International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 01, January-2018

"Effect of Vertical Geometric Irregularity on Flat slab system with Response spectrum Analysis"

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ABSTRACT: Steel structures today are edging towards the end of their design life. The increase of the urban population desires to construct big prestigious buildings for residence and business cause. The development of multi-storey building and big span structures is becoming a vital a part of our living style. Seismic evaluation is a subset of structural evaluation and is the calculation of the reaction of a structure to earthquakes. The prevailing goal of this work is to examine the numerous parameters like base shear, story displacement and story drift & stresses performing on flat slab system. Analysis of the large systems built the usage of flat slab in rectangular shape layout will be carried out with the help of Staad pro 2007 software via using is 456-2000Code. The main objective of the analysis is to study the behaviour of flat slab system in geometric vertical irregular multi-storied steel building against different forces acting on it during earthquake. The analysis is carried out using STAAD Pro2007 software. Steel structure frame with R.C.C flat slab without drop, steel column with I section & steel cantilever Beam with T section for vertical irregularity are modeled and analyzed for the dynamic loading. The analysis is made between Steel frame flat slab structure of G+10 story 150 %, 200%, 300% & 600% vertical irregular building with center, right & left edge positions. Response spectrum analysis results provide a more realistic behaviour of structure response and hence it can be seen that the displacement values in X directions are least in model with vertical irregularity in center when compared to all other models. Analysis of 150% 200%, 300% & 600% irregular building from center, left edge & right edge position with flat slab system in steel frame and results are carried out. It's concluded that the flat slab vertical geometric irregular Structure at the center position with mass irregularity 200% is more sustainable for the effect of dynamic load on the performance of building as compare to other cases of irregularity in present study. Comparison in made between principal stresses, von mis stresses, tresca stresses & shear stresses in flat slab system, bending moment, node displacement, peak storey shear, Story drift & the result are brought out.

KEYWORDS: Flat slab, Response Spectrum Analysis, Geometric Vertical Irregularity

I. INTRODUCTION

Steel structures today are edging towards the end of their design life. Recently, the frequency and value of loadings are becoming considerably greater in contrast to the preliminary design load at the time of construction. Seismic evaluation is a subset of structural evaluation and is the calculation of the reaction of a structure to earthquakes. These days excessive high-rise steel frame building is nicely setting up in metro towns. Steel frame generally refers to a building approach with a "skeleton body" of Vertical steel columns and horizontal cantilever T-beams, constructed in a rectangular grid to aid the flooring, roof and partitions of a constructing which are all attached to the frame. The prevailing goal of this work is to examine the numerous parameters like base shear, story displacement and story drift & stresses performing on flat slab system. Analysis of the large systems built the usage of flat slab in rectangular shape layout will be carried out with the help of Staad pro 2007 software via using is 456-2000Code. The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design become more complicated. There are two types of irregularities.

Plan Irregularities

Vertical Irregularities.

II. METHOD OF ANALYSIS

2.1 Code-based procedure for seismic analysis Main features of seismic method of analysis based on Indian standard 1893(Part 1): 2002 are described as follows (a) Equivalent static lateral force method (b) Response spectrum method (c) Square roots of sum of squares (SRSS method) (d) Complete Quadratic combination method (CQC) (e) Elastic response spectrum methods

(a) Equivalent Static Analysis All design against seismic loads must consider the dynamic behaviour of the load. Regular structures were analysis by equivalent linear static methods and it's generally adequate. Most codes of practice allow this method for regular, low- to medium-rise buildings. It starts with an estimation of base shear load and its distribution on every storey calculated via the use of formulas given in the code. equivalent static analysis can consequently work well for low to medium-rise buildings without extensive coupled lateral-torsional modes, in which simplest the first mode in each course is considered. Tall buildings (over, say, 75 m), wherein 2nd and higher modes can be vital, or buildings with torsional consequences, are a lot much less appropriate for the technique, and require more complex methods to be used in these situations.

(b) Response Spectrum Method The representation of the most response of idealized single degree freedom system having certain period and damping, throughout earthquake ground motions. The maximum response plotted in against two of un-damped natural period and for various damping values and may be expressed in terms of maximum absolute acceleration, most relative velocity or maximum relative displacement. For this motive response spectrum case of analysis have been executed in line with IS 1893.

III. MODEL AND ANALYSIS

Table 1 Design parameters

S.No	Particulars	Dimension/Size/Value
1	Model	G+10
2	Seismic Zones	IV_{th}
3	Floor height	3m
4	Depth of foundation	1.5m
5	Building height	33.5M
6	Columns	ISHB 450
7	Cantilever Beam	ISHT 100
8	Thickness of slab	200mm
9	Type of soil	Medium soil Type-II
10	Live load	$1.5KN/M^2$
11	Dynamic Analysis	**Response Spectrum Analysis**
12	Natural Period of Building	$Ta = 0.075\ h^{0.75}$
13	Zone factor Z	0.24
14	Response Reduction factor (RF)	5
15	Importance factor (I)	1
16	Rock and soil factor (SS)	2
17	Type of structures	2
18	Damping Ratio	0.05

Table 2 Modeling

S.no	Model ID	Model Description
1	**IR_150_C**	Building having geometric vertical irregularity 150% at center Position
2	**IR_150_L**	Building having geometric vertical irregularity 150% at Left Position
3	**IR_150_R**	Building having geometric vertical irregularity 150% at right Position
4	**IR_200_C**	Building having geometric vertical irregularity 200% at center Position
5	**IR_200_L**	Building having geometric vertical irregularity 200% at Left Position
6	**IR_200_R**	Building having geometric vertical irregularity 200% at right Position
7	**IR_300_C**	Building having geometric vertical irregularity 300% at center Position
8	**IR_300_L**	Building having geometric vertical irregularity 300% at Left Position
9	**IR_300_R**	Building having geometric vertical irregularity 300% at right Position
10	**IR_600_C**	Building having geometric vertical irregularity 600% at center Position
11	**IR_600_L**	Building having geometric vertical irregularity 600% at Left Position
12	**IR_600_R**	Building having geometric vertical irregularity 600% at right Position

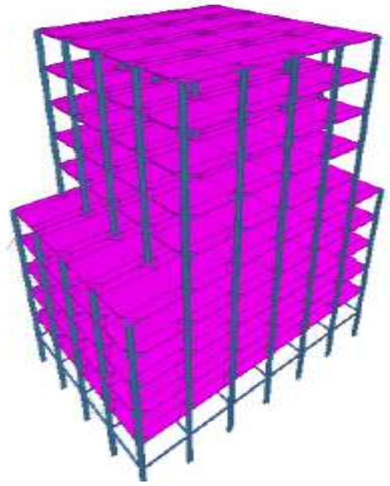


Figure 1 Vertical geometric irregularity of 150%

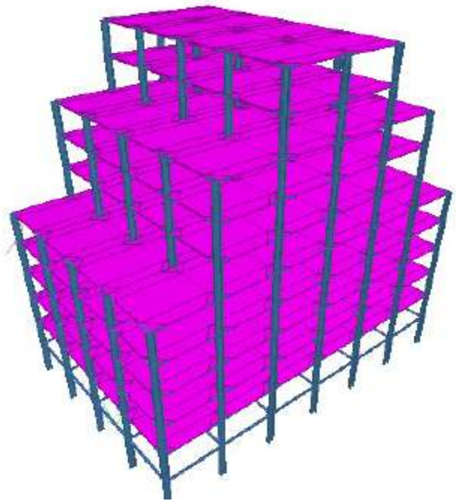


Figure 2 Vertical geometric irregularity of 200%

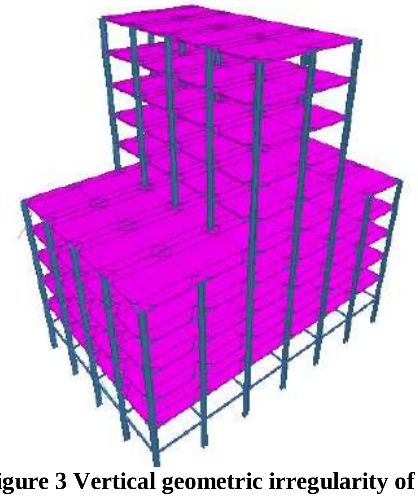


Figure 3 Vertical geometric irregularity of 300%

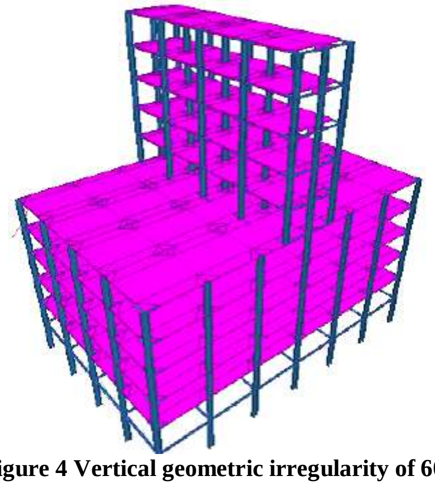
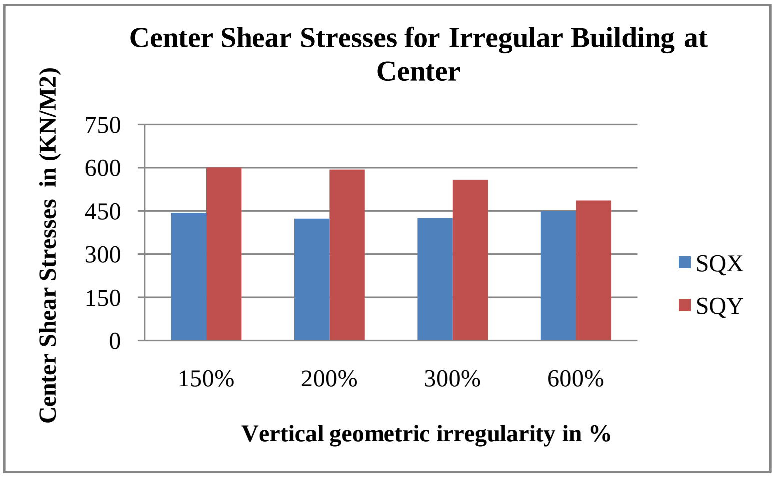


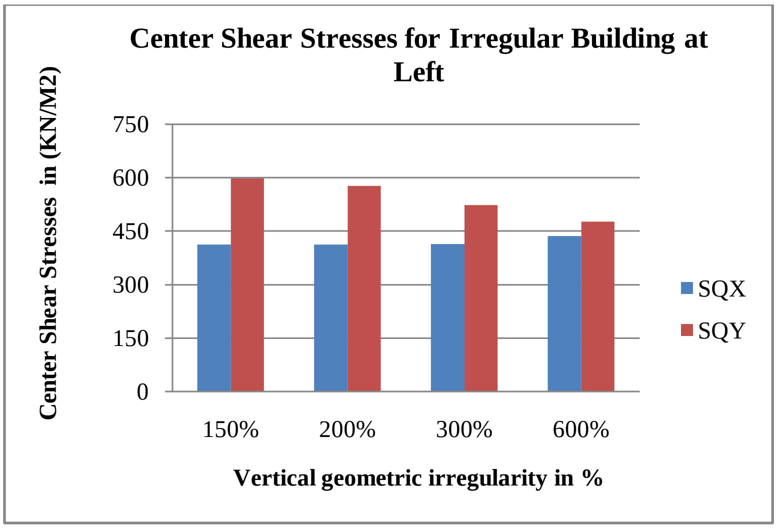
Figure 4 Vertical geometric irregularity of 600%

IV. RESULT

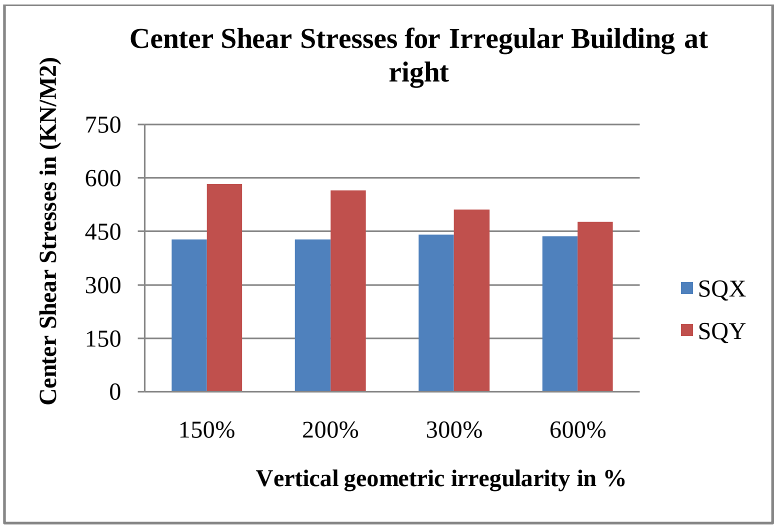
Response spectrum analysis results provide a more realistic behaviour of structure response and hence it can be seen that the displacement values in X directions are least in model with vertical irregularity in center when compared to all other models. Analysis of 150% 200%, 300% & 600% irregular building from center, left edge & right edge position with flat slab system in steel frame and results are carried out and the following conclusions are drawn from the study of graph as shown below-



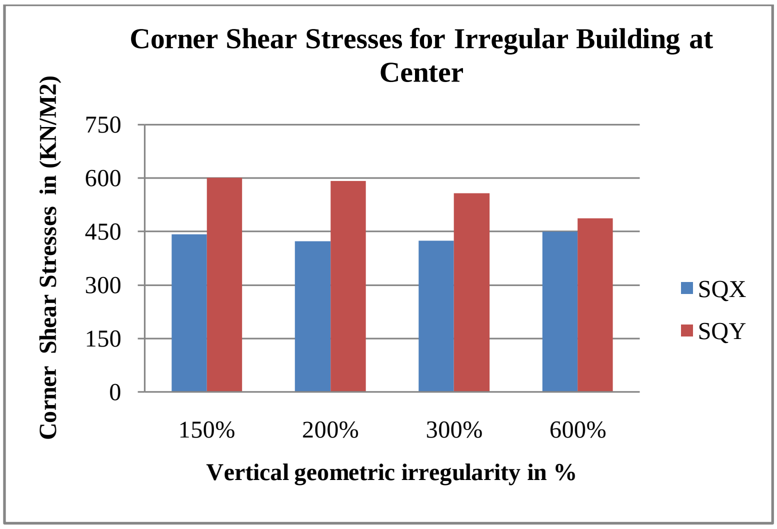
Graph 1 Center Shear Stresses for irregular building at centre



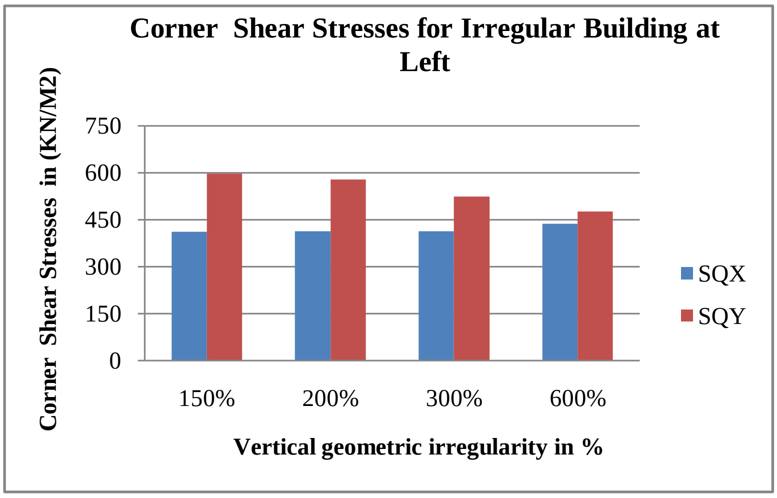
Graph 2 Center Shear Stresses for irregular building at left



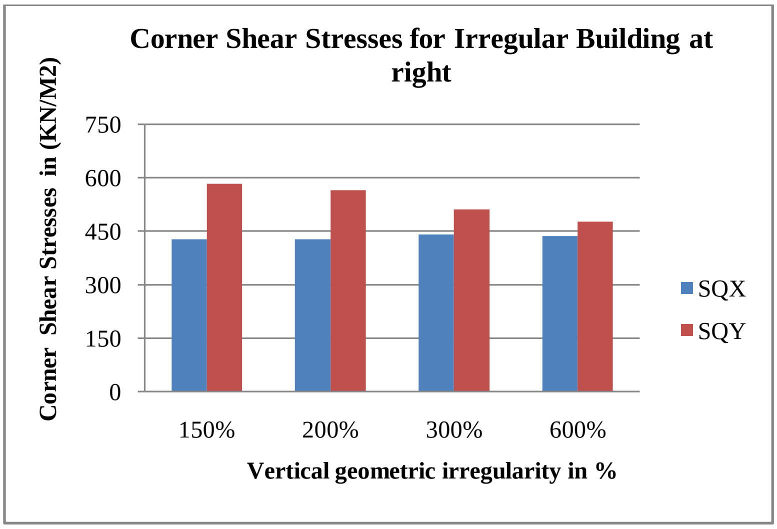
Graph 3 Center Shear Stresses for irregular building at right



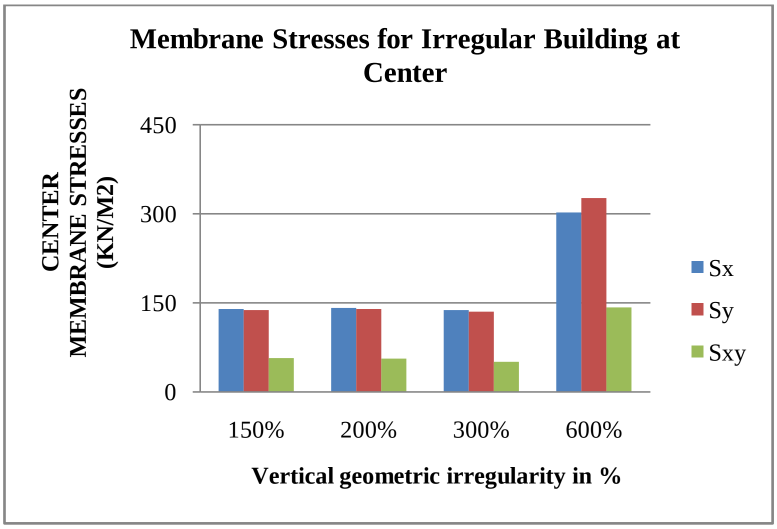
Graph 4 Corner Shear Stresses for irregular building at centre



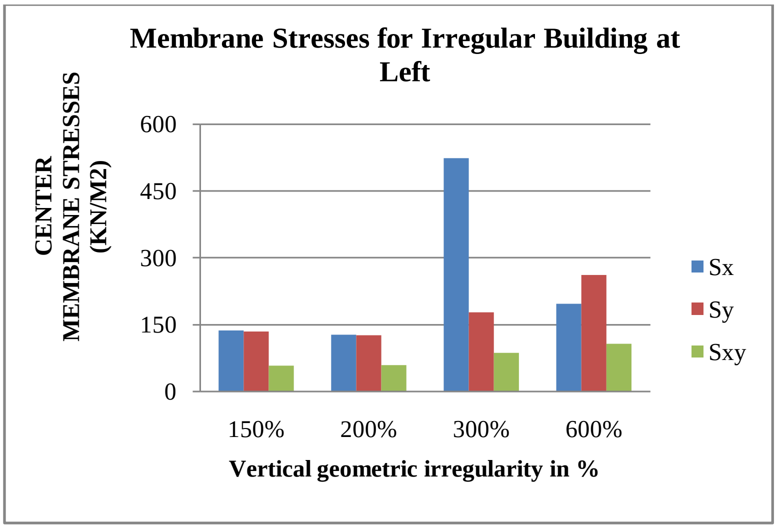
Graph 5 Corner Shear Stresses for irregular building at left



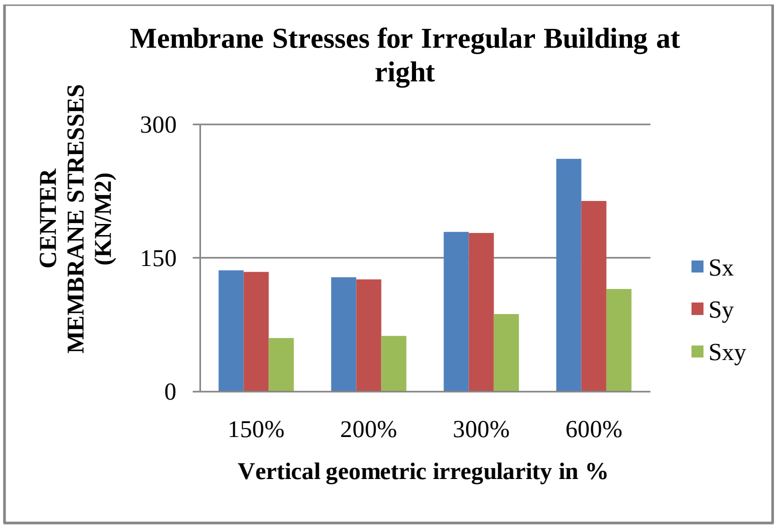
Graph 6 Corner Shear Stresses for irregular building at right



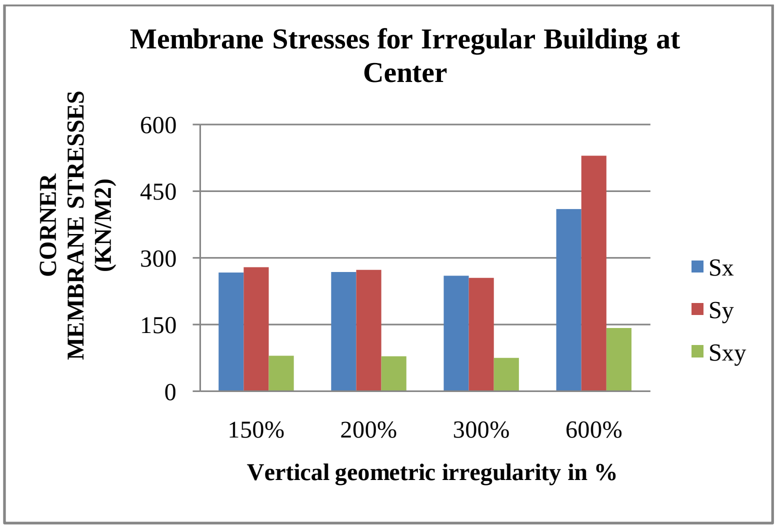
Graph 7 center membrane stresses for irregular building at centre



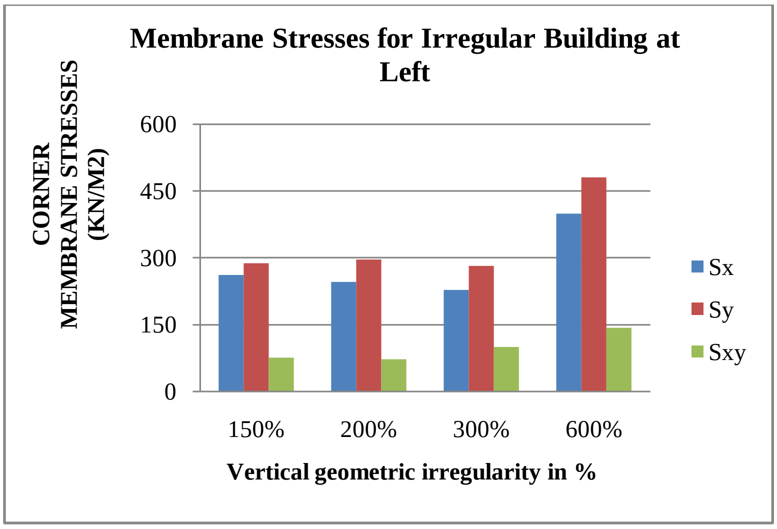
Graph 8 center membrane stresses for irregular building at left



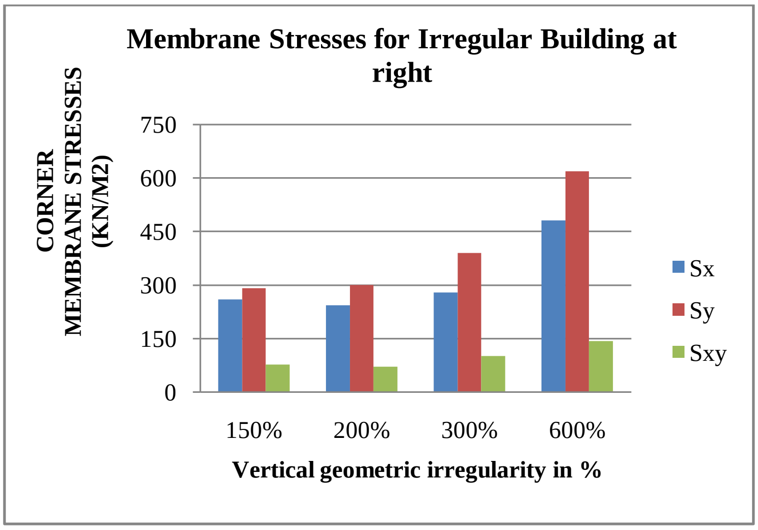
Graph 9 center membrane stresses for irregular building at right



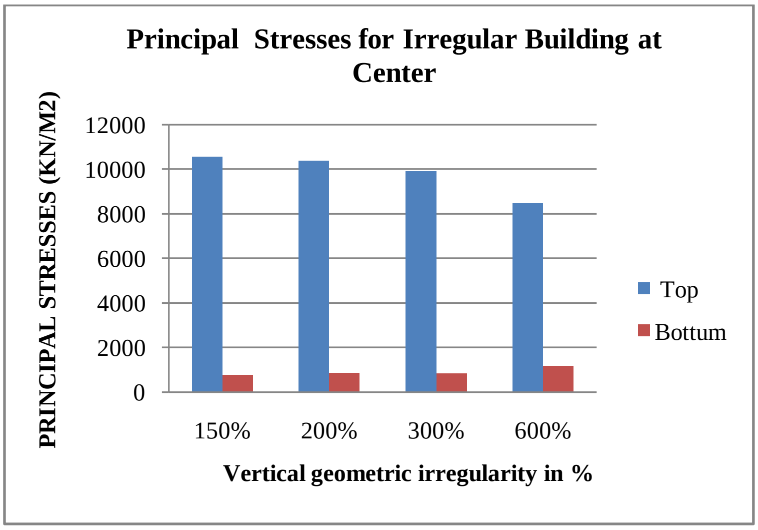
Graph 10 Corner membrane stresses on flat slab for irregular building at centre



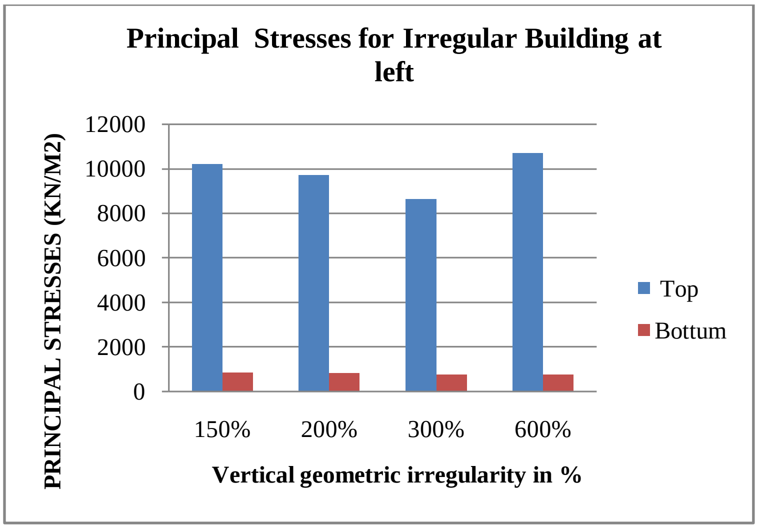
Graph 11 Graph 10 Corner membrane stresses on flat slab for irregular building at left



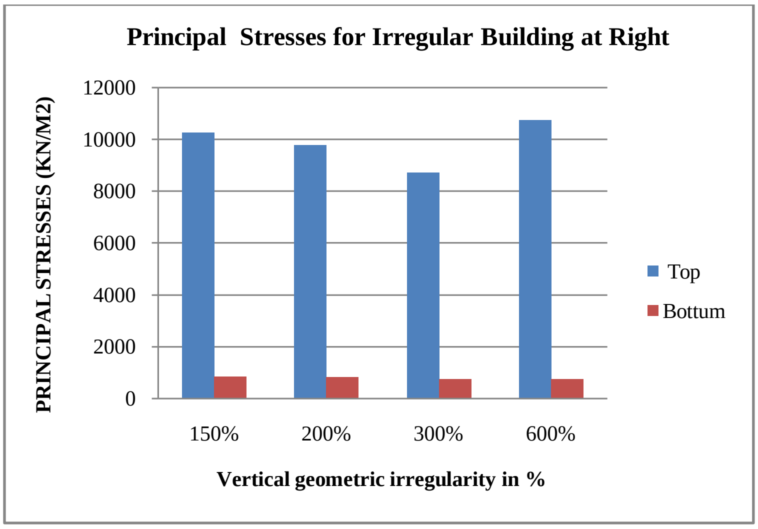
Graph 12 Graph 10 Corner membrane stresses on flat slab for irregular building at right



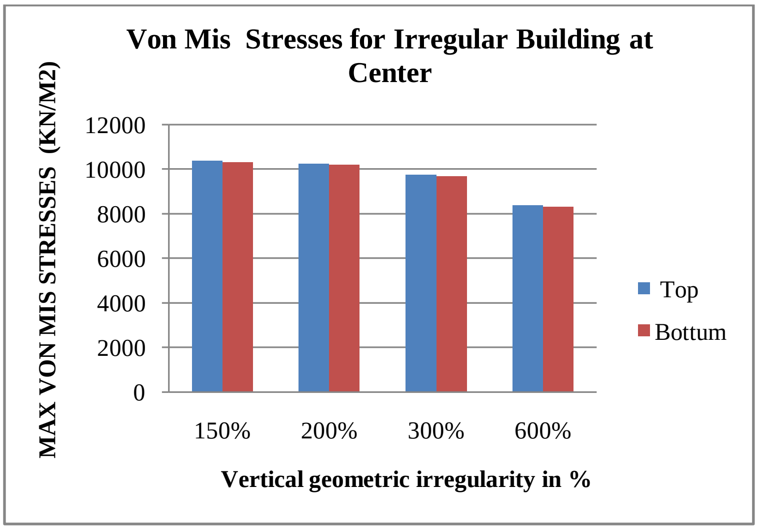
Graph 13 Principal Stresses for Irregular Building at Center



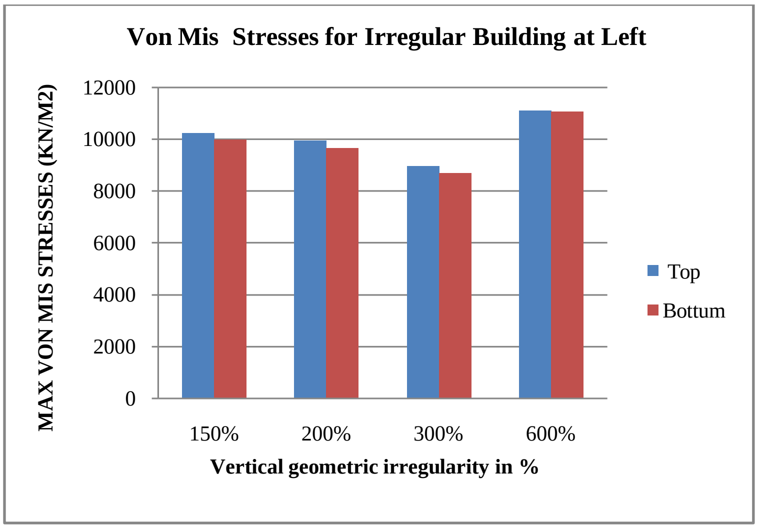
Graph 14 Principal Stresses for Irregular Building at left



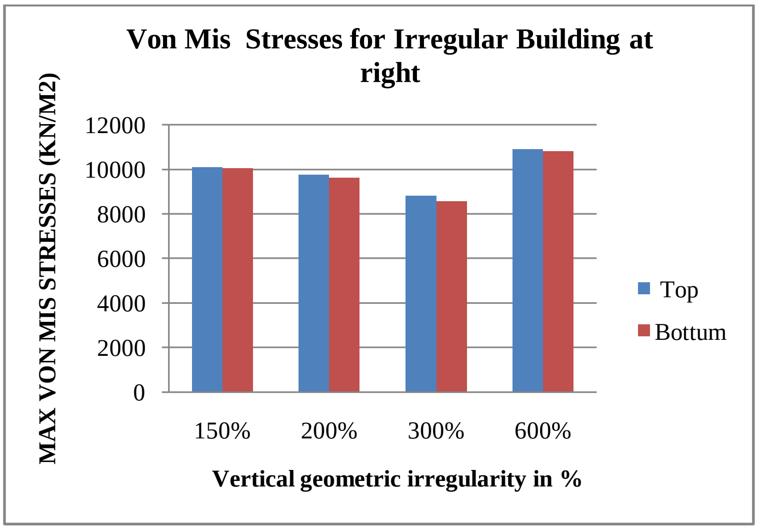
Graph 15 Principal Stresses for Irregular Building at right



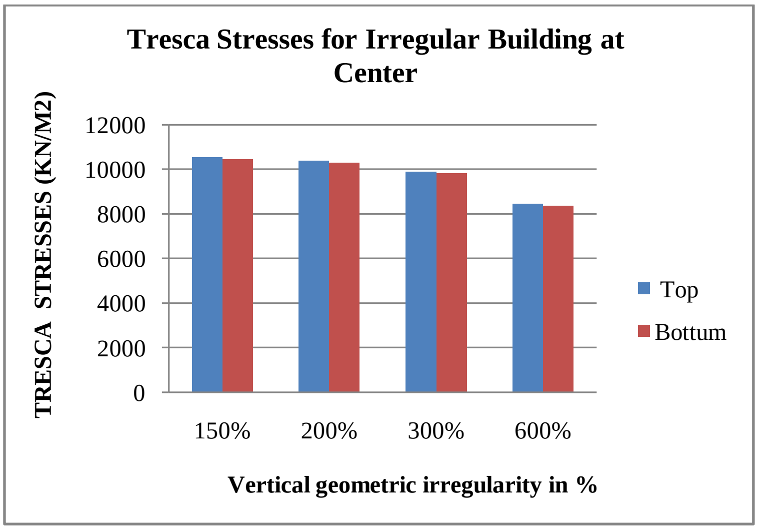
Graph 16 Von Mis Stresses for Irregular Building at Center



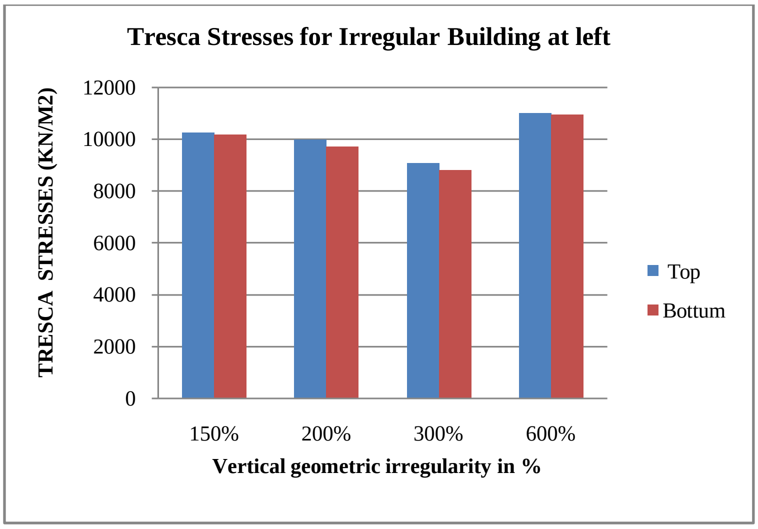
Graph 17 Von Mis Stresses for Irregular Building at left



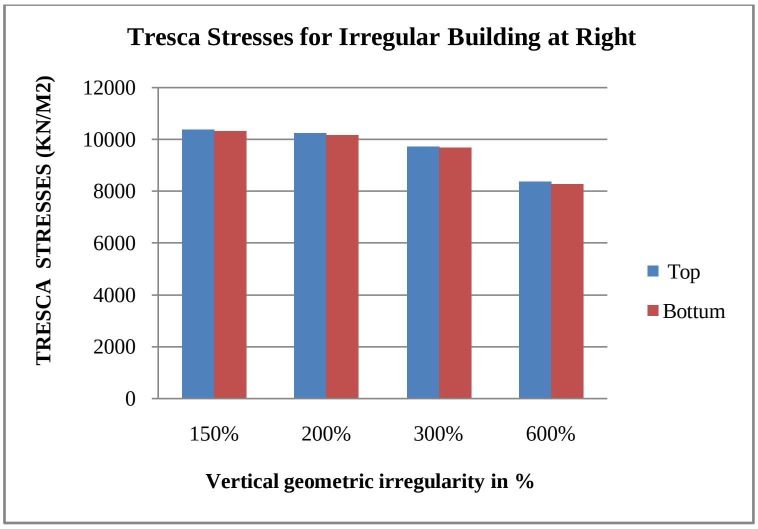
Graph 18 Von Mis Stresses for Irregular Building at right



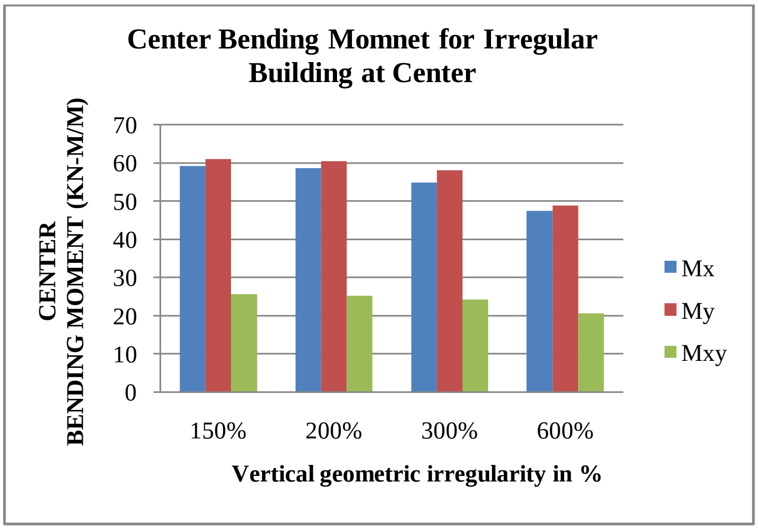
Graph 19 Tresca Stresses for Irregular Building at Center



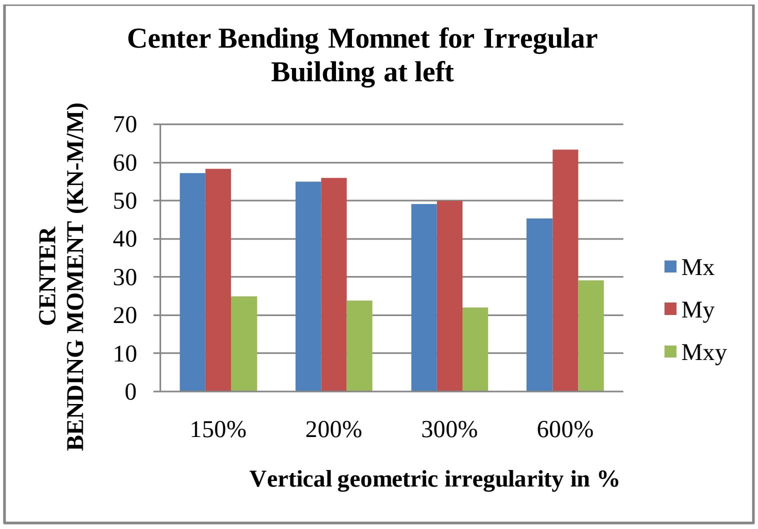
Graph 20 Tresca Stresses for Irregular Building at left



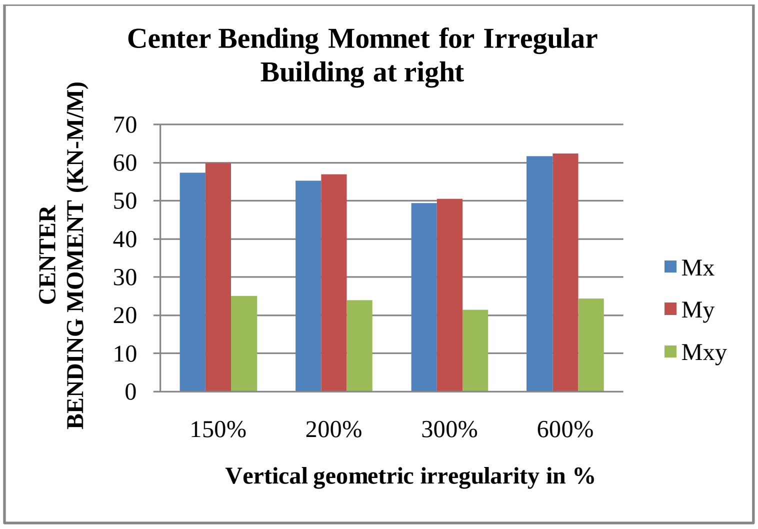
Graph 21 Tresca Stresses for Irregular Building at right



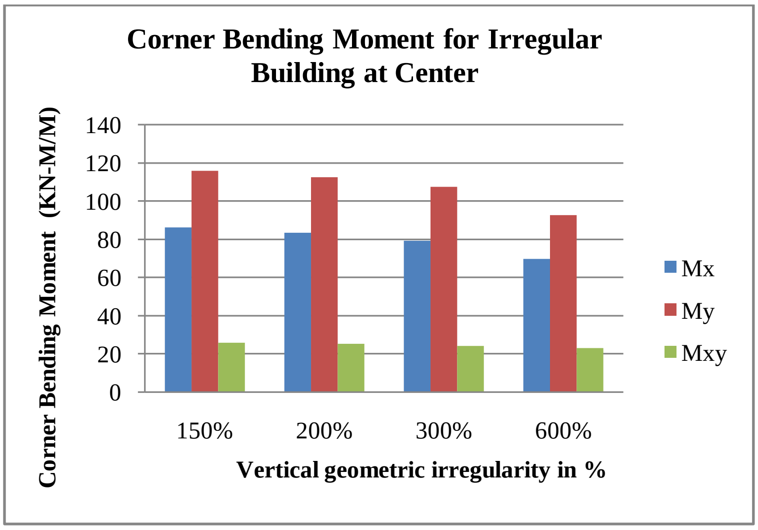
Graph 22 Center Bending Moment for Irregular Building at Center



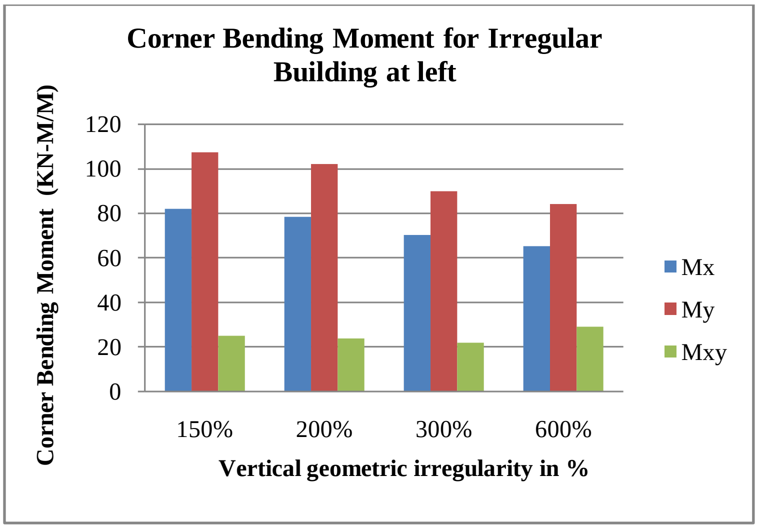
Graph 23 Center Bending Moment for Irregular Building at left



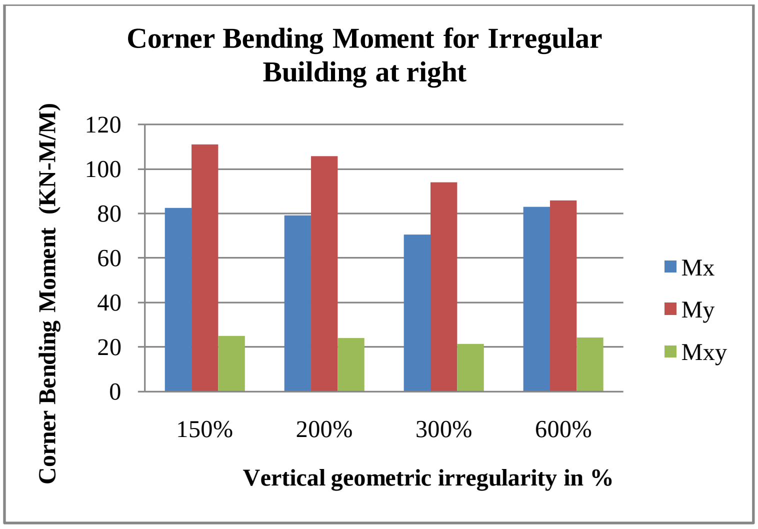
Graph 24 Center Bending Moment for Irregular Building at right



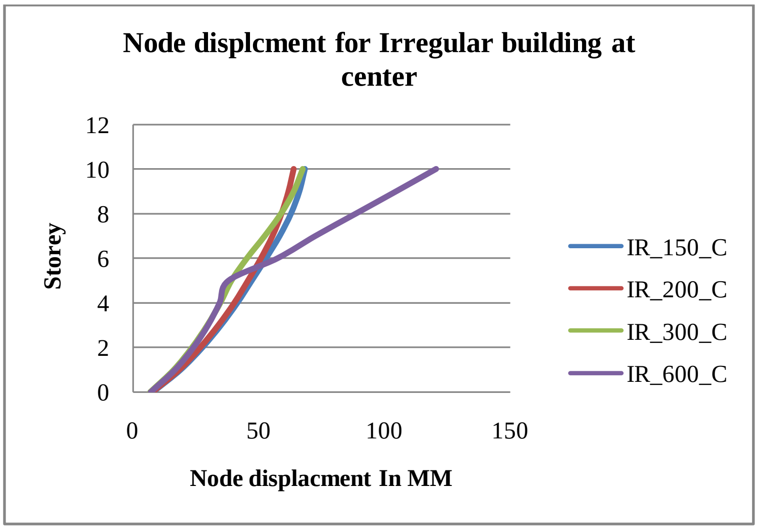
Graph 25 Corner Bending Moment for Irregular Building at Center



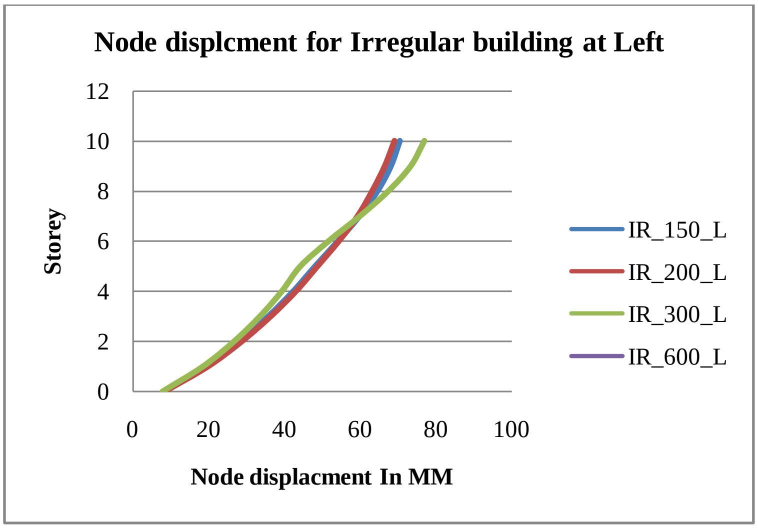
Graph 26 Corner Bending Moment for Irregular Building at left



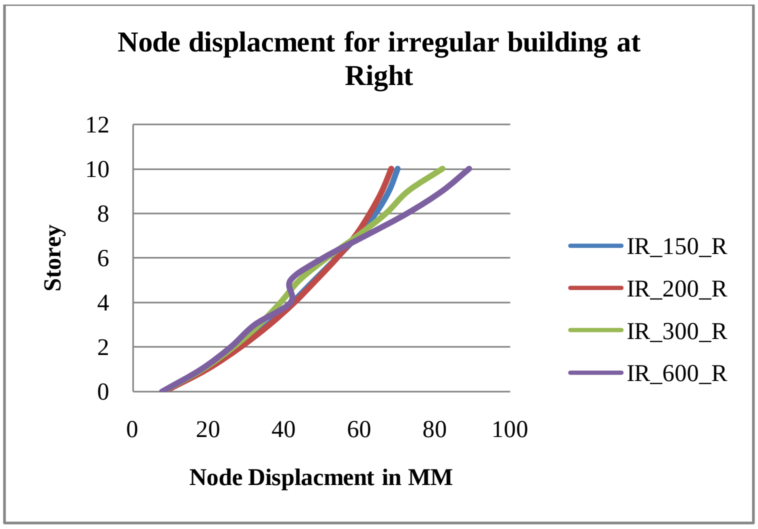
Graph 27 Corner Bending Moment for Irregular Building at right



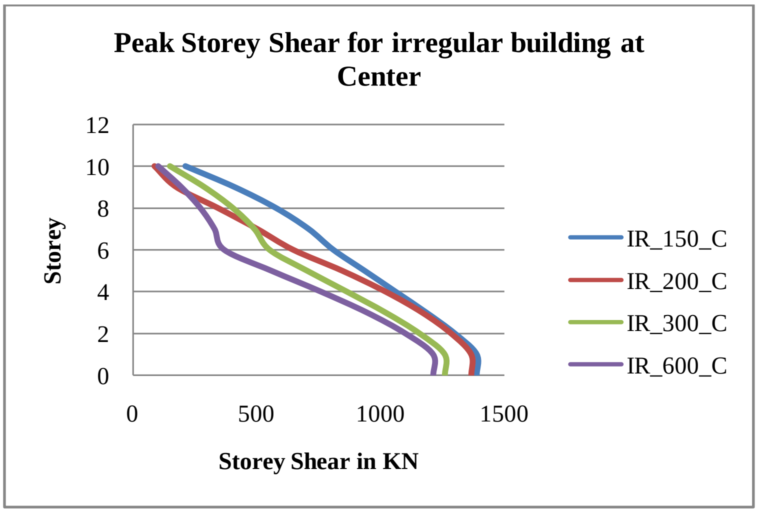
Graph 28 Node Displacement for X direction for irregular building at centre



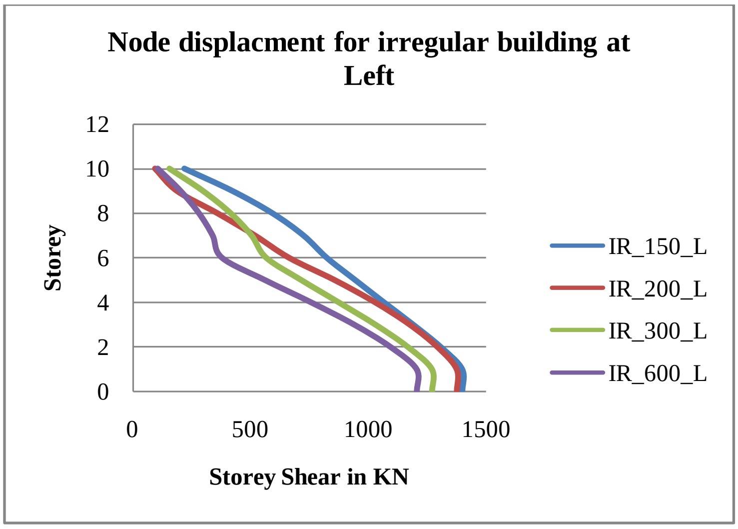
Graph 29 Node Displacement for X direction for irregular building at left



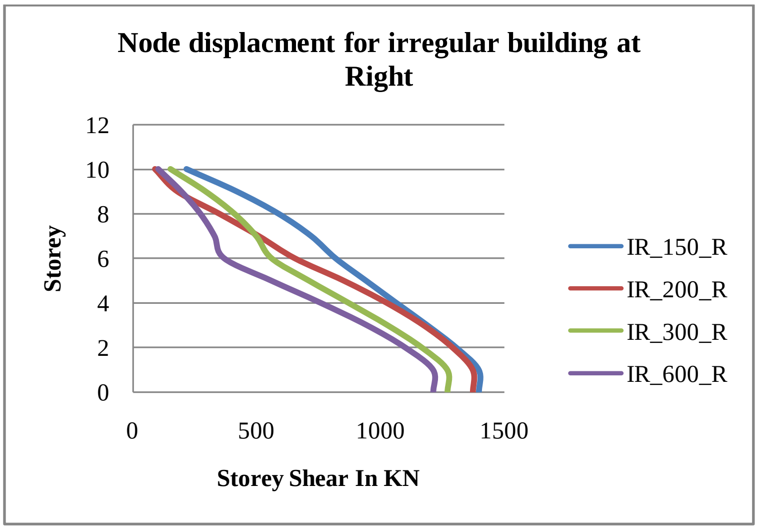
Graph 30 Node Displacement for X direction for irregular building at right



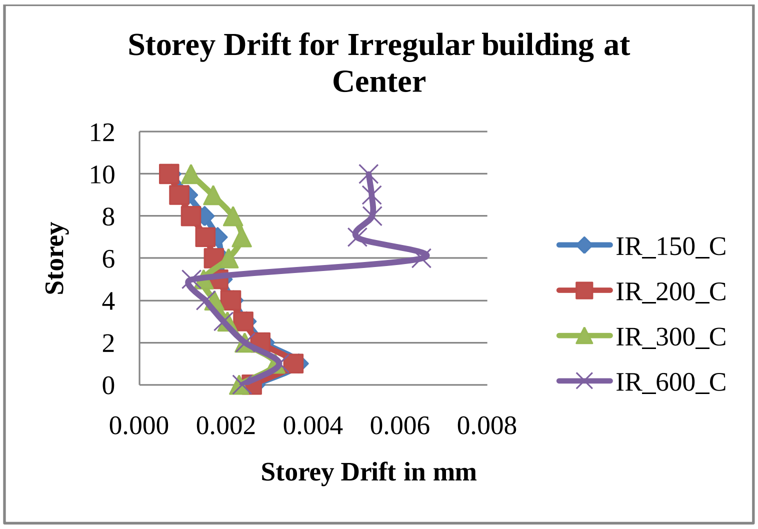
Graph 31 Peak Storey Shear for irregular building at Center



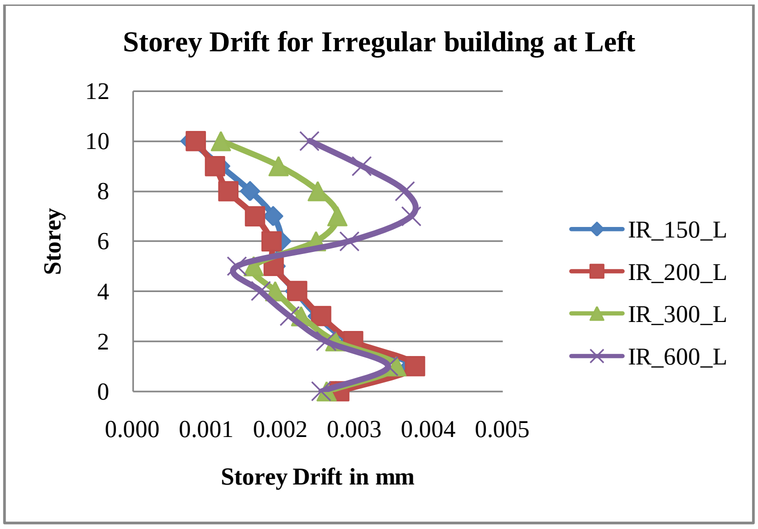
Graph 32 Peak Storey Shear for irregular building at left



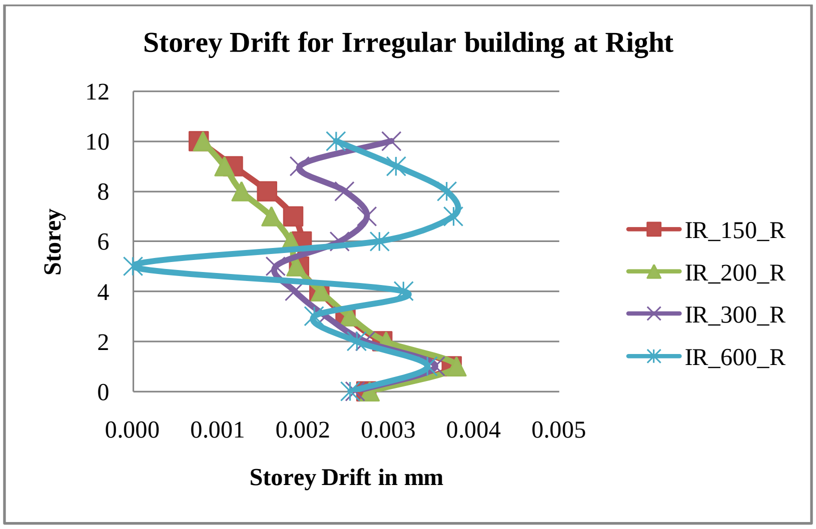
Graph 33 Peak Storey Shear for irregular building at right



Graph 34 Storey Drift for Irregular building at Center



Graph 35 Storey Drift for Irregular building at left



Graph 36 Storey Drift for Irregular building at right

V. CONCLUSION

- 1. Center shear stresses SQX in flat slab is decrease in 200% & 300% irregular building but increases in 150% & 600% irregular building. Also, when we compare building irregularity at center position with left and right position it's conclude that SQX decreases in left edge position & increases in right edge position. Similarly results found in SQY.
- Corner shear stresses SQX and SQY in flat slab are same as the Center shear stresses there are no change found in center & corner stresses in the flat slab.
- The principal top and bottom stresses in flat slab increases with decrease in vertical irregularity. There is no effect of position of vertical building irregularity on principal stresses of flat slab.
- The max von Mis top and bottom stresses in flat slab increases with decrease in vertical irregularity. There is no effect of position of vertical irregularity on principal stresses of flat slab.
- The Tresca top and bottom stresses flat slab increases with decrease in vertical irregularity. There is no effect of position of vertical irregularity on principal stresses of flat slab.
- Center membrane stresses Sx, Sy & Sxy in flat slab more increase in 600% irregular building & negligible variation in 150% to 300% irregular building and Membrane stresses more increase in center position as compare to other two i.e. left & right edge positions.
- Corner membrane stresses in flat slab similarly with center position there no variation found in result.

- Center bending moment MX, MY & MXY in flat slab system more decrease when irregularity increases 150% to 600%. Bending moment reduces in left & right edge position as compare to center position except 600% irregular building.
- Similarly Corner bending moment MX, MY & MXY in flat slab system more decrease when irregularity increases 150% to 600%. Bending moment reduces in left & right edge position as compare to center position except 600% irregular building.
- Node displacement in X direction will be more restricted in 200% irregular building with center position as compare to all other model and dramatically increases in 600% irregular building. It does also conclude that from the result the negligible effect of position of vertical irregularity on node displacement.
- Total Peak Storey shear increase with decreases the vertical irregularity also the negligible effect of position vertical irregularity on the Peak storey shear of the building.
- The values of story drift are found to be within permissible limit i.e. not more than 0.004 times the story height as per norms according to IS 1893:2002 Part-1 in all models except 600% irregular model with center position i.e. IR_600_C.
- When compare 150%, 200%, 300% & 600% vertical Irregular building with vertical irregularity position at center, left & right edge of the building about the vertical centroid axis and the result in terms of flat slab shear stresses, Bending Moment, node displacement, Peak story shear (Base shear) & story drift the Building 200% irregularities with center position i.e. model "**IR_200_C"** show good results which brought out in tabular form.

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