Dynamic Analysis of Flat Slab System in Vertical Irregular Building with & without Shear Wall

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Abstract- **During an earthquake, failure of structure starts off-evolved at factors of weak spot. This weak point arises due to discontinuity in mass, stiffness and geometry of structure. The systems having this discontinuity are termed as irregular systems. Irregular structures contribute a massive portion of city infrastructure. The effect of vertically irregularities within the seismic overall performance of systems will become definitely vital. Whilst such buildings are built in high seismic zones, the analysis and design turn into more complexes. The main objective of the analysis is to study the behaviour of flat slab system in vertical irregular multi-storied building against different forces acting on it during earthquake. Also, the objective of analysis is to study the structural behaviour of shear wall – flat slab interaction with opening. The analysis is carried out using STAAD Pro2007 software. Flat slab system with shear wall are modelled and analysed for the dynamic loading. The analysis is made between in the three types of G+9 storey building with 0 % vertical irregularity, 200 % vertical irregularity and 300% vertical irregularity. In all these building's shear wall is provided with & without 20% opening. Total 15 modelled are studied and their results were compared. Response spectrum analysis results provides a more realistic behaviour of structure response hence the analysis of flat slab system in regular, 200% Irregular and 300% Irregular multi-storied buildings without shear wall and buildings with shear wall at different location & opening is carried out. It's concluded that the flat slab Structure with shear wall along central periphery is suitable for the effect of dynamic load on the performance of building & negligible effects of opening of size 20% of the shear wall on the stiffness of the system. Comparison in made between Stresses & Bending Moment on flat slab, node displacement, Base shear, Story drift & the result are brought out.**

Keywords: **Flat slab, Vertical geometric irregularity, shear wall with opening, Response Spectrum analysis, etc.**

I. INTRODUCTION

During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example, structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building.

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.

A reinforced concrete flat slab, also called as beamless slab, is a slab supported directly by columns without beams. A part of the slab bound on each of the four sides by center lines of columns is called a panel. The flat slab is often thickened near to supporting columns to provide adequate strength in shear and to reduce the quantity of negative reinforcement in the support regions. The thickened portion meets the floor slab or a drop panel, is enlarged so as to increase primarily the perimeter of the critical section, for shear and hence, increasing the capacity of the slab for resisting two-way shear and to reduce negative bending moment at the support.

II. IRREGULARITIES IN BUILDINGS

There are two types of building irregularities, they are

- **Plan Irregularities.**
- **Vertical Irregularities.**

In plan irregular building there are of five types, they are

- Torsion Irregularity.
- Re-entrant Corners.
- Diaphragm Discontinuity.
- Out-of-Plane Offsets.
- Non-parallel Systems.

In vertical irregularity buildings there are also five types, they are

- Stiffness Irregularity.
  - Soft Storey.
  - Extreme Soft Storey.
- Mass Irregularity.
- Vertical Geometric Irregularity.
- In-Plane Discontinuity in Vertical Elements Resisting Lateral Force.
- Discontinuity in Capacity - Weak Storey.

III. OBJECTIVE OF THE WORK

1) The main objective of the analysis is to study the behaviour of flat slab system in vertical irregular multi-storied building against different forces acting on it during earthquake. The analysis is carried out using STAAD Pro2007 software. Conventional R.C.C structure i.e. flat slab, shear wall, column for vertical irregularity are modelled and analyzed for the dynamic loading.

2) The analysis is made between the conventional R.C.C flat slab structure of G+10 story regular building, 200 % vertical irregular building and 300% vertical irregular building without shear wall and with shear wall at different location with 20% opening. Also, the objective of analysis is to study the structural behaviour of shear wall – flat slab interaction with opening.

3) To know the effect of Geometric irregularity on the shape (vertical geometric) irregular building the geometry is changed by reducing the no. of bays in X-direction vertically downward, as per the IS 1893:2002 (part-1).

IV. PARAMETRIC STUDY

A reinforced concrete frame with 10(G+9) storey of dimension 30mx20m, has been taken for seismic analysis. 15 flat slab building models with varying of vertical geometric irregularities are considered for comparison:

Model-1: Regular building without shear wall.

Model-2: Regular building with shear wall at center.

Model-3: Regular building with shear wall at center with 20% opening.

Model-4: Regular building with shear wall at central periphery.

Model-5: Regular multistoried building with shear wall at central periphery with 20% opening.

Model-6: 200% Irregular building without shear wall.

Model-7: 200% Irregular building with shear wall at center.

Model-8: 200% Irregular building with shear wall at center with 20% opening.

Model-9: 200% Irregular building with shear wall at central periphery.

Model-10: 200% Irregular building with shear wall at central periphery with 20% opening.

Model-11: 300% Irregular building without shear wall.

Model-12: Flat slab 300% irregular building with shear wall at center.

Model-13: 300% Irregular building with shear wall at center with 20% opening.

Model-14: 300% Irregular building with shear wall at central periphery.

Model-15: 300% Irregular building with shear wall at central periphery with 20% opening.

These 15 building models are analyzed for the Linear dynamic analysis (response spectrum method) for zone-IV for soil type-II (medium soil) as per IS 1893(part 1):2002.

V. METHOD OF ANALYSIS

The study undertakes the following analysis

- Linear Dynamic Analysis (Response Spectrum Analysis)

VI. DESCRIPTIONS OF BUILDING

Description of building	
Structure type	Special Moment Resisting Frame[SMRF]
Plan dimension	30x20m
Storey height	3m
Height of building	33.5m
Grade of concrete	M25
Grade of steel	Fe415
Cantilever Beam sizes	500x2000mm
column sizes	500x500mm
slab thickness	200mm
Live load	1.5kN/m2
Floor finish	1.0kN/m2
Shear wall Thickness	200mm
Zone factor	II and V
Soil type	Medium soil type-2
Importance factor	1
Response reduction factor	5.0(SMRF)

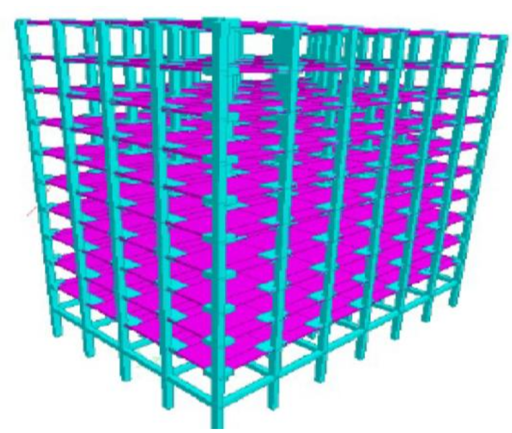

Fig 1: Elevation of regular building

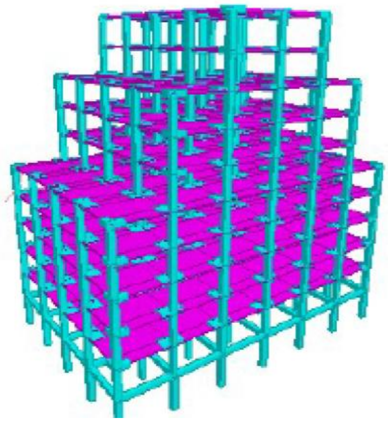

Fig 2: Elevation of 200% irregular building

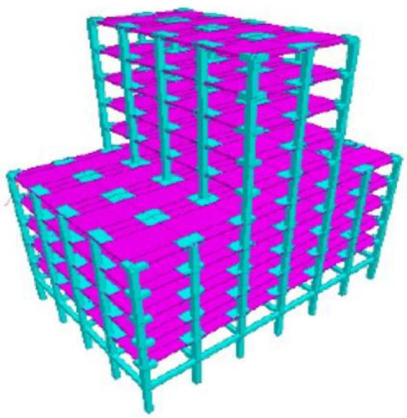

Fig 3: Elevation of 300% irregular building

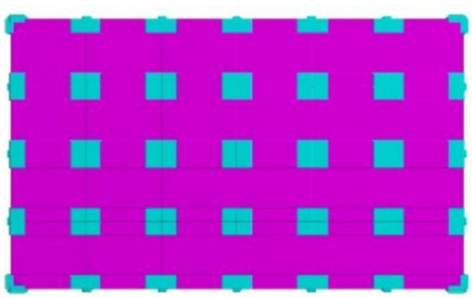

Fig 4: Plan of Regular, 200% Irregular & 300% Irregular Building

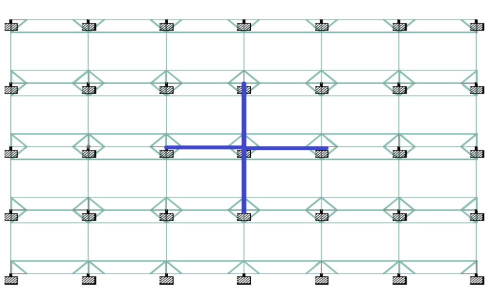

Fig 5: Plan of shear wall position vertical irregular building

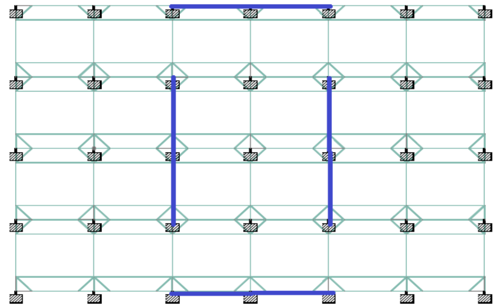

Fig 6: Plan of shear wall position vertical irregular building

VII. RESULTS AND DISCUSSION

A. Base Shear

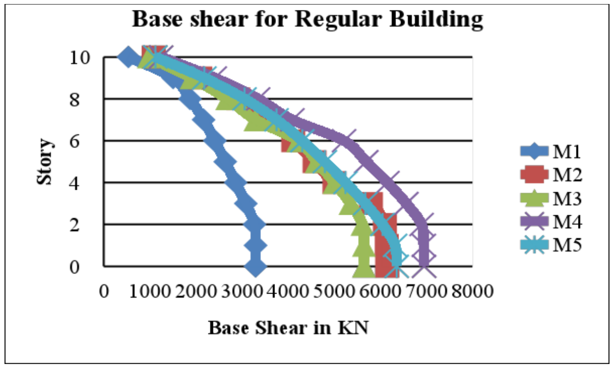

Fig 7: Base Shear of Regular building models

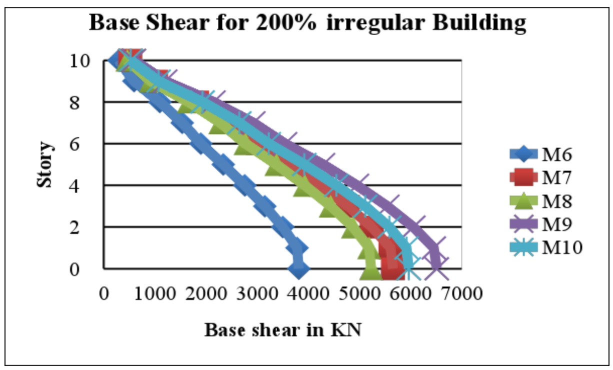

Fig 8: Base Shear of 200% irregular building models

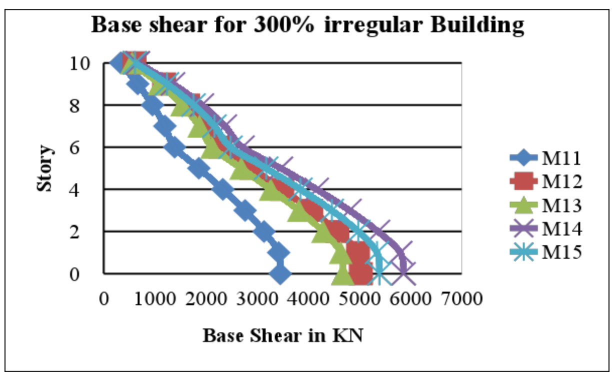

Fig 9: Base Shear of 300% irregular building models

B. Node Displacement

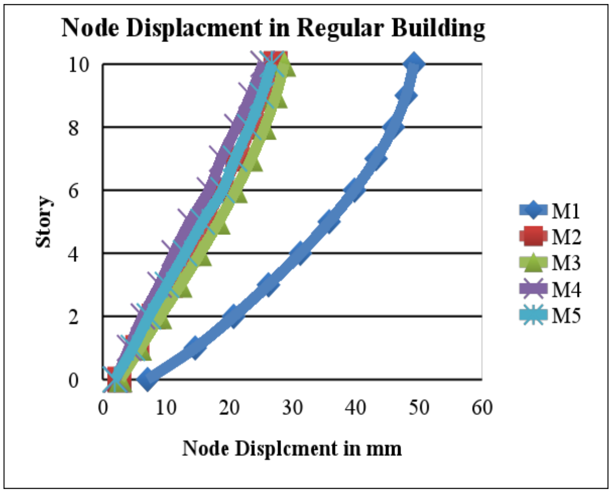

Fig 10: Node displacement in regular building models

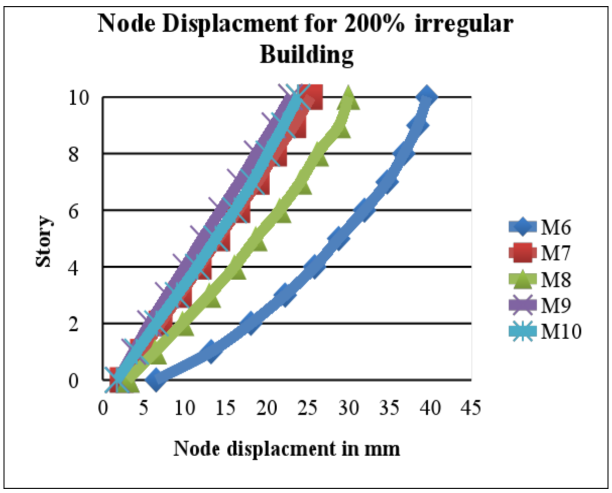

Fig 11: Node displacement in 200% irregular building models

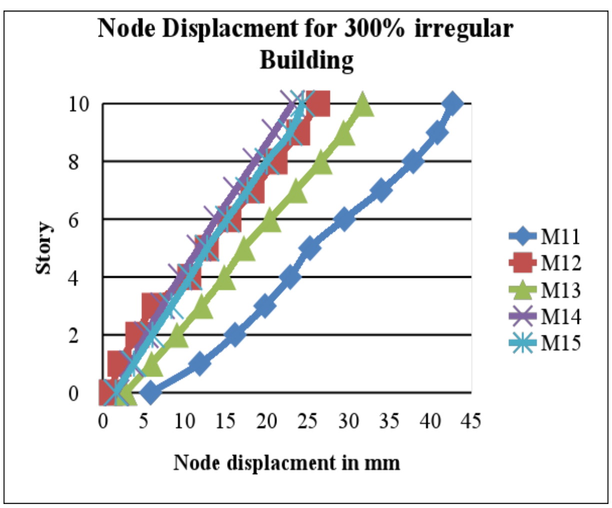

Fig 12: Node displacement in 300% irregular building models

C. Storey Drift

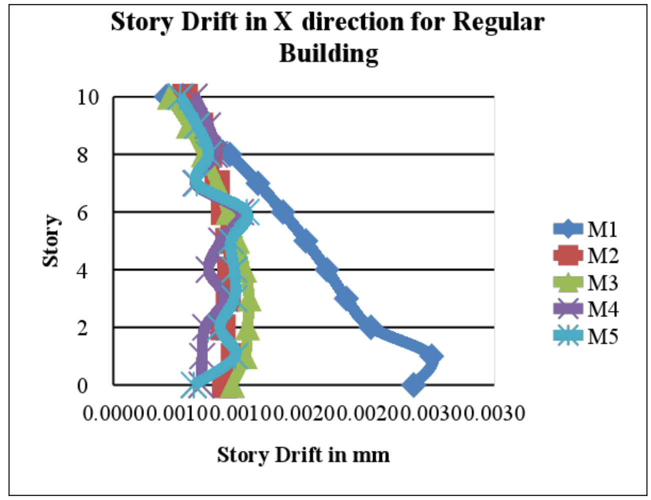

Fig 13: Storey Drift in regular building models

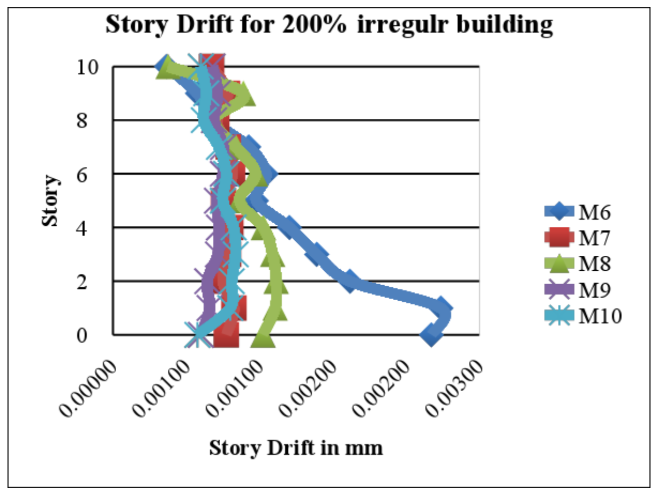

Fig 14: Storey Drift in 200% irregular building models

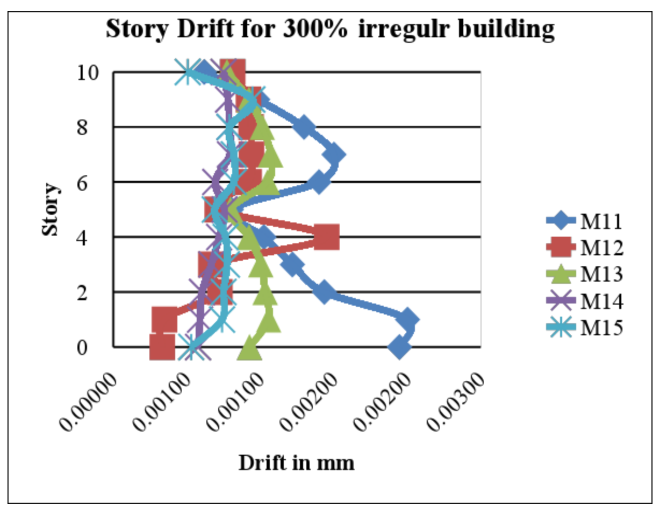

Fig 15: Storey Drift in 300% irregular building models

D. Center Shear stresses on Flat slab

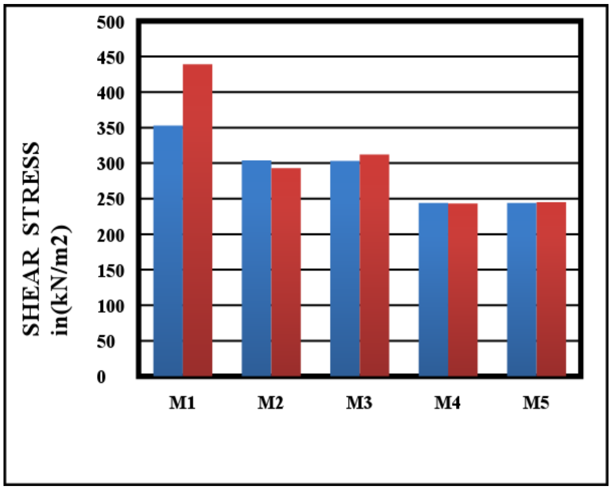

Fig 16: Center shear stresses for regular building models

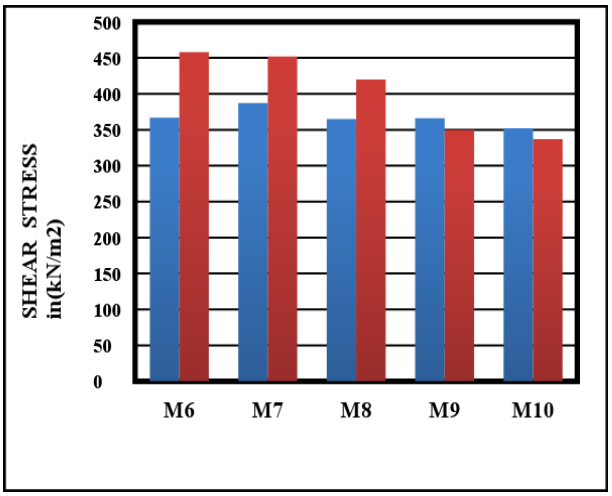

Fig 17: Center shear stresses for 200% irregular building models

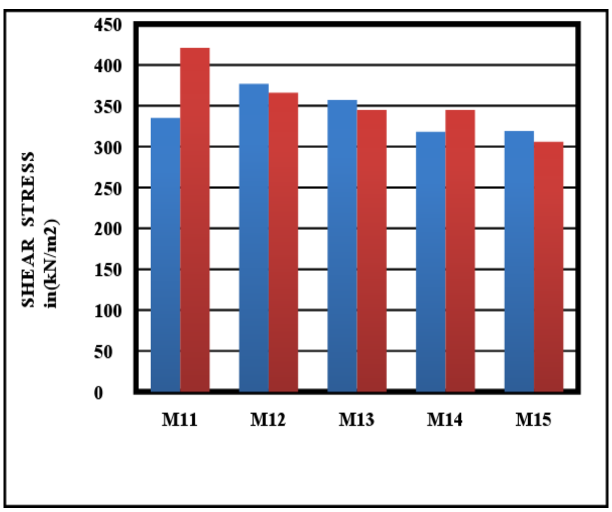

Fig 18: Center shear stresses for 300% irregular building models

E. Corner shear stresses on Flat slab

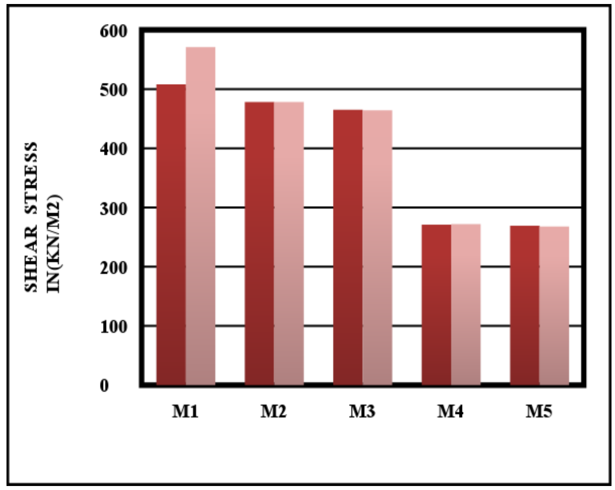

Fig 19: Corner shear stresses for regular building models

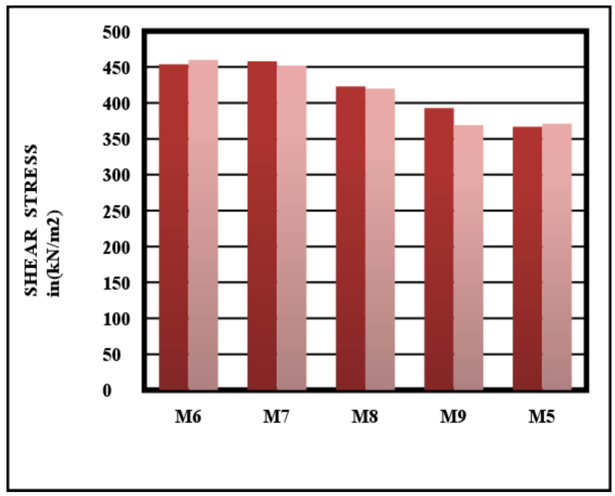

Fig 20: Corner shear stresses for 200% irregular building models

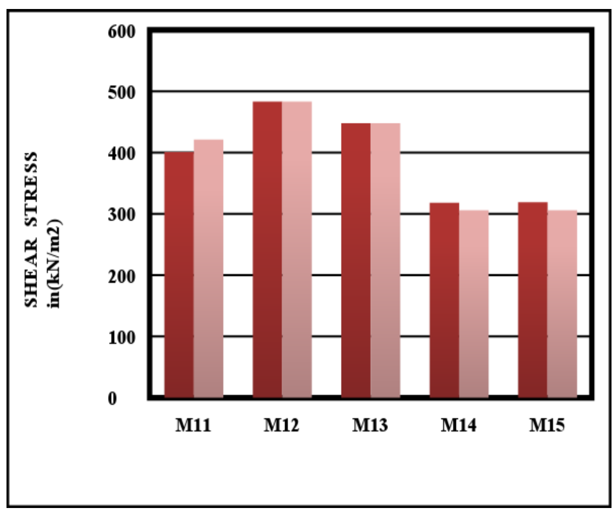

Fig 21: Corner shear stresses for 300% irregular building models

F. Von mis stresses on Flat slab

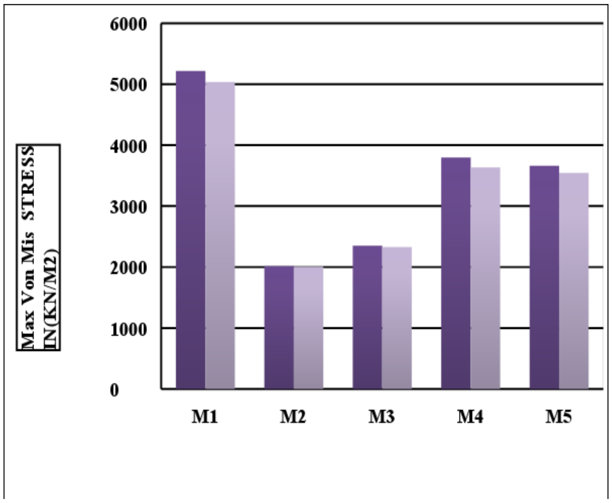

Fig 22: Von mis stresses for regular building models

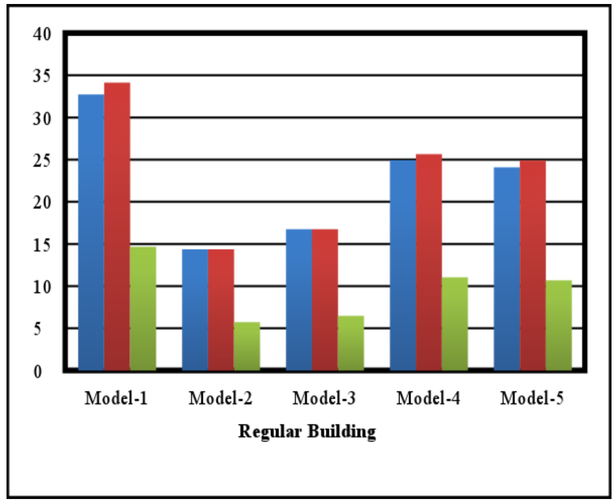

Fig 24: Bending moment for regular building models

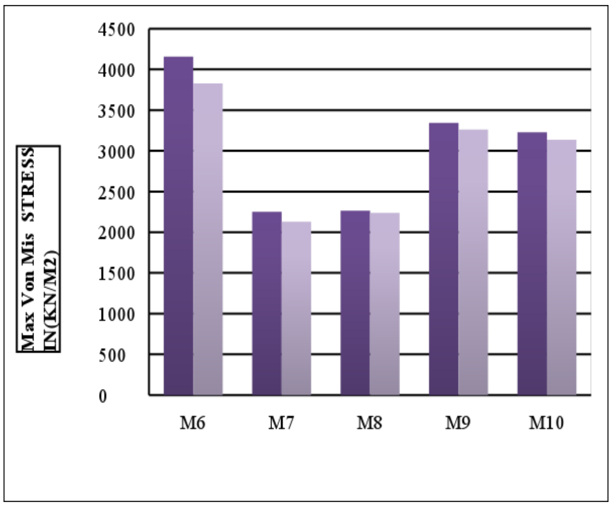

Fig 23: Von mis stresses for 200% irregular building models

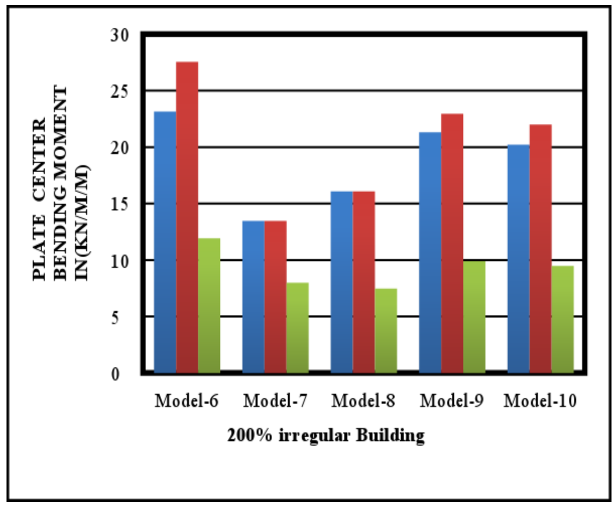

Fig 25: Bending moment for 200% irregular building models

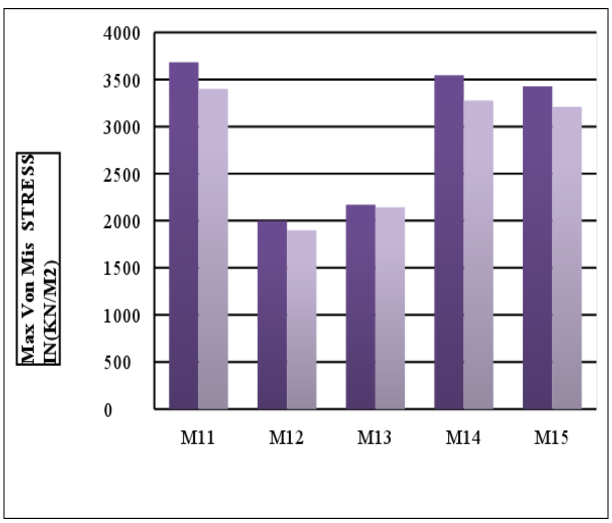

Fig 24: Von mis stresses for 300% irregular building models

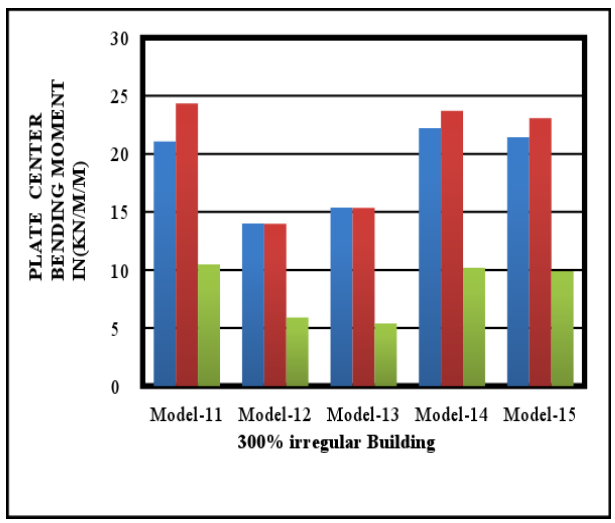

Fig 26: Bending moment for 300% irregular building models

G. Bending Moment on Flat slab

VII. CONCLUSIONS AND FUTURE SCOPE

A. Conclusions

1. Center shear stresses SQX and SQY in Flat slab more decrease when shear wall provided at central periphery in Regular, 200% irregular & 300% irregular multi storied building.
2. Corner shear stresses SQX and SQY in flat slab more decrease when shear wall provided at central periphery in Regular, 200% irregular & 300% irregular multi storied building.
3. The Von Mis top and bottom stresses in flat slab more decreases when shear wall provided at centre in Regular, 200% irregular & 300% irregular multi storied building
4. Bending moment MX,MY & MXY in flat slab more decrease when shear wall provided at centre in Regular , 200% irregular & 300% irregular multi storied building.
5. Total base shear increase when shear wall provides at the central periphery in 200% & 300% irregular multi-storey building.
6. Node displacement in X direction will be more restricted when shear wall provides at central periphery in all type of model i.e. regular & irregular building
7. The values of storey drift are found to be within permissible limit i.e. not more than 0.004 times the storey height as per norms according to IS 1893:2002 Part-1.
8. It's concluded that the Structure with shear wall along central periphery is suitable for the effect of Dynamic load on the performance of building.
9. It's concluded that from the result effects of opening of size 20% of the shear wall can be neglected on the stiffness of the system. There is neglected variation
10. When compare Flat slab system in Regular building with 200% irregular & 300% Irregular building without shear wall & with shear wall at different location i.e. (Centre or Core & Central periphery) with 20% opening and the result in terms of plate shear stresses, Bending Moment, node displacement, Base shear, story drift & Shear wall surface stresses the Building 300% irregularities with shear wall at central periphery i.e. model-9 show good results which brought out in tabular form.

B. Future Scope

The review has shown that in the previous decade, much progress has been made in developing and understanding practical structural Flat Slab with Shear Wall structures in multi-storeyed building frames. An appraisal of these recommendations indicates that further work is needed in the following areas:

1. Identical building of (5 bay x 5 bay) is taken in problem for simplicity, but commercial and residential building are irregular shape in plan can also be taken up for further work.
2. The problem building is only symmetric square building; one can take rectangle, L-shape, C-shape building with eccentricity.
3. Shape of shear wall is taken in this building is rectangular; one can take different shapes such as L,U,C for further work.
4. The structure can be analyzed for different seismic zones.
5. The Time history analysis of structure can also be carried out.

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