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A Comparative Study on Seismic Performance of Irregular RCC Frames with Shear Wall and Bracings

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Abstract: In the present study, seismic performance of Irregular RCC frames is investigated using ETABS software. Regular frame, type s1 vertical geometrical irregular frame, type s1 with shear wall and type s1 with bracings are considered and are modelled as per IS 1893–Part 1 (2002). Seismic parameters viz. storey displacement, storey shear, auto lateral loads for the developed RCC models are obtained by response spectrum analysis as per IS 1893–Part 1 (2002) in seismic zone V.
Keywords: Vertical geometrical irregular building, Shear wall, Bracings, ETABS software, Response spectrum analysis, Seismic zone V.

I. INTRODUCTION

Earthquake is one of the most devastating of all the natural hazards and is considered to be the most powerful disaster which is unavoidable. IS 1893–Part 1 (2002) stipulates the criteria for earthquake resistant design of structures With the Increase in the modern architecture, different complex design of buildings has been introduced in the construction field. These architectural works sometimes create problem for the structural engineer regarding the structure’s stability and safety. In most of the cases it is the vertical irregularity of the building. Vertical irregularity in building refers to variations or deviations from a regular pattern in the vertical alignment or distribution of a building's structural components, such as columns, beams, walls, or floors. This paper demonstrates how a regular and vertical geometric irregular structure performs and behaves when subjected to seismic activity.

II. BUILDING DESCRIPTION

Table 1 Shows the parameters of the developed regular frame and Irregular RCC Models.

Table 1 : Parameters of the developed bare frame and OGS RCC models

Sl. No.	Parameter	Remarks
1	Structure type	G+9
2	Total No. of stories	10
3	Total height of building from base to terrace	30 m
4	Size of column	600 x 600 mm
5	Size of beam	600 x 450 mm
6	Thickness of slab	200 mm
7	RCC wall thickness	230 mm
8	Typical storey height	3 m
9	Base storey height	3 m

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Sl. No.	Parameter	Remarks
10	Grade of concrete for structural components	M 45
12	Grade of steel (rebar)	Fe 550
13	Density of concrete	25 kN/m^3
14	Live load	2 kN/m^2
16	Floor finish	1.5 kN/m^2
18	Soil type	Medium
19	Seismic zone	V
20	Importance factor (EQ)	1.5
21	Response factor value	5

Table 2 shows the identity for the developed RCC frame models.

Table 2: Identity for the developed RCC frame models

Sl. No.	Model ID	Description
1	M 1	Regular frame
2	M 2	Type s1 vertical geometrical irregular model is modelled as per IS 1893–Part 1 (2002) codal provisions
3	M 3	Type s1 vertical geometrical irregular model with shear wall is modelled as per IS 1893–Part 1 (2002) codal provisions
4	M 4	Type s1 vertical geometrical irregular model with bracings is modelled as per IS 1893–Part 1 (2002) codal provisions

Figure 1 to 4 shows plan and elevation of the developed RCC models.

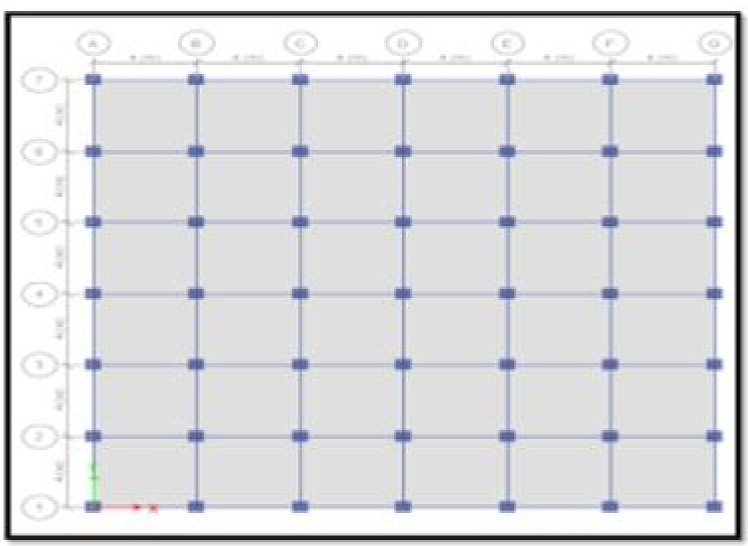

Fig. 1 Plan of RCC model

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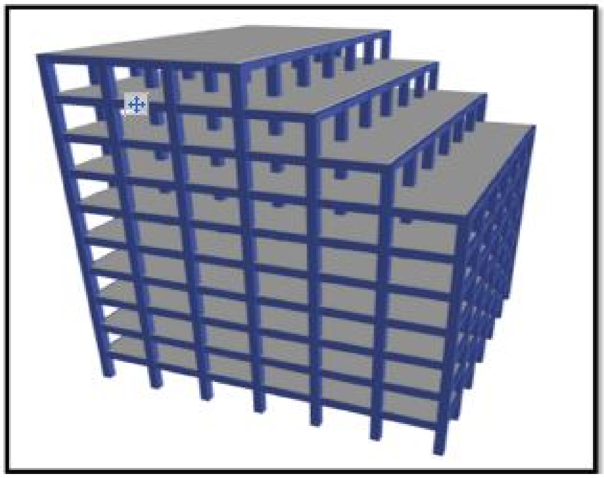

Fig. 2 3D Rendered view of Type S1 Structure

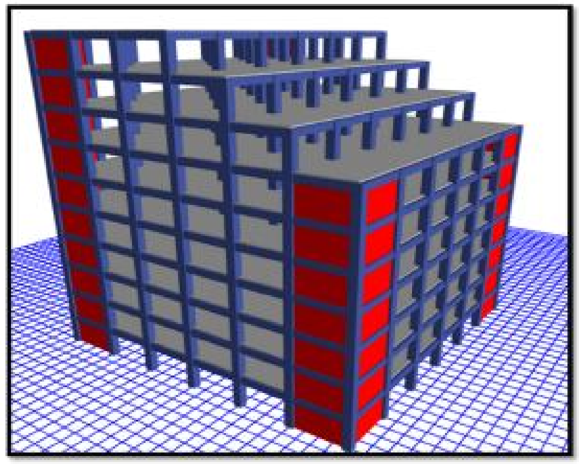

Fig. 3 3D Rendered View of Type S1 with Shear Wall

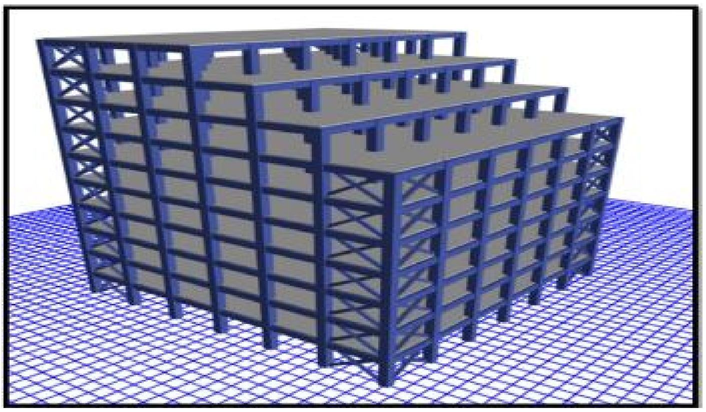

Fig. 4 3D Rendered View of Type S1 with X-Bracings

III. SEISMIC ANALYSIS OF RCC MODELS

Using ETABS 2017 software, the developed regular frame and irregular RCC models are subjected to response spectrum analysis as per IS 1893–Part 1 (2002). Seismic parameters viz. storey displacement, storey shear, and auto lateral loads are obtained from the analysis for all the developed models in seismic zone V

IV. RESULTS AND DISCUSSION

Figures 5 to 12 show the results and comparison of base shear, response reduction factor, displacement, storey shear, auto lateral loads over the number of stories in both X and Y directions obtained for all the RCC models by response spectrum analysis.

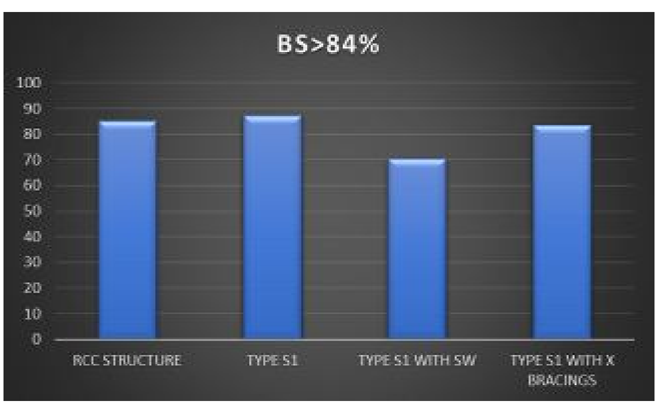

Fig. 5 Comparison Graph of Base Shear

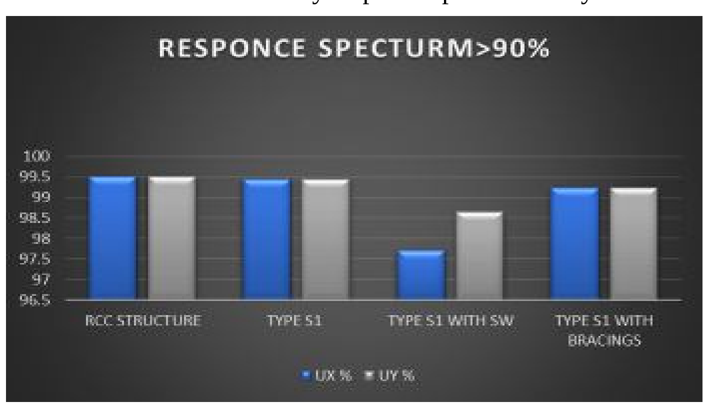

Fig. 6 Comparison Graph of Response Reduction Factor

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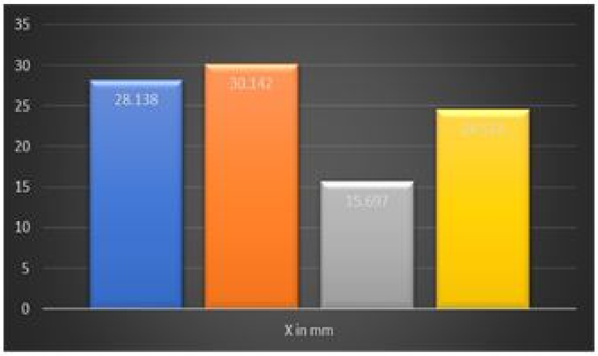

Fig. 7 Comparison Graph of Displacement in X-Direction

Fig. 8 Comparison Graph of Displacement in Y-Direction

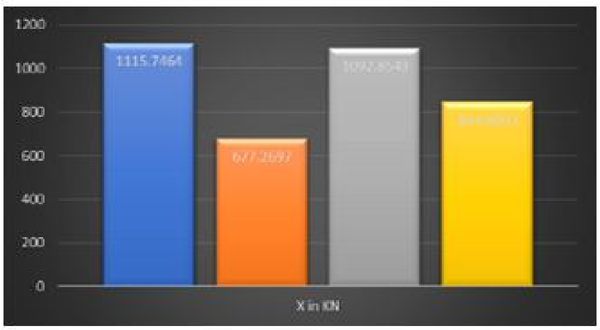

Fig. 9 Comparison Graph of Storey Shear in X-Direction

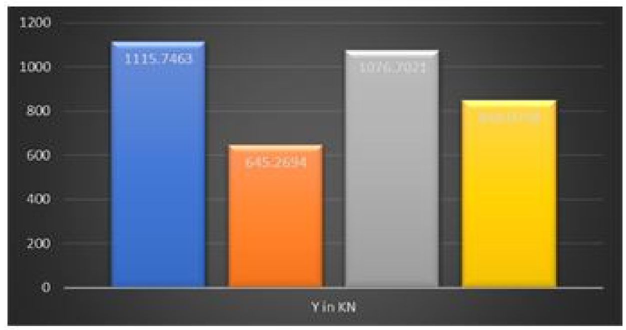

Fig. 10 Comparison Graph of Storey Shear in Y-Direction

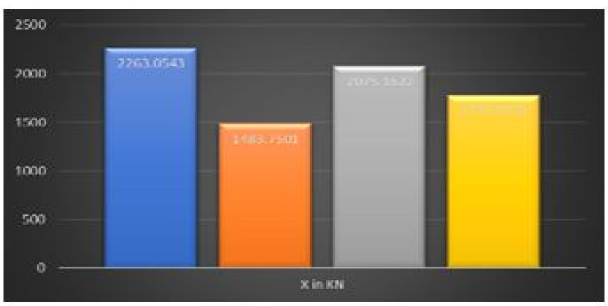

Fig. 11 Comparison Graph of Auto Lateral Loads in X-Direction

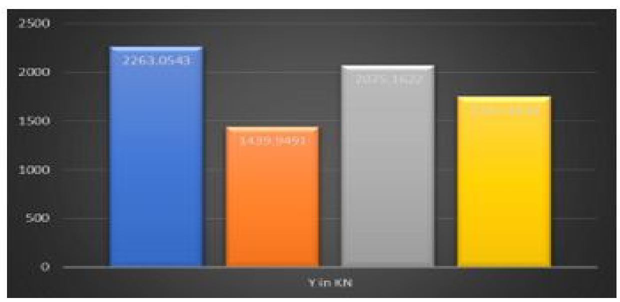

Fig. 12 Comparison Graph of Auto Lateral Loads in Y-Direction

From Fig. 5 for the seismic zone V, it is observed that TYPE S1 model shows promising performance in terms of base reactions, while additional analysis and review may be needed for the TYPE S1 model with Shear Walls (SW) to understand the differences in behaviour compared to the other models.

From Fig. 6 for the seismic zone V, it is observed that all models (except shear wall model) achieved an outstanding 99% response reduction factor. This suggests that these models are designed with robust lateral load-resisting systems and effective energy dissipation mechanisms, making them highly resilient against seismic forces.

From Figs. 7 and 8 for the seismic zone V, it is observed that the TYPE S1 model with Shear Walls (SW) is the best performing model, and the model with bracings is the second best. These findings indicate that the inclusion of shear walls and bracings significantly enhances the structure's seismic performance by reducing lateral displacements.

From Figs. 9 and 10 for the seismic zone V, it is observed that the TYPE S1 model is the best performer, and the model with bracings is the second best. These findings suggest that both the TYPE S1 model and the model with bracings effectively resist lateral forces in the X-direction. From Figs. 11 and 12 for the seismic zone V, it is observed that TYPE S1 model performs the best in terms of auto lateral loads in the Y-direction, and the model with bracings ranks as the second-best performer. Here's a summary of the auto lateral results in the Y-direction for each model, ranked from best to second best.

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V. CONCLUSIONS

Based on the analysis and comparison of the results in terms of displacement, storey shear, and auto lateral load, the following conclusions can be drawn:

1) Performance of type s1 model: the type s1 model without any additional lateral load-resisting systems has demonstrated excellent seismic performance in all aspects, including displacement, storey shear, auto lateral loads, and response reduction factor.
2) Shear walls and bracings: The inclusion of shear walls and bracings in the structural models showed improvements in certain aspects of seismic performance. The models with shear walls and bracings had lower displacements and storey shears compared to the basic type s1 model.
3) Best performing model: Considering all results, the type s1 model without shear walls, bracings, or any additional lateral load-resisting systems stands out as the best performer. It demonstrated superior seismic resistance compared to other models, including those with shear walls and bracings.
4) Importance of proper design: The results highlight the critical role of a well-designed and balanced structural system in achieving optimal seismic performance. Careful consideration of lateral load-resisting systems, their configuration, and detailing is crucial to ensuring structural safety and resilience during seismic events.
5) Project-specific considerations: It's important to remember that every project is unique, and the selection of lateral load-resisting systems should be tailored to the specific building design, site conditions, and local seismic requirements.
6) Professional expertise: Engaging experienced structural engineers and seismic experts is vital to conduct a thorough analysis, interpret results accurately, and make informed decisions during the design process.
7) Continuous monitoring and maintenance: Even with a well-designed structure, ongoing monitoring and maintenance are essential to ensure long-term resilience against seismic hazards.

In conclusion, based on the analysis results, the type s1 model without additional lateral load-resisting systems emerges as the optimal choice for the given project, demonstrating superior seismic performance across all evaluated criteria.

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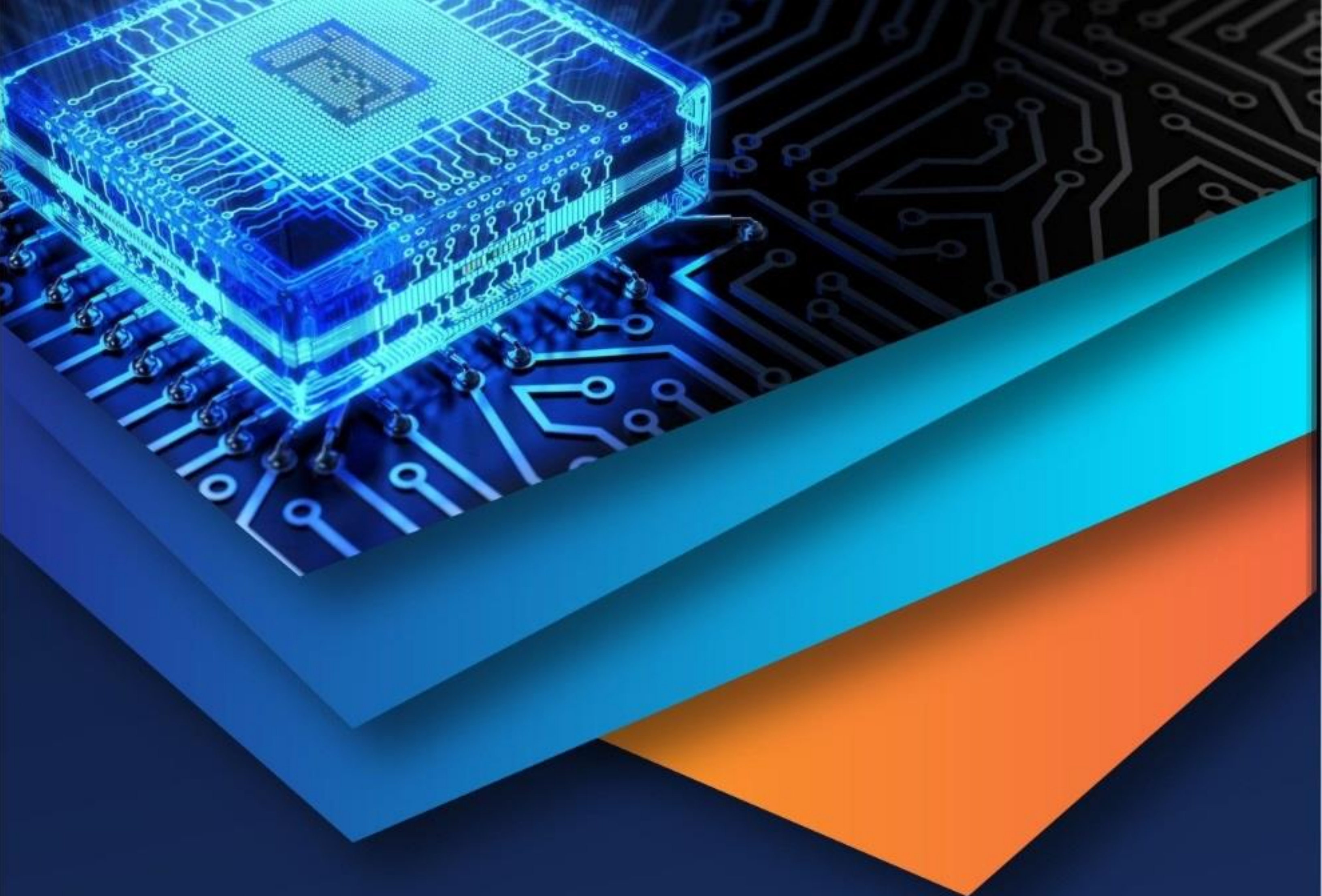

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