**A Comparative Analysis of Seismic Performance for Multistory Buildings Using STAAD.Pro**

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**Abstract**:

This study conducted a comparative analysis of seismic performance across various building models using STAAD.Pro software. The primary objective was to evaluate and compare how different buildings respond to seismic loads. The analysis involved modifying external factors like the placement of shear walls and examining the relationships between horizontal and vertical forces, reactions, and moments. The findings offer valuable insights into each structure's behavior under seismic forces. Notably, Model-2 exhibited a significant maximum combined horizontal displacement (X) of 165 mm, indicating substantial movement in that direction. On the other hand, Model-5 showed a maximum combined horizontal displacement (Z) of 171 mm, suggesting greater horizontal movement in the Z direction. Regarding Combined Vertical Displacement (Y), Model-2 recorded the highest vertical displacement at 21.7 mm. These comparative results serve as crucial guidance for optimizing building configurations to enhance their seismic resilience. They can inform decision-making during the design and construction phases, contributing to safer and more robust constructions in earthquake-prone areas.

Keywords: STAAD, multistory, seismic, displacement and shear wall

1. **Introduction**

As part of this analysis, we need to calculate the maximum lateral displacement for each wing at concave angles. The sum of these displacements represents the required spacing between blades to allow for deflection without impact, using expansion joints for blade connections. When treating each wing as a separate model, the angle is often disregarded [6]. In considering the vertical and lateral loads on individual blades, the resultant force angle is typically overlooked, complicating angle adjustments without specialized connections and joints in the design [7].

Another design approach gaining traction for concave corners is using an eight-shaped configuration instead of the traditional 90° angle. This modification reduces the resulting force when altering the angle, and it's recommended to "securely interconnect the building along tension lines and resistance points to minimize torsion" [8]. Although this method more directly addresses re-entry issues than previous methods, it still falls short in fully accounting for the impact of the re-entry angle on load distribution.

These designs, including simpler ones, are permitted by current building codes as they contribute to improved structural integrity or aesthetics [9]. ASCE 7-10 defines a "rotational irregularity" as having two planar surfaces of a structure deviating by more than 15% of the total height of the structure in one direction, leading to diaphragm beam or buttress failures when the wall's main line is shifted relative to an outer wall [10]. Such irregularities require redistributing forces in the opposite direction through rotation.

The challenge with concave angles lies in accurately determining the transferred force magnitude. Several factors contribute to this challenge. Firstly, the difference in material strength due to sample width variation. Secondly, torsional forces applied to the structure induce significant distortions across various locations [11]. These concurrent issues add complexity to analyzing concave angles' force effects.

The disparity in material strength arises from different specimen widths. One part of the structure bends along its strong axis, while another bends along its weak axis, as depicted in Figure 1.

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| Figure 1:Rigidity of Separate Buildings |

In this scenario, the ground motion is in the east-west direction. The building shown on the left side of the diagram is oriented along the east-west axis (strong axis), so it will experience tighter response compared to structures oriented north-south (weak axis). The deviation in the pattern also influences the variation in motion between these orientations. The stiffness of the gap between the motion difference and the structure leads to stress in the "notches" at the concave corners [13].

1. **LITERATURE REVIEW**

A Comparative Study on Seismic Analysis of Vertically Irregular and Regular Frames Using Nonlinear Behavioral History Analysis (RHA) with Lohith B C 20 Ground Motions. In this study, seismic requirements for vertically irregular and "orderly" frames were compared using strict nonlinear behavioral history analysis (RHA) with a set of Lohith B C 20 ground motions. The analysis included 48 inconsistencies across 12-floor structures, featuring strong columns and weak beams, and varying types of inconsistencies (strength, stiffness) at eight different elevation locations.

Observations by Madan Singh et al. focused on storey drift and average storey displacement due to vertical irregularities, comparing results from modal pushover analysis (MPA) and nonlinear RHA. They found that while irregularities in stiffness or strength did not significantly affect MPA estimates, certain deviations were noted in the analysis.

Mehmed Causevic et al. discovered that MPA was less accurate in predicting seismic behavior for different frame types. They highlighted the importance of ground diaphragms supporting high-rise walls and discussed the distribution of shear forces and bending moments.

Rajiv Banerjee et al. explored the use of nonlinear shear models to assess wall reinforcement and shear forces, emphasizing the need for careful design solutions in high walls to prevent shear failure.

Ravi Kanth et al. identified that irregularities in stress and strength led to increased seismic demand. They emphasized the importance of considering vertical irregularities in building design and seismic analysis.

Overall, these studies contribute to understanding the seismic behavior of vertically irregular structures and highlight the importance of accurate modeling and design solutions in seismic-resistant construction.

1. **SYSTEM DEVELOPMENT**

**3.1 General**

This section encompasses the analysis method for a building featuring re-entrant corners, along with the incorporation of bracings and shear walls at various identified positions. The analysis involves creating different models using STAAD.Pro.

The models described in the section outline different configurations for a multistory building subjected to seismic analysis using STAAD.Pro software. Model-I represents the baseline scenario without any shear walls or bracings. In Model-II, bracings are introduced at a specific location to enhance structural stability. Model-III incorporates a shear wall at another designated location to resist lateral forces. Model-IV combines both shear wall and bracings at the same location for reinforced seismic performance. Similar variations continue with Models V through X, each introducing different combinations of bracings and shear walls at various locations to assess their impact on the building's seismic response and overall structural integrity.

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| Figure 1: Elevation of model-I |

The above figures is related to elevation of the model-I, the geometry once created using STAAD-PRO software, the elevation can be easily known.

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| Figure 2: Plan of model-I |
| The above figures is related to plan of the model-I, the geometry once created using STAAD-PRO software, the plan can be easily known. |
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| Figure 3: Properties assigned to model-I |

The above figure is related to Properties assigned to model-I, after the geometry is created then the properties can be assigned to the model.

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| Figure 4: Loads assigned to model-I |

The above figure is related to Loads assigned to model-I, after the geometry is created then the loads can be assigned to the model.

1. **PERFORMANCE ANALYSIS**

The results obtained in terms of the displacement, reactions, beam forces and plate stresses for all the models.

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| Figure 5: Combined Horizontal (X) Displacement for all the models |

The above graph is related to Combined Horizontal (X) Displacement for all the models, the horizontal displacement is maximum for the model-2 with the value of 165 mm.

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| Figure 6: Combined Horizontal (Z) Displacement for all the models |

The above graph is related to Combined Horizontal (Z) Displacement for all the models, the horizontal displacement is maximum for the model-5 with the value of 171 mm.

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| Figure 7: Combined Vertical (Y) Displacement for all the models |

The above graph is related to Combined Vertical (Y) Displacement for all the models, the Vertical (Y) displacement is maximum for the model-2 with the value of 21.7 mm.

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| Figure 8: Resultant Displacement for all the models |

The above graph is related to Resultant Displacement for all the models, the Resultant Displacement is maximum for the model-5 with the value of 174 mm.

Table 1: Combined Reactions for all the models

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|  | Horizontal | Vertical | Horizontal | Moment | | |
| Models | Fx kN | Fy kN | Fz kN | Mx kNm | My kNm | Mz kNm |
| Model-1 | 358.968 | 8097.33 | 358.846 | 721.276 | 2.14425 | 753.128 |
| Model-2 | 597.165 | 8095.25 | 359.678 | 722.435 | 7.62188 | 767.529 |
| Model-3 | 3428.06 | 18196.5 | 3335.04 | 475.954 | 9.7785 | 721.636 |
| Model-4 | 631.152 | 10565 | 1817.7 | 706.212 | 11.6336 | 726.264 |
| Model-5 | 359.9 | 8094.95 | 618.426 | 725.216 | 7.88175 | 754.423 |
| Model-6 | 1818.74 | 12390.9 | 1851.41 | 689.52 | 10.7708 | 739.923 |
| Model-7 | 1794.82 | 10748.5 | 650.289 | 687.947 | 10.8878 | 758.923 |
| Model-8 | 609.602 | 8093.56 | 631.054 | 705.124 | 6.95363 | 746.459 |
| Model-9 | 1979.83 | 12747.1 | 1966.42 | 604.55 | 8.7885 | 473.384 |
| Model-10 | 3197.1 | 17395.9 | 3067.12 | 448.416 | 10.7708 | 647.071 |

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| Figure 9: Combined Reactions (Horizontal-Fx) for all the models |

The above graph is related to Combined Reactions (Horizontal-Fx) for all the models, the Combined Reactions (Horizontal-Fx) is maximum for the model-3 with the value of 3400 kN.

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| Figure 10: Combined Reactions (Horizontal-Fz) for all the models |

The above graph is related to Combined Reactions (Horizontal-Fz) for all the models, the Combined Reactions (Horizontal-Fz) is maximum for the model-3 with the value of 3335 kN.

1. **CONCLUSIONS**

The following conclusions are drawn based on the present study.

1. In terms of combined horizontal displacement (X), Model-2 exhibits the maximum displacement with a value of 165 mm. This indicates that Model-2 experiences the highest lateral movement among all the models considered.
2. Similarly, for combined horizontal displacement (Z), Model-5 demonstrates the highest displacement of 171 mm. This suggests that Model-5 experiences significant horizontal movement in the Z-direction.
3. Moving on to combined vertical displacement (Y), Model-2 exhibits the highest displacement with a value of 21.7 mm. This indicates that Model-2 experiences the most significant vertical movement compared to the other models.
4. When considering the resultant displacement, which accounts for the combined effects in all directions, Model-5 exhibits the highest displacement of 174 mm. This implies that Model-5 experiences the most overall displacement among the analyzed models.
5. Shifting focus to the combined reactions, Model-3 displays the maximum combined horizontal reaction (Fx) with a value of 3400 kN. This suggests that Model-3 experiences the highest resistance to horizontal forces.

**REFERENCES**

1. Agarwal, P. and Shrikhande, M., Earthquake Resistant Design of Structures, Prentice hall of India Pvt. Ltd.,2006.
2. Ahmad J. Durrani, S.T. Mau, Amr Ahmed AbouHashish and Yi Li “EarthQuake Response of Flat-Slab Buildings” Vol.120 No. 3, March, 1994. ©ASCE,ISSN 0733-9445/94/0003-0947
3. Akshay Nagpure1, S. S. Sanghai (2018) “Effect of Diaphragm Flexibility on the Seismic Response of RCC Framed Building Considering Diaphragm Discontinuity”, International Journal of Innovations in Engineering and Science, Vol. 3, No.5, 2018 www.ijies.net
4. Amin Alavi, P. Srinivasa Rao, Effect of Plan Irregular RC Buildings in High Sesimic Zones, Australian Journal of Basic and Applied Sciences, 7(13) November 2013, Pages: 1-6
5. Anil K. Chopra and Chatpan Chintanapakdee “Seismic Response of Vertically Irregular Frames: Response History and Modal Pushover Analysis” Vol. 130, No. 8, August 1, 2004. ©ASCE,ISSN 0733-9445/2004/8-1177–1185
6. Applied Technology Council (ATC 40) document, Seismic Evaluation and Retrofit of Concrete Buildings, Vol. 1, Report no. SSC 96-01, California, 1996.
7. ASCE, FEMA 356, Pre standard and commentary for seismic rehabilitation of buildings, Reston, Virginia, USA, 2000.
8. Babak Rajaee Rad and Perry Adebar “Seismic Design of High-Rise Concrete Walls: Reverse Shear due to Diaphragms below Flexural Hinge”(2009) Vol. 135, No. 8, August 1, 2009. ©ASCE, ISSN 0733-9445/2009/8-916–924
9. Babita Elizabath baby and shreeja s (2015) “analysis of building with slab discontinuity” international journal of science and research. ISSN: 2319-7064, volume 5 issue 9, September 2016.
10. Chopra A.K., Dynamics Of Structures, 3rd edition, Prentice Hall Of India., 2007.
11. Computers and Structures, INC. CSI Analysis Reference Manual for ASP 2000, ETABS and SAFE, Berekeley, California.,2009.
12. Devesh P. Soni and Bharat B. Mistry “Qualitative Review Of Seismic Response Of Vertically Irregular Building Frames”, Vol. 43, No. 4, December 2006, pp. 121-132
13. Dhiman Basu and Sudhir K. Jain “Seismic Analysis of Asymmetric Buildings with Flexible Floor Diaphragms”, Vol. 130, No. 8, August 1, 2004. ©ASCE, ISSN 0733-9445/2004/8-1169–1176
14. Divyashree . M, Gopi siddappa, Seismic Behaviour Of RC Buildings With Re-Entrant Corners And Strengthening, IOSR Journal Of Mechanical And Civil Engineering., pg – 63 to 69.
15. Dubey, S.K and Sangamnerkar., Seismic Behaviour of Asymmetric Rc Buildings., International journal of advanced engineering technology, 2(4): 296-301., 2011.
16. Eduardo Miranda and Carlos J. Reyes “Approximate Lateral Drift Demands in Multistory Buildings with Non uniform Stiffness” Vol. 128, No. 7, July 1, 2002. ©ASCE, ISSN 0733-9445/2002/7-840–849
17. ETABS Nonlinear v9.6, Extended Three-dimensional Analysis of Building Systems, Computers and Structures Inc., Berkeley, California, USA, 1995.
18. IS- 1893- Part I: 2002, Criteria for Earthquake Resistant Design of Structures,Bureau of Indian Standards, New Delhi.
19. IS: 456-2000, “Code of Practice for Plain and Reinforced Concrete”, Bureau of Indian Standards, New Delhi, India.
20. IS:1893-2002(Part 1) Criteria for Earthquake Resistant Design of Structures, part 1-General provisions and buildings, fifth revision, Bureau of Indian Standards, New Delhi, India
21. Kazi Muhammed mustaqeem and md mansoor ahmad (2016) “impact of intermittent diaphragm and re-entrant corners on seismic response of multistoried RC framed buildings” international journal of engineering research and technology. ISSN: 2278-0181, vol. 5 issue 07, July-2016
22. Komal R. Bele1, S. B. Borghate (2015) “Dynamic Analysis of Building with Plan Irregularity”, Journal of Civil Engineering and Environmental Technology, ISSN: 2349-8404, Volume 2, April – June, 2015