Study on Steel & Concrete structure's seismic performance with and without BRB (Buckling-Restrained Frame)

Ankit Ladhani[1], Milli Sankhla[2]

[1]M. E student, L.J university
[2]Professor, Dept. of Civil Engineering, L.J university, Gujarat, India

---***---

Abstract – *Steel & concrete constructions exhibit varying responses to earthquake forces depending on their design, which can range from minor cracks to complete collapse under severe shaking. In regions prone to seismic activity, many existing structures may not meet the current seismic code requirements for strength. The collapse of steel-concrete composite structures could jeopardize the safety and lives of occupants. Therefore, improving design to enhance seismic resistance is crucial, leveraging the inherent strengths of composite construction and effective methodologies. The design should prioritize energy dissipation, which plays a critical role in structural performance. Buckling-Restrained Braces (BRBs) are highly effective seismic resistance systems due to their ability to dissipate significant energy, making them suitable for both new lateral seismic loads and retrofitting existing structures. Linear and non-linear analyses using ETABS were conducted to evaluate the seismic performance optimization of a 10& 20-story steel and concrete structure incorporating single diagonal buckling restrained braces.*

Key Words: BRB- Buckling Restrained Brace, Earthquake, ETABS.

1.Intoduction

Earthquakes cause significant loss of life and property by collapsing buildings, especially impacting structural elements like beams and columns during intense seismic waves. Traditional lateral load resisting systems often fail under medium to severe earthquakes, prompting the introduction of buckling restrained braces (BRBs). These structural steel frames prevent buckling during seismic activity. BRBs comprise a steel core, bond-preventing layer, and outer casing. The core restrains axial forces with central yielding and rigid non-yielding parts at both ends. A bond-preventing layer allows core expansion and contraction during tension and compression, while the casing prevents buckling. Earthquakes result from sudden energy releases, such as geological faults, volcanic activities, landslides, or human-induced events like mine blasts. Dynamic seismic loads can swiftly collapse structures, causing significant harm. To withstand lateral forces from earthquakes and wind, buildings require bracing systems like shear walls that uniformly transfer these forces without compromising structural stability. Such lateral loads induce stresses, sway movements, and vibrations, necessitating structures with robust vertical load strength and lateral force resistance. Buckling Restrained Braces (BRBs) are crucial for preventing compression-induced buckling. They exhibit balanced hysteresis loops, providing yielding behavior in compression and tension, thereby enhancing seismic resilience and protecting structures during earthquakes.

1.1 Buckling Restrain Brace

The evaluation of the building's performance for this project will adhere to the guidelines specified in ASCE 41-06. Specifically, the focus will be on assessing the efficacy of Buckling Restrained Braced Frames (BRBFs) as the primary lateral force resisting system in both new construction and seismic retrofit projects. BRBFs represent a specialized form of concentrically braced frames distinguished by the incorporation of Buckling Restrained Braces (BRBs). These braces are engineered with a mechanism that prevents buckling, which is separate from the load-resisting steel core. This design effectively eliminates the potential for buckling failure modes by reducing the un-braced length of the compression member to zero. The core feature of BRBs is their ability to yield in both compression and tension, ensuring relatively uniform compressive strains compared to tensile strains. This characteristic significantly enhances the seismic resilience of the structure by facilitating controlled energy dissipation during seismic events while preserving structural integrity.

2. Problem Formulation

This chapter outlines the building data used in this study, emphasizing the installation of Buckling Restrained Braces (BRBs) at the four corners of buildings to enhance seismic force control during earthquakes. The study examines various building structures, specifically 10 and 20-floor buildings located in Gujarat.

DYNAMIC ANALYSIS OF BUILDING

- To Prepare 10 storey and 20 storey without BRB in RCC and Steel.
- To Prepare 10 storey and 20 storey with BRB in RCC and Steel.
- Analysis is performed by response spectrum
- Seismic Zone IV and V with Medium and Hard soil.
  - RCC and Steel Structure without BRB

- Building with 10 floors.
- Building with 20 floors.
- RCC and Steel and Structure with BRB
- Building with 10 floors.
- Building with 20 floors.

Building data

Location: Ahmedabad

Storey Height: 3 m

Table -1: lateral loads

Weight	25.54 kN
Depth	406.4 mm
Width	304.8 mm
Area of yielding core	171 cm2
Stiffness of elastic segment	4334353.557 kN/m
Length of yielding core	4.2672
Length of elastic segment	2.2713

Table -2: Size of frame

Particular	**Concrete**	**Steel**
Thickness of slab	125mm	125mm
Column	600 mm x 600 mm	ISMB350
Beam	300 mm x 600 mm	ISHB350

Table -3: BRB material

Dead Load	Default Value is taken by E-TABS 2019
Live Load	3.0 KN/m^2
Floor Finish Load	1.0 KN/m^2
Importance Factor, I	1
Response Reduction Factor, R	5
Seismic Zone	IV and V
Time History	Bhuj Time History

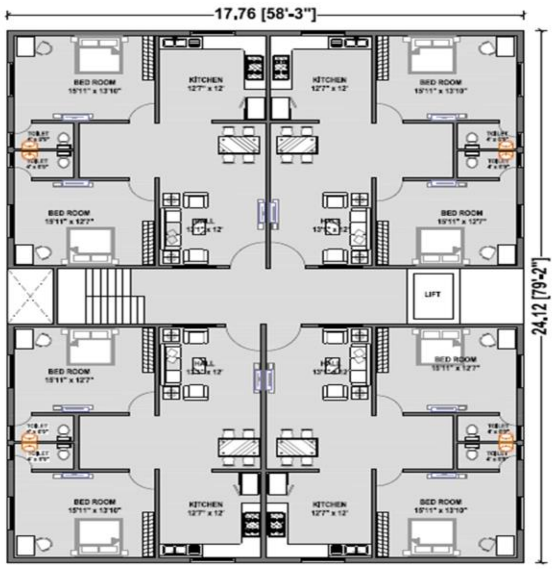

Fig.1: Plan

3. Results and discussion

ETABS software was used to model RCC buildings with conventional and flat slab designs, considering soft, medium, and hard soil conditions. Models were developed for both G+9 and G+19 structures, analyzed using response spectrum and time history methods. The analysis covered two building conditions and five soil types. Seismic parameters such as displacement, base shear, story drift, and period were evaluated and compared across fixed base conditions, different soil types, and slab configurations.

Figures summarizes seismic parameters including story displacement, base shear, story drift, and displacement obtained from response spectrum and time history analyses for G+9 and G+19 buildings. Comparative graphical representations of these parameters across various models with different slab types and soil conditions using response spectrum and time history methods are presented in subsequent figures. (few of many results)

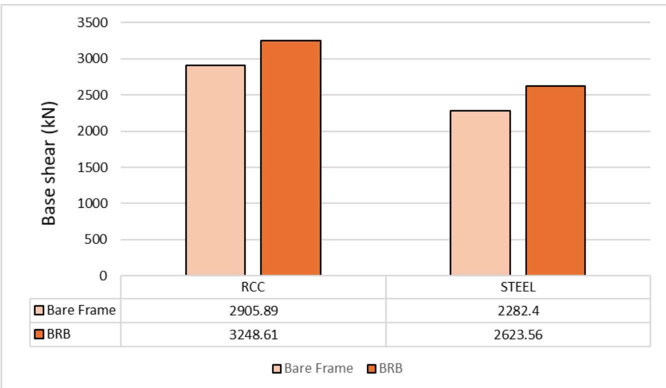

Fig.2 Comparison of Base shear of 10 Storey (Zone 4, Soft Soil)

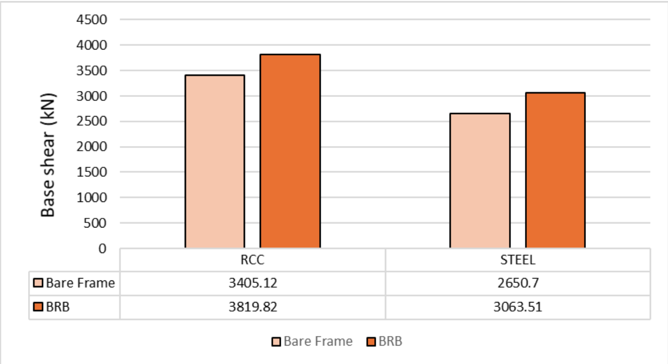

Fig.3 Comparison of base shear 20 storey (zone 4 soft soil)

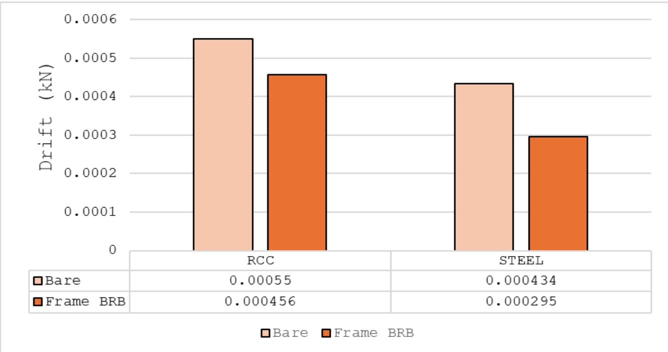

Fig.4 Comparison of drift 10 storey (zone 4 medium soil)

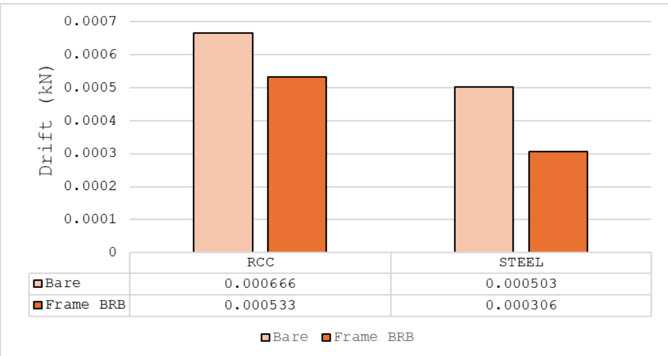

Fig.5 Comparison of drift 20 storey (zone 4 medium soil)

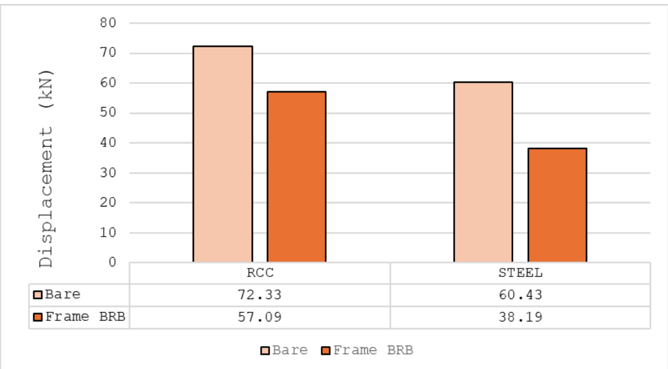

Fig.6 Comparison of displacement 20 storey (zone 5 soft soil)

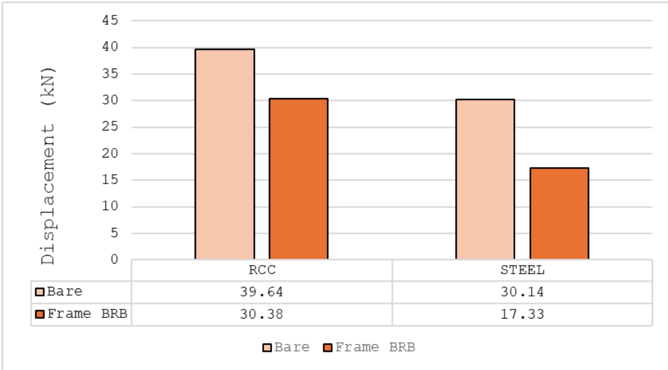

Fig.7 Comparison of displacement 10 storey (zone 5 soft soil)

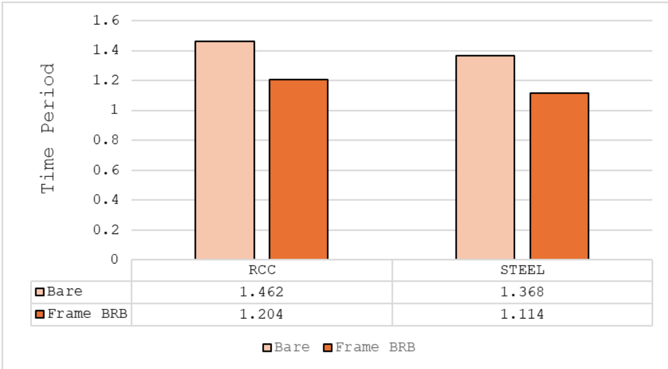

Fig.8 Comparison of time period 10 storey

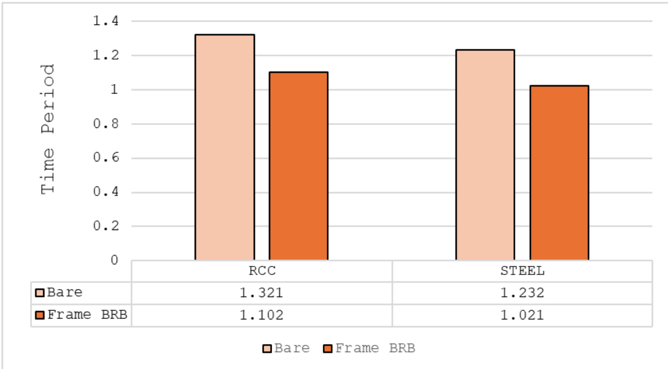

Fig.9 Comparison of time period 10 storey

CONCLUSION

- The inclusion of BRBs in steel structures leads to an increase in base shear by 13% to 25% compared to bare frames.
- BRBs in RCC structures result in a base shear increase of 10% to 14% compared to bare frames.
- In steel structures, displacement decreases by 25% to 65% with BRBs compared to bare frames.
- In RCC structures, displacement decreases by 15% to 29% with BRBs compared to bare frames.

- Drift decreases by 32% to 60% in steel structures with BRBs compared to bare frames.
- Drift decreases by 17% to 43% in RCC structures with BRBs compared to bare frames.
- The effectiveness of BRBs is highest in steel structures, where both displacement and drift are significantly reduced with minimal increase in base shear.

REFERENCES

1. E. Talebi, and F. Zahmatkesh, "Performance of BRBF and Comparing it with the OCBF", International Journal of Civil, Environment, Structural, Construction and Architectural Engineering, Vol.4, No.8, 2010.
2. Nikhil D. Sontakke, and P. S. Lande, "Comparative Study of Buckling Restrained Braced and Conventional Braces in a Medium Rise Building", International Journal of Engineering Research, Vol.5, pp.625-628, 2016.
3. C. J. Black, N. Makris, and I. D. Aiken, "Component Testing, Seismic Evaluation and Characterization of Buckling-Restrained Braces", Journal of Structural Engineering, Vol.130, No.6, pp.880-894, 2004
4. W. N. Deulkar, C. D. Modhera, and H. S. Patil, "Buckling Restrained Braces for Vibration Control of Building Structure", International Journal of Recent Research and Applied Studies, Vol.4, No.4, pp.363-372, 2010.
5. K. P. Shadiya, and R. Anjusha, "Bracing Configuration Effect on Buckling Restrained Braced Frames", International Journal of Innovative Research in Science, Engineering and Technology, Vol.4, No.4, pp.2552-2560, 2015.
6. K. G. Viswanath, K. B. Prakash, and Anant Desai, "Seismic Analysis of Steel Braced Reinforced Concrete Frames", International Journal of Civil and Structural Engineering, Vol.1, pp.114-122, 2010.
7. Ahmad Fayed Ghowsi and Dipti Ranjan Sahoo, "Seismic Performance of Buckling Restrained Braced Frames with Varying Beam-column Connections" International journal of steel structures, Vol.13, No.4, pp.609-621, 2013.
8. D. R. Panchal and P. M. Marathe "Comparative Study of R.C.C, Steel and Composite (G+30 Storey) Building" institute of technology, NIRMA university, Ahmedabad Dec, 2011.
9. ETC…