RETROFITTING OF HYBRID STRUCTURE USING BRACING

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Abstract:
This project examines the retrofitting of an existing building with a total of 10 storeys—7 storeys of RCC and 3 storeys of steel—by adding 2 more storeys of steel to the existing structure. To assess the impact of different bracing systems on the structural performance of the retrofitted building, ETABS version 21 is used for modeling and analysis. The study evaluates several bracing configurations, including X-bracing, V-bracing, a combination of Single Diagonal and X-bracing, and Inverted V-bracing. The structural behavior is analyzed using both Equivalent Static Analysis and Response Spectrum Analysis methods. The findings indicate that the Inverted V-bracing configuration yields the most favorable results, significantly enhancing the building's stability and preventing any member failures under the specified loads. This project provides valuable insights into the effectiveness of various bracing techniques for retrofitting hybrid structures, contributing to the development of safer building.

Keywords: Retrofitting, ETABS 21, Bracing.

I. INTRODUCTION:

Hybrid structures, which combine different materials and construction techniques to achieve optimal performance, are increasingly prevalent in modern engineering. These structures leverage the strengths of materials like steel, concrete, and timber, often integrating them in innovative ways to address specific design challenges. However, as with all construction, the lifespan of hybrid structures can be affected by factors such as environmental conditions, changing use patterns, in design standards and materials technology.

Retrofitting refers to the process of upgrading or modifying existing structures to improve their performance, safety, or functionality. In the context of hybrid structures, retrofitting aims to enhance their resilience and extend their service life. This may involve strengthening components, improving load-carrying capacity, updating materials, or incorporating new technologies.

II. BRACING:

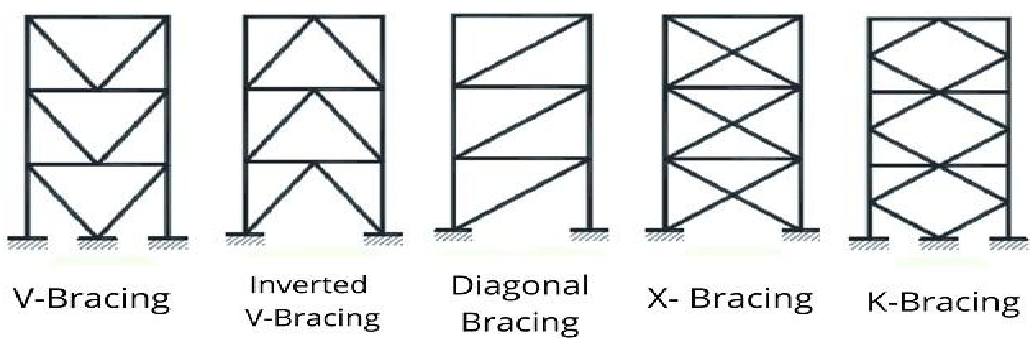
Bracings are essential components in structural engineering, particularly for enhancing stability and load resistance in various types of buildings and structures.

Single diagonals: By inserting diagonal structural elements into a frame's rectangular sections, single diagonals enable the creation of a truss or triangulation that aids in frame stabilization. A single diagonal brace needs to be robust enough to support compression and tension forces equally when used.

Cross-bracing, or X-bracing, consists of two diagonal members that intersect each other. These braces are designed to handle tension only, with one brace at a time counteracting lateral forces depending on the load's direction.

K-braces are attached to the columns at mid-height, allowing more flexibility for placing openings in the facade and minimizing bending in the floor beams. However, K-bracing is typically avoided in seismic areas due to the risk of column failure if the compression brace buckles during an earthquake.

V-braces improve lateral stability against the forces such as wind and seismic force, enhance load distribution, and provide a cost-effective solution with minimal disturbance to ongoing load transfer. They are particularly beneficial for seismic upgrades in earthquake-prone areas, wind load enhancement for high-rises, reinforcement of existing frames and columns, and adapting buildings for new uses.



III. OBJECTIVES OF THE STUDY

- To incrementally add storeys to a structure that already exists.
- To determine whether the building can support the additional weight.
- To retrofit the composite structure using bracing.
- Based on the characteristics of storey drift, base shear, displacement and stiffness, evaluate structural performance of hybrid models.

IV. METHODOLOGY

MODEL 1: It is an hybrid structure which includes 7 storey of RCC and 3 storey of steel.

MODEL 2: An addition of 2 stories of steel is added to the model 1.

MODEL 3: Retrofitting of model 2 with X bracing for failed members.
MODEL 4: Retrofitting of model 3 with V bracing.
MODEL 5: Retrofitting of model 4 with Single Diagonal and X bracing
MODEL 6: Retrofitting with Inverted V bracing for failed members.

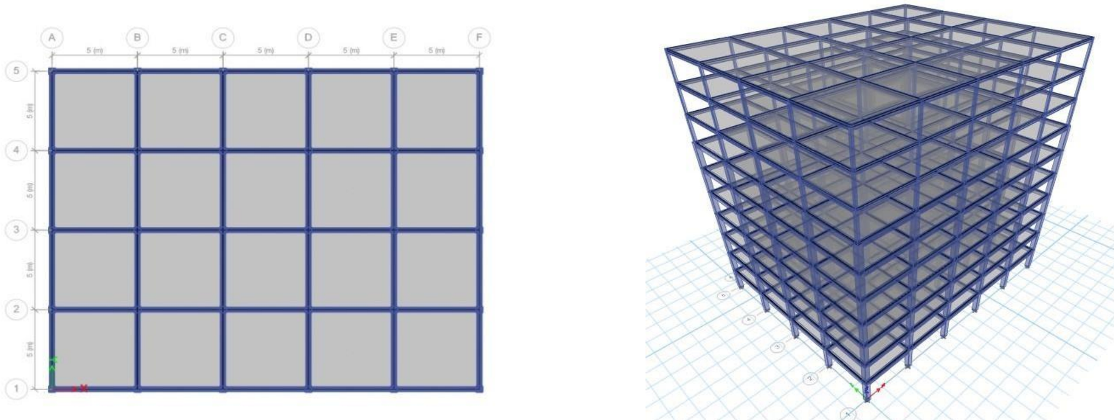
BUILDING PARAMETERS

Table 1: Building details

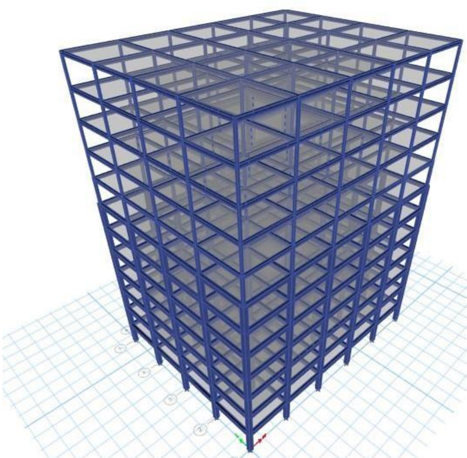
Number of floors	10
Story height	3m
Support condition	Fixed at base
Slab thickness	150mm
Deck slab thickness	150mm
RCC COLUMN	400mm X 400MM
STEEL COLUMN	
Story 8	200mm X 200mm
Story9 & 10	150mm X 150mm
BEAM SIZE	
RCC Beam	300mm X 400mm
Steel Beam	ISWB300
Materials Characteristics	
Fck	M30
Steel-Grade	Fe 500 & Fe 250
Loads	
Live load	3 kN/m^2
Floor finishes	1 kN/m^2
Wall load	11.96 kN/m^2 &10.8 kN/m^2

Table 2: Earthquake parameters (IS 1893 part 1: 2016)

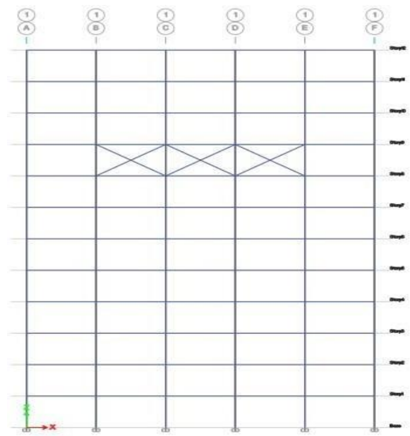
Zone factor, Z	Zone 3 (0.16)
Soil type	II (Medium)
Importance factor, I	1.2
Response reduction factor, R	5
Damping ratio	5%
Eccentric ratio	0.05



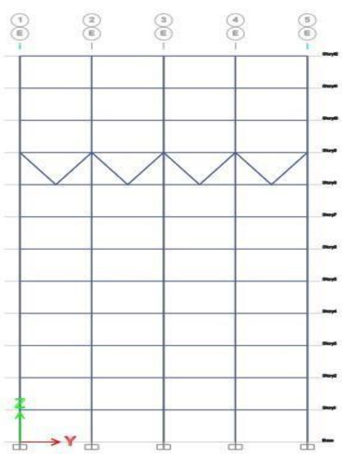
MODEL 1 [Plan & 3D view]



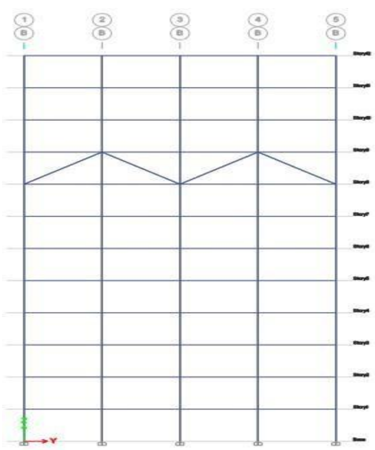
MODEL 2 3D view



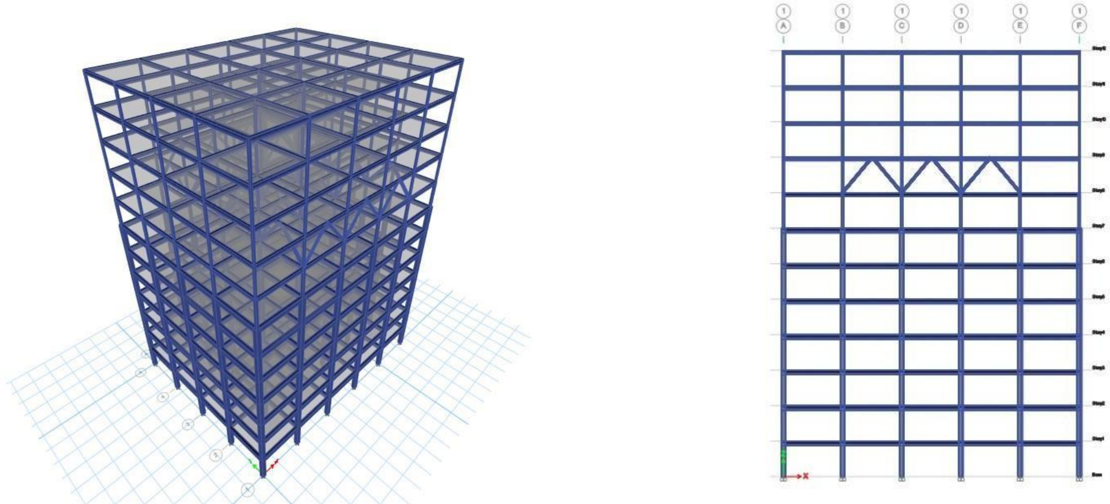
MODEL 3 Elevation view



MODEL 4 Elevation view



MODEL 5



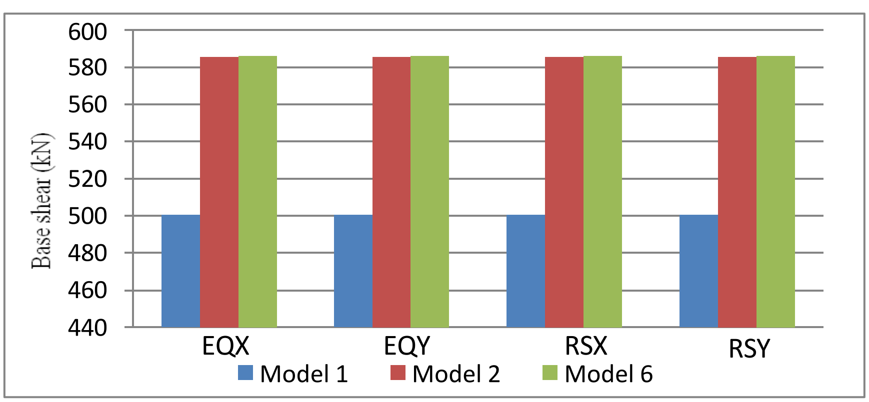
MODEL 6 [Plan & 3D view]

V. ANALYSIS AND RESULTS

These is an existing building (Model 1) was analyzed using both the static and dynamic methods. Model 2 is analysed by adding two more stories to Model 1, and the structure undergoes a similar statically and dynamically analysis. Model 2 was then retrofited by adding bracing to create Model 3, 4, 5 and 6 which was also analysed both the static and dynamic analysis.

Table 3: Max- Base Shear

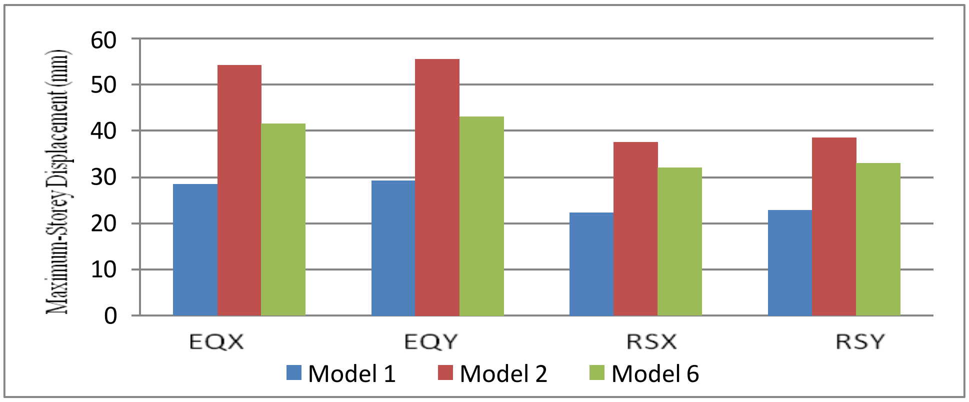
Type of building	Equivalentstatic analysis		Response-spectrum analysis	
	EQX	EQY	RSX	RSY
Model 1	500.3044	500.3044	500.3077	500.3044
Model 2	585.4979	585.4979	585.4636	585.4824
Model 6	586.05	586.05	586.0792	586.0843



Comparison of Base Shear

Table 4: Max- Storey Displacement

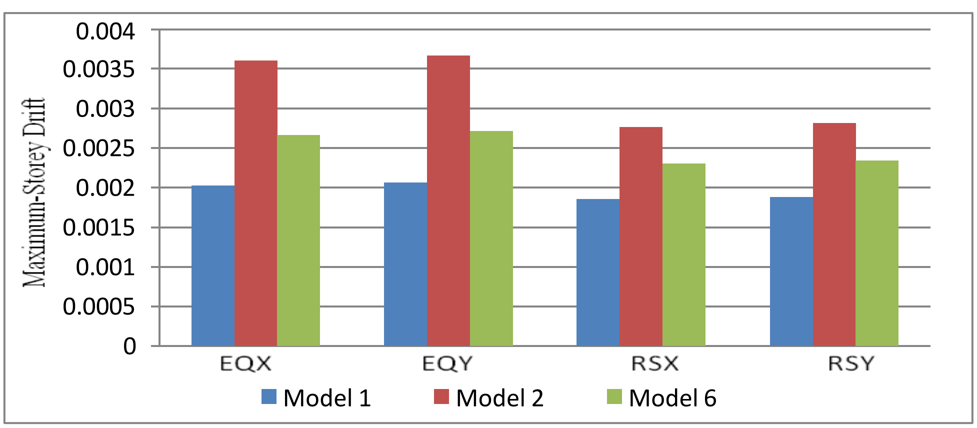
Type of building	Equivalentstatic analysis		Response-spectrum analysis	
	EQX	EQY	RSX	RSY
Model 1	28.387	29.198	22.259	22.87
Model 2	54.207	55.643	37.495	38.52
Model 6	41.62	43.038	32.01	33.017



Comparison of Storey Displacement

Table 5: Maximum-Storey Drift

Type of building	Equivalentstatic analysis		Response-spectrum analysis	
	EQX	EQY	RSX	RSY
Model 1	0.002028	0.002064	0.001854	0.001882
Model 2	0.003603	0.003668	0.002764	0.002817
Model 6	0.002664	0.002713	0.002296	0.002338



Comparison of Storey Drift

VI. RESULTS DISCUSSION AND CONCLUSIONS

- **Model 2 (G+11 building before retrofitting)** Showed increased displacement compared to Model 1(G+9 hybrid building) due to the added storeys, which likely led to reduced stiffness and increased flexibility.
- **Model 6 (G+11 building after retrofitting)** Demonstrated reduced displacement compared to Model 2. The introduction of inverted V-bracing improved the overall stiffness and reduced the lateral movements of the structure.
- **Model 2** Increased base shear compared to Model 1 due to the higher load demands with the additional storeys.
- **Model 6** Exhibited a reduction in base shear relative to Model 2. The bracing system helps in distributing the loads more effectively, thus reducing the shear forces experienced by the base.
- **Model 2** Higher storey drift was observed in Model 2, reflecting the increased flexibility and reduced lateral resistance of the extended structure.
- **Model 6** Storey drift was significantly lower compared to Model 2. The inverted V-bracing contributes to greater lateral rigidity and thus reduces inter-storey drifts.
- **Model 2** Reduced storey stiffness due to the added height and the inherent flexibility of the extended steel structure.
- **Model 6** Increased storey stiffness compared to Model 2. The bracing system enhances the overall rigidity of the structure, leading to improved resistance against lateral loads.
- **Model 3, 4, 5 -** X Bracing, V bracing, Single diagonal & X Bracing combination, Inverted V Bracing are used to retrofit the structure. Inverted V Bracing shows the best method to retrofit the structure.
- For the retrofitting ISMB200 & ISMB25 steel section was used for the bracing members.
- While using the inverted V Bracing the structure was safe without any member failures and the retrofitted stories showed the higher stiffness vales.
- We conclude by say that we adopted different method of bracing system and there combination to retrofit the hybrid structure, but inverted V Bracing suited the structure.

VII. REFERENCE

1. G Navya and Pankaj Agarwal. “Seismic Retrofitting of Structures by Steel Bracings”. (2015)

2. Georgios S. Papavasileiou, Dimos C. Charmpis and Nikos D. Lagaros. “Optimized seismic retrofit of steel-concrete composite buildings”. (2020)

3. Mansi Trivedi, Aayushi Doshi, Kshema Sara Koshy and S. C. Mohan. “Comparative Study on Seismic Performance of Existing Building with and without Retrofitting Using Lateral Load Resisting Systems”. (2022)

4. Magdy ISMAIL. “Seismic retrofit of steel frame structures”. (2020)

5. Safvana P and Anila S. “seismic analysis of braced steel and composite structures using etabs software”. (2018)

6. Anuj Chandra and Ganesh Jaiswal. “Retrofitting of the Structure using Composite Material FRP”. (2021)

7. Syeda Sakina Mustafa, Ummer Farooq Pasha and Dr. N S Kumar. “comparitive study on different types of retrofitting techniques using etabs”. (2021)

8. Amritha Ranganadhan and Anju Paul. “Seismic retrofitting of an existing structure”. (2015)

9. Bo Wang, Huijuan Dai, Tao Wu, Guoliang Bai and Yongtao Bai. “Experimental Investigation on Seismic Behavior of Steel Truss-RC Column Hybrid Structure with Steel Diagonal Braces”. (2018)

10. Vinay V. Gupta, G.R. Reddy, Sandeep S. Pendhari. “Performance-Based Design of RC Structures Subjected to Seismic Load Using a Hybrid Retrofitting Method with Friction Damper and Steel Bracing”. (2022)

11. IS 456 (2000)- Code of practice for Plain and Reinforced concrete .

12. IS 875-1987 (Part 1) - Code of Practice for Design Loads for Buildings and Structures for Dead Loads.

13. IS 875-1987 (Part 2) - Code of Practice for Design Loads for Buildings and Structures for Live Loads.

14. IS 1893- 2016 (Part 1) – Criteria for Earthquake Resistant Design of Structure General Provisions and Buildings