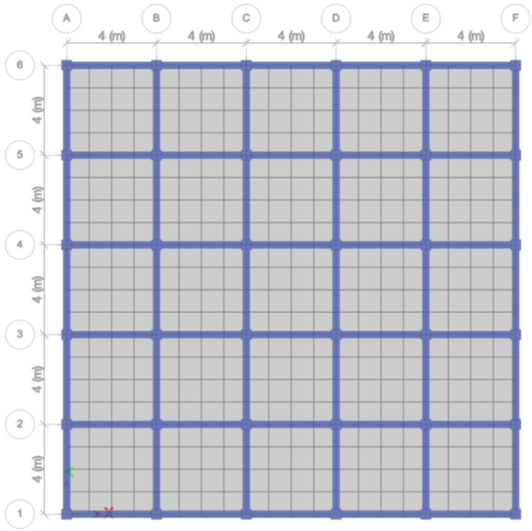


Fig. 2 Regualr shape model

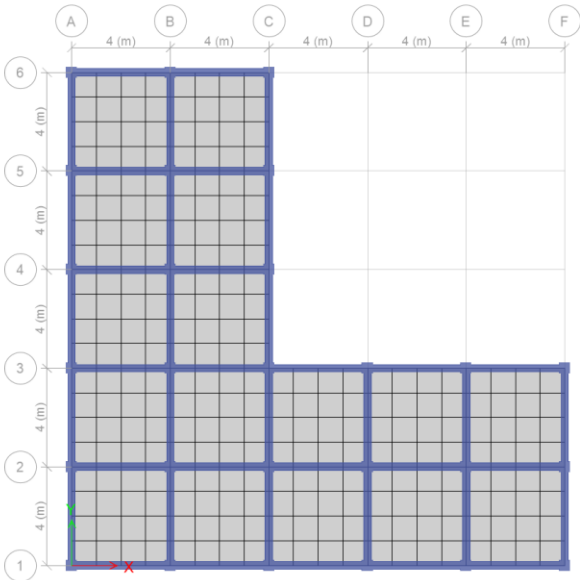


Fig. 3 L-shape building with 36% cut-off

Fig. 4 L-shape model with 48 % cut-off

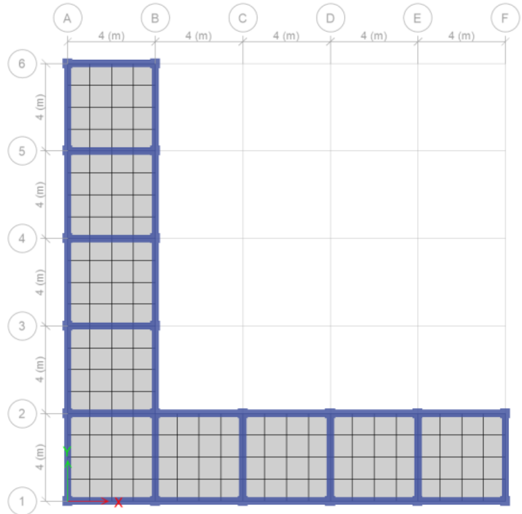


Fig. 5 L-shape model with 64% cut-off

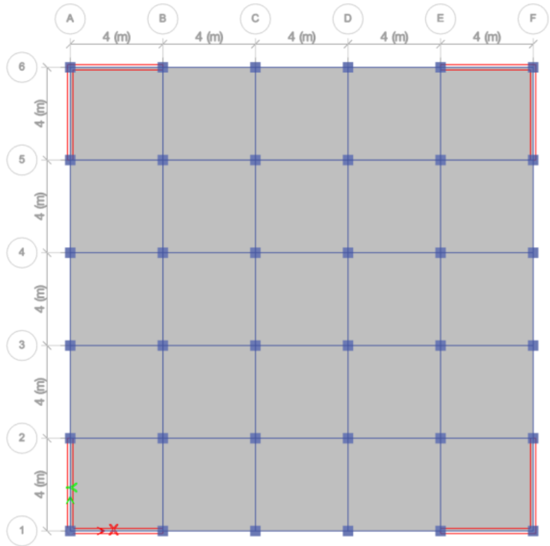


Fig. 6 Square Building with Shear Wall at Corner

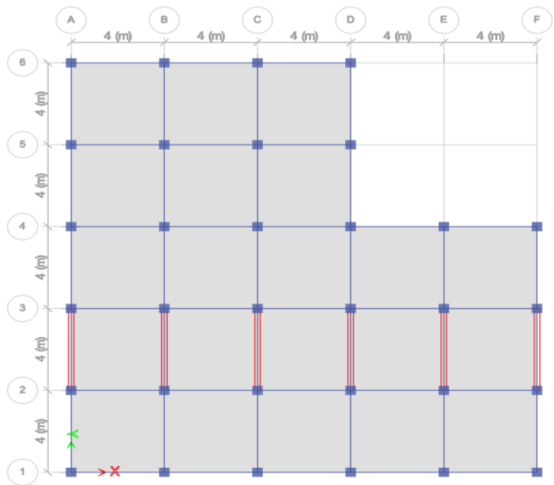


Fig. 7 L-Shape Building with Shear Wall along X-direction

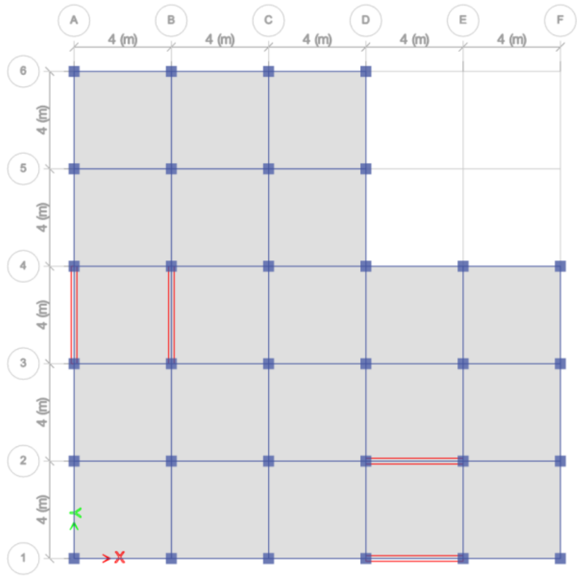


Fig. 8 L-Shape Building with Shear Wall along both direction

IV. MATERIAL SPECIFICATIONS CONSIDERED FOR DESIGN & ANALYSIS OF CASES

Concrete and reinforced steel are the two main components of these building frame models. The properties of the materials taken into consideration for the design and analysis of all RCC frame buildings are displayed in the table below.

Table 3 Material Properties used in all Frames

Particular	Details
Grade of Concrete	M30
Grade of Main Steel	Fe500
Grade of Secondary Steel	Fe500
Beam & column cover	0.025 & 0.040 m
Density of Reinforced Concrete	25000 N/m^3
Density of Brick walls, Plaster	18000 N/m^3
Young's modulus of steel	2 X 10^2 KN/mm^2

V. LOADING SPECIFICATION & CALCULATIONS COMMON FOR ALL FRAMES USED IN SOFTWARE

The loads which are to be studied in the project is discussed under following clauses below in which their calculation detail is also been discussed such as Primary load, Seismic Load & their load combination etc.

A. Primary Loads Applied for Analysis -

The loads are taken into account in software in the form of load cases, specifically primary load cases and combinations of primary load cases, which are applied to all frame buildings. In table 3.4 below, the primary load cases that were used in the ETABS software analysis are listed along with their load type and numbers.

Table 4 Primary Load Cases

Load Case Number	**Load Type**	**Name**
1	Dead Load	DL
2	Live Load	LL
3	Seismic Dynamic Load	DQX
4	Seismic Dynamic Load	DQY

B. Load Calculations Used for All Frame Cases

The calculated load acting on the structures of dead load, floor live load, roof live load is given below-

1) Dead Load (D.L) –

In this analysis, dead load includes dead load of the slab, dead load of beam & column, dead load of external walls and dead of internal walls as per IS 875 part 1 [11] . DEAD LOAD is designated as D.L in ETABS

Self-Weight of Slab/Plate = (unit weight of concrete X thickness of slab)

= 25 X 0.15

= 3.75 KN/m^2

Self-Weight of Column (0.45x0.45) =

= (unit weight of concrete X size of column)

= (25 X 0.45X 0.45)

= 5.0625 KN/m (per meter height)

Self-Weight of Beam in all floors =

= (unit weight of concrete X depth of beam X width of beam)

= 25 X 0.45 X 0.23

= 2.5875 KN/m

2) Live Load (L.L) –

As it is taken from the commercial building category listed in IS 875 Part -2 [12], live load in this study includes live loads for all floors. Live loads for the roof are also taken from the same code. L.L. stands for LIVE LOAD, and ROOF for roof. In ETABS, LIVE LOAD is identified as R.L.L. Here, we look at-

Live load for all the floors = 5 KN/m^2

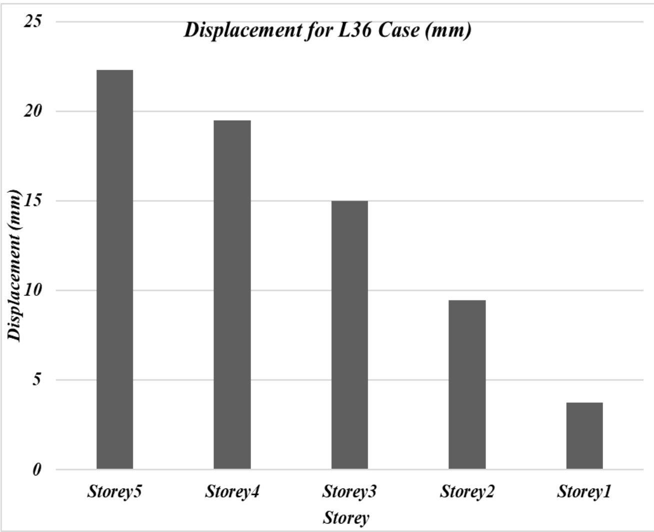
Live load for roof (at Terrace) = 1.5 KN/m^2

3) Earthquake or Seismic Load (EQX & EQZ) -

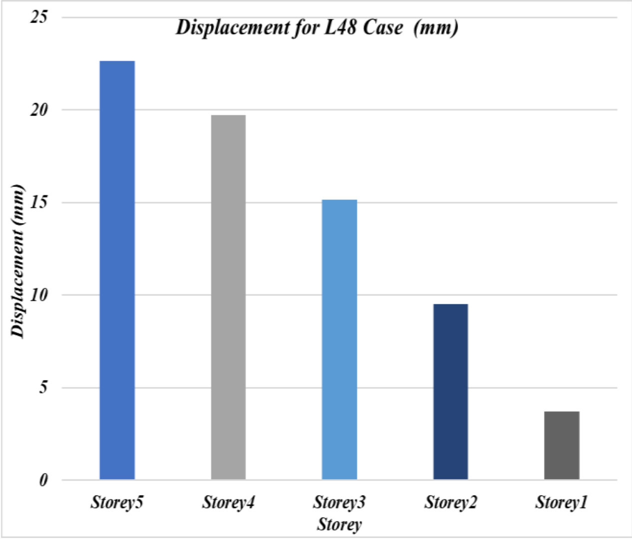
According to IS 1893:2016 considerations, the full dead load plus the percentage of the live or imposed load must be taken into account when calculating earthquake or seismic load. Additionally, per IS 1893, each floor's seismic weight is comprised of both its full dead load and an approximation of its live or imposed load. In this study, approximately 50% of the total live load as per IS 1893 (Table 8) is taken into account as live or imposed load, and the remaining calculations are made with the aid of ETABS Software. DQX & DQY are the abbreviations for SEISMIC OR EARTHQUAKE LOAD, where "DQ" stands for Dynamic Earthquake load and X & Y represent their respective lateral directions.

VI. RESULT & DISCUSSIONS

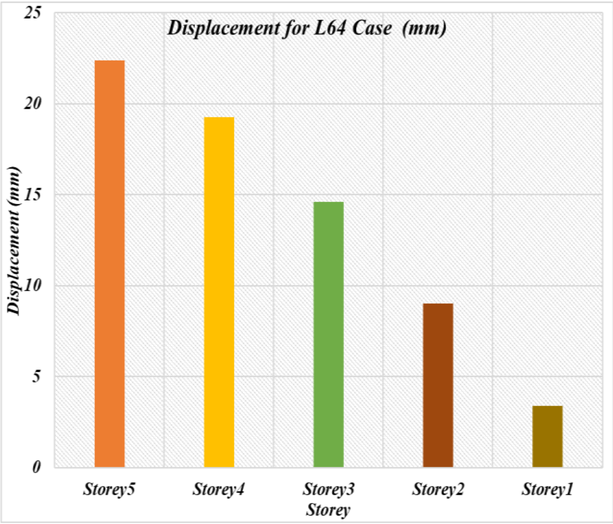
The reports for the analysis is been exported from the modelling, and further collected and compared with all the cases shown below-



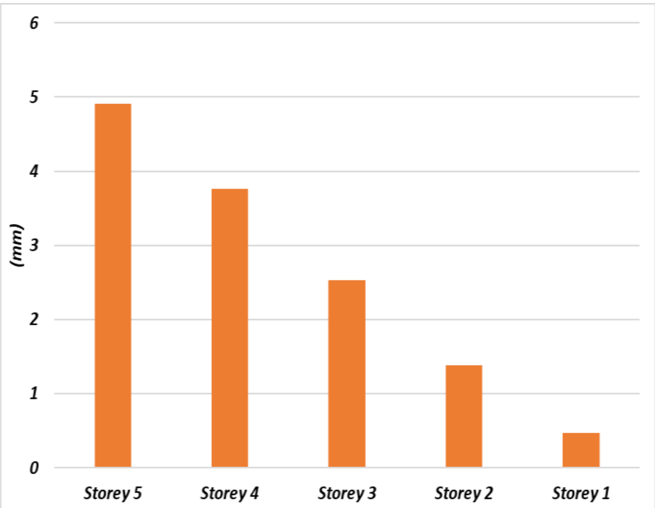
Graph 1 Displacement of L-Shape Building made with 36 % deduction



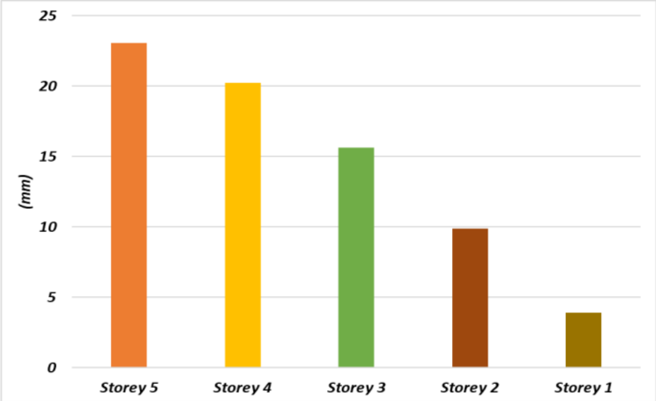
Graph 2 Displacement of L-Shape Building made with 48 % deduction



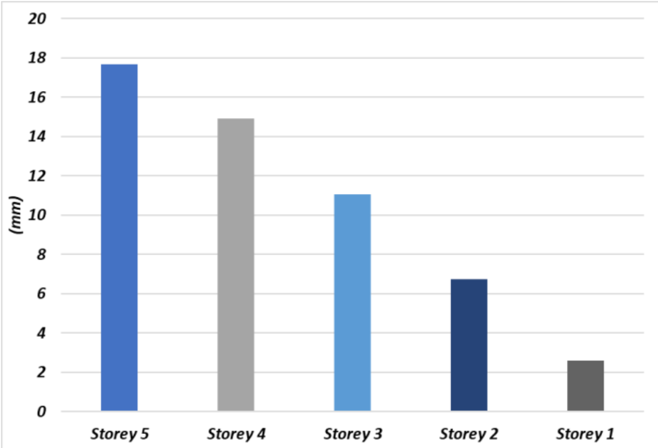
Graph 3 Displacement of L-Shape Building made with 64 % deduction



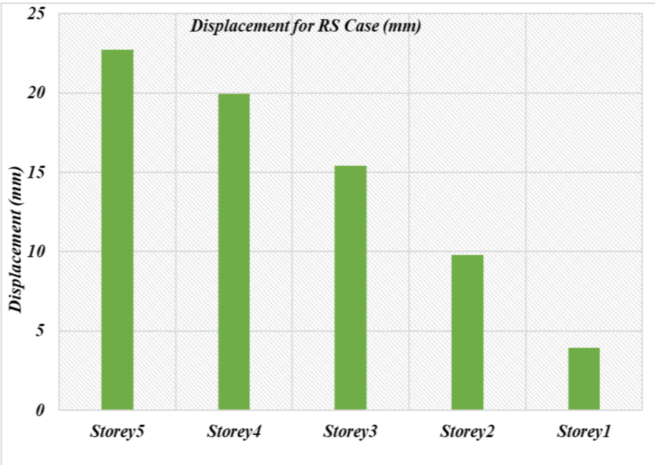
Graph 4 Displacement of Regular Building with shear wall at Corner



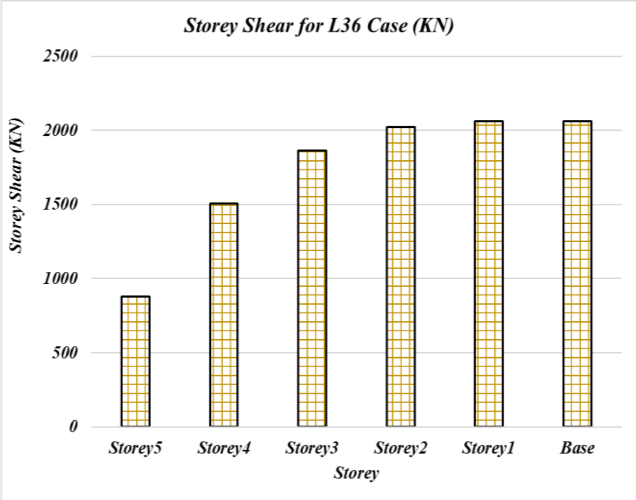
Graph 5 Displacement of L-shape Building with shear wall at X-direction



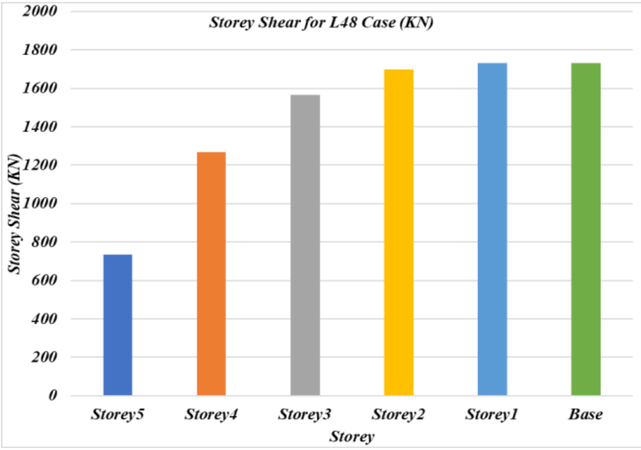
Graph 6 Displacement of L- shape Building with shear wall at both direction



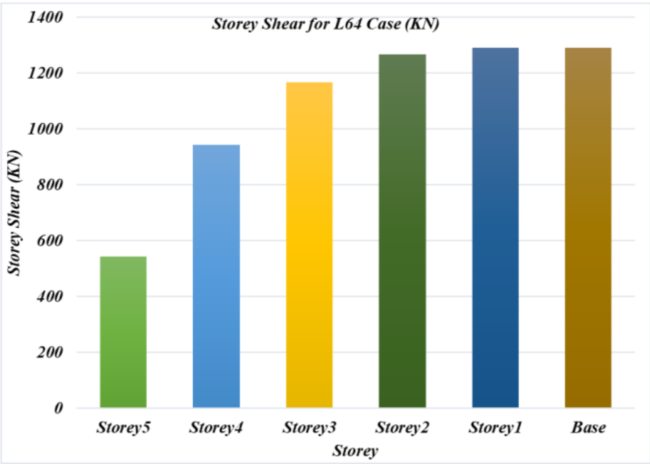
Graph 7 Displacement of Regular Square Shape Building Frame



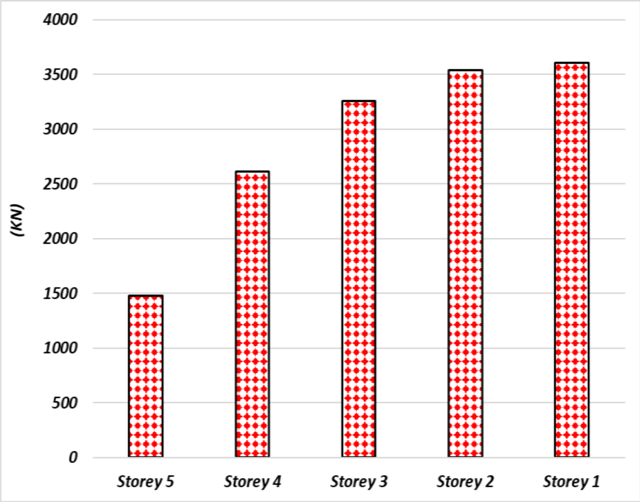
Graph 8 Storey Shear of L-Shape Building made with 36 % deduction



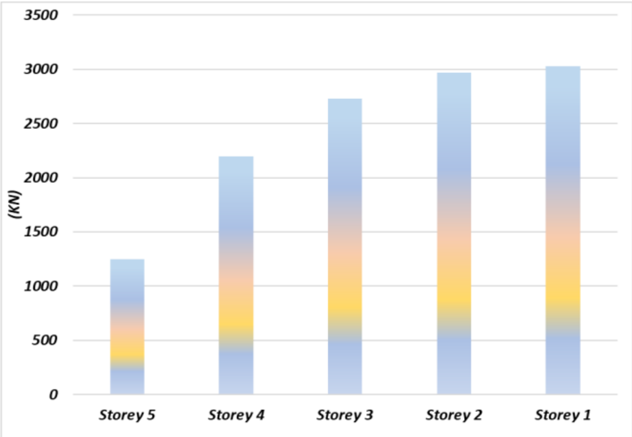
Graph 9 Storey Shear of L-Shape Building made with 48 % deduction



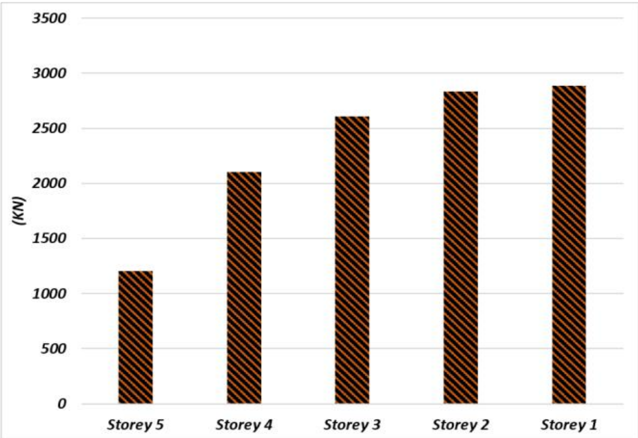
Graph 10 Storey Shear of L-Shape Building made with 64 % deduction



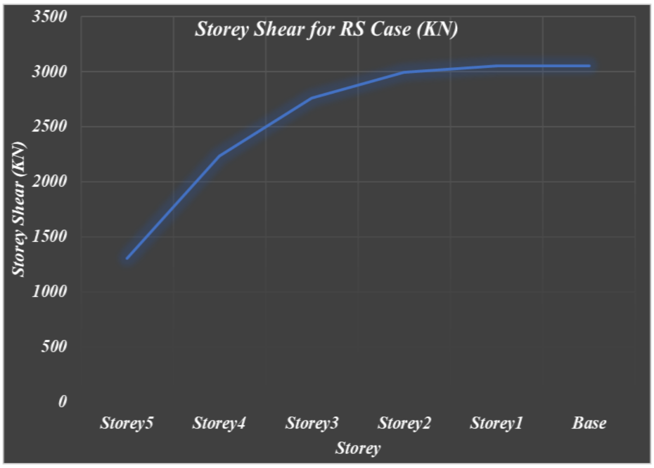
Graph 11 Storey Shear of Regular Shape Building with shear wall at Corner



Graph 12 Storey Shear of L- shape Building with shear wall at X-direction



Graph 13 Storey Shear of L- shape Building with shear wall at both direction



Graph 14 Storey Shear of Regular Square Shape Building Frame

VII. CONCLUSIONS

The following conclusions were made from the investigation-

1) It is been concluded that the displacement of REG (22.71 mm) is approximately 3 % more than L-shape frame (22.66 mm) This shows that L-shape frames has more rigid members which result in lesser displacement. **It concluded that as re-entrant corner increases, displacement increases.**
2) Storey shear for L48, L64 model is showing maximum base shear. The shear value for L48 is 43% and L64 frame cases is 57 % less than the REG frame case. **This shows that as re-entrant corner is increases, the shear value decreases.**
3) It has been seen that the regular square building displacement is reduced from 22.71 mm to 4.9 mm when shear wall is applied at the corner. This states that the shear wall at the corner has reduced displacement up to 81 % which is a very confined structure.
4) Lastly, it has been seen that plan irregularity has a significant effect on the seismic response of buildings. The results show that except regular square shape building other cases comes under re-entrant irregularity. Therefore, the case beyond criteria of re-entrant corner (i.e., 15 %) need to be carefully designed at the time of execution of work.

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