Dynamic Analysis of Mass-Irregular RC Buildings Subjected To Earthquake Loads

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Abstract- *This thesis investigates the impact of mass irregularity on the seismic performance of a reinforced concrete (RC) framed building. Mass irregularity occurs when the seismic weight of a storey exceeds 200% of that of an adjacent storey, as per IS 1893 (Part 1): 2002. A four-storey RC building model was analyzed using STAAD PRO software, with mass ratios increased from 1.0 to 4.0 in increments of 0.5 for each storey. Key parameters evaluated include frequency, time period, spectral acceleration, base shear, storey shear, storey drift, and mass participation factors. Results indicate that mass irregularity significantly affects dynamic properties, with maximum impacts observed when irregularity is at the top storey for frequency and drift, and at lower storeys for shear forces. The study highlights the need for careful consideration of mass distribution in seismic design to ensure structural integrity.*

Keywords: Mass irregularity, seismic analysis, RC framed building, storey drift, base shear

I. INTRODUCTION

Background

Regular buildings are defined as structures with uniform distributions of storey strength, stiffness, weight, and geometry over their height. However, real-life structures often deviate from this ideal due to various functional requirements, leading to irregularities. Mass irregularity arises when the seismic weight of one storey exceeds 200% of an adjacent storey, as per IS 1893 (Part 1): 2002. This can result from heavy machinery, libraries, or parking floors. Irregular buildings are more susceptible to damage during earthquakes, as evidenced by past events like the 1971 San Fernando Earthquake.

Motivation of Study

In seismically active zones, structural engineers must account for irregularities to ensure safety. This study aims to quantify the effects of mass irregularity on building behavior, providing insights for better design practices.

Specific Point of Study

The focus is on a real four-storey RC building modeled in STAAD PRO, with mass ratios varied from 1.0 to 4.0. Seismic analysis follows IS 1893 and IS 875.

Organization of Dissertation

The thesis is structured into six chapters: Introduction, Objectives, Literature Review, Programme of Study, Results and Discussion, and Conclusions, with appendices.

Objectives of Study

- To model a real building and study mass irregularity criteria. To review IS 1893 and IS 875 provisions.
- To analyze effects of mass changes on seismic performance.
- To compare effects across storeys and develop characteristic equations.

ii. literature review

Evidence of Damage to Irregular Structures

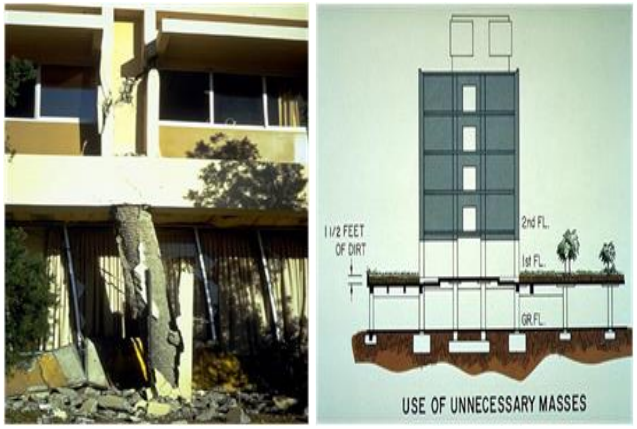

Figure 1 shows damage to Olive View Hospital during the 1971 San Fernando Earthquake due to mass irregularity.

Past Studies

- Valmundsson and Nau (1997): Studied mass ratios up to 5, finding minimal effects on ductility.
- Al-Ali and Krawinkler (1998): Mass irregularities have small effects on drifts. Michalis et al. (2006): Mass irregularity comparable to stiffness irregularity.
- Das and Nau (2003): Irregularities alter inelastic response but rarely exceed limits.
- Saleh Malekpour et al.: Static procedures overestimate forces for irregular structures. Mohammad Hossein et al.: Location and number of irregularities affect performance.
- Mohammad Ali Hadianfard and Mahdieh Gadami: Linear analyses underestimate demands.
- Vinod K. Sadashiva et al.: Position of irregularity more influential than magnitude. Poncet, L. et al.: Mass irregularity has limited effects on braced frames.

Codal Provisions

- IS 1893 (Part 1): 2002 – Mass irregularity at 200%.
- UBC: 150%.
- NEHRP: 150%.
- Iranian Code: 150%.
- IBC: 150%.

III. PROGRAMME OF STUDY

Introduction

A four-storey RC building is analyzed for mass irregularity effects.

Input Parameters

- Building dimensions: 15.45m height, 15.65m width, 33.0m length, 4 storeys. Materials: M25 concrete, Fe415 steel.
- Loads: Dead and live loads as per tables.
- Seismic data: Zone factor 0.24, importance factor 1.5, etc.

Earthquake Lateral Force Analysis

Equivalent static and response spectrum methods are used, per IS 1893.

Output Parameters

Details of Steps Performed

Mass ratios applied to each storey, analysis in

IV. RESULTS AND DISCUSSION

(Include all tables and figures from the context, with descriptions. For brevity, summarize key findings here. Add interpretations.)

Variation of Frequency vs. Mass Ratio

Table 1

VARIATION OF FREQUENCY VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	1.086	1.086	1.086	1.086	1.086
1.5	1.086	1.074	1.054	1.025	0.993
2	1.085	1.061	1.023	0.966	0.927
2.5	1.084	1.048	1.006	0.926	0.873
3	1.084	1.035	0.967	0.887	0.826
3.5	1.083	1.022	0.941	0.852	0.786
4	1.082	1.009	0.917	0.82	0.751

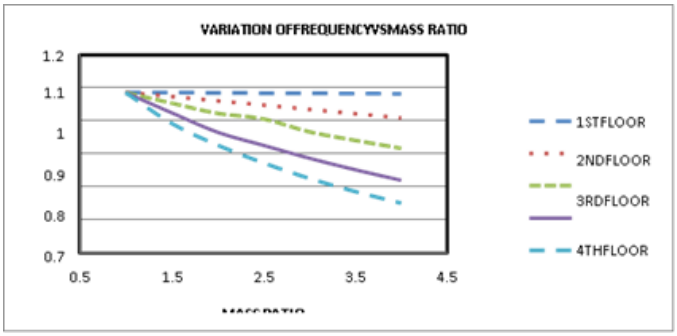

Figure 2 show frequency decreases with mass, most at top storey.

Variation of Time Period vs. Mass Ratio

Table 2

VARIATION OF TIME PERIOD VS MASS RATIO					
MASS RATIO	IST FLOOR	2ND FLOOR	3RD FLOOR	4TH FLOOR	ROOF
1	0.92063	0.92063	0.92063	0.92063	0.92063
1.5	0.92115	0.93128	0.94852	0.97594	1.00728
2	0.92172	0.94268	0.97735	1.03531	1.07832
2.5	0.9228	0.95461	0.99063	1.0795	1.14598
3	0.92287	0.96654	1.03452	1.12771	1.21026
3.5	0.92342	0.97881	1.06243	1.17416	1.27224
4	0.924	0.99133	1.08998	1.21904	1.33073

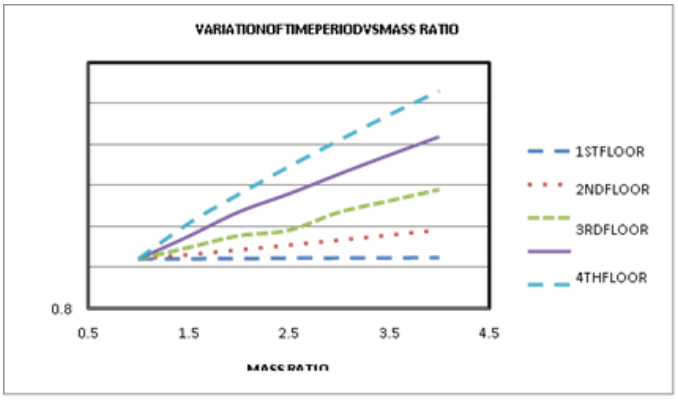

Figure 3: Time period increases, opposite to frequency.
(Continue for all sections, incorporating tables and figures.)

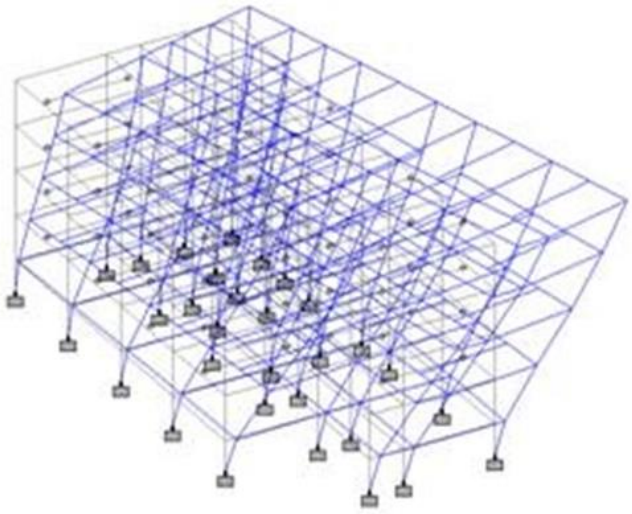

Figure 4

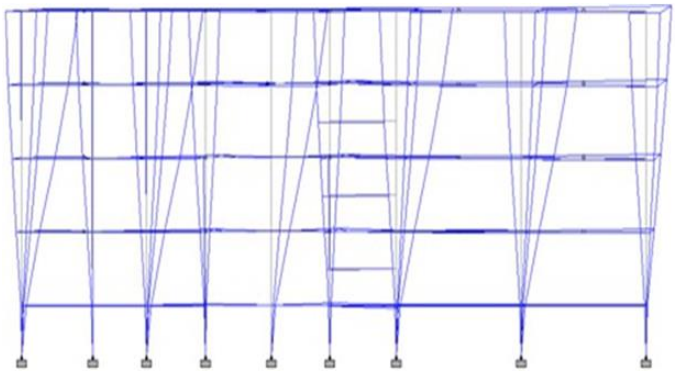

Figure 5: Mode shapes in X and Z directions.

V. CONCLUSIONS

- Mass irregularity significantly impacts seismic parameters. Design codes should consider location-specific effects.
- Further studies on different building types are recommended.

Scope of Further Study

Expand to different building configurations, soil types, and nonlinear analyses.

REFERENCES

[1] IS 1893 (Part 1): 2002.
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