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Analytical Study on Composite Building with Different Configuration Buckling Restrained Bracing Under Static and Dynamic Analysis Using ETABS

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Abstract:
This paper represents the behavior of the composite building with buckling restrained bracing under static and dynamic load. For the parametric study seven story composite building is considered. To check the behavior of the buckling restrained bracing, the various structural parameters are compared with the normal building. The various parameters are story displacement, story drift and time period of the structure. From this study, analysis of the different BRB brace layout has been carried out. The selection of BRB arranged has been adopted different configurations are considered for the study of building.

***Index Terms* – introduction, research methodology, result, conclusion.**

I. INTRODUCTION

In the past, we usually chose between concrete and stone structures. Due to the many masonries and multi-story RCC building failures caused by the earthquake, structural engineers had to look for alternative construction methods. Due to sizeable ability in enhancing the ordinary overall performance thru alternatively modest modifications in constructions technology, use of composite shape is of interest. During an earthquake, seismic ground forces have the effect of applying lateral loads to buildings. If these loads are strong enough, they can damage the structure, leading to an economic loss or even loss of human life. To prevent these from happening, it is deciding to have buildings that can withstand seismic loads they may be subjected to structures fitted with buckling restrained bracing system are likely to absorb even more energy as both in tension and compression are resisting the lateral loads. Many existing buildings do now no longer meet the lateral strength necessities of present-day seismic codes due to the layout of constructing simplest gravity load, extrude withinside the use of constructing and strength deterioration because of gravity load, extrude withinside the use of constructing and power failure because of getting old or preceding earthquake. Such homes are crumble withinside the occasion of destiny earthquake. Reduce those damages on the prevailing shape with the aid of using introducing new factors along with shear wall or traditional metal bracings. Conventional steel braces. after the study concluded that the provided in the BRB in center alternative 4 bay story displacement and story drift are very low and in corner bay time period is very high.

This study is about to conduct time history analysis of building structure with buckling restrained braces. Plan area is taking as 20 x 20 and story height is considered 10. Based on the findings of different indicators, it has been determined that the buckling restricted brace building performs better brace building. BRB reduced the story force which provides the stability of the building. Using BRB instead of traditional bracing in the construction is safer. The study's prototype building is a six-story office structure. The structure features a rectangle floor layout. The building's plan is 25 meters long and 15 meters broad. Static pushover analysis and time history earthquake analysis were used to test the seismic upgrade of a 6-story RC-building utilizing single diagonal BRBs.By using diagrid BRBs in one bay of each peripheral frame of an RC building, the original RC building's base shear capacity is increased. Using BRBs to reinforce RC buildings is an effective way to increase the PGA ability of the RC frame construction. This study measured the effectiveness of composite structures to that of traditional RCC structures when subjected to seismic loading. The layout of a design with 4 x 4 bays of equal length of 5m is presented in this document. The buildings under consideration include composite and RCC structures of five, ten, and fifteen floors. For building models, the story height is kept consistent at 3 building. BRB, story displacements, column axial forces, column bending moments and shear forces, beam shear forces and bending moments, timeline of the structure, and dead weight of the structure are all structural factors that are compared. Giving BRB in two bays reduced story displacement by 45 percent, and installing BRB in four bays reduced story displacement by 57 percent. Inverted V geometric braces are much more effective in BRBFs than any other form of steel structure.

1.1 COMPOSITE STRUCTURE:

Components of composite structure: -

- Steel beam: - Composite beam includes a metal beam, over which a strengthened concrete slab is made with shear connectors.
- Composite column: - Column is conventionally a compression member in which steel element is a structural steel section. Two types of composite column generally used in buildings, steel section encased in concrete and steel section in-filled with concrete.
- Shear connectors: - connectors are used to develop the composite action between steel beam and concrete slab to improve the load carrying capacity and overall rigidity.
- Composite slab: -Composite floor system comprises of steel beams, deck and concrete slab. Composite floors using the GI profiled sheet decking. In the composite floor system, the structural behavior will be similar to a reinforced concrete RC slab, with the steel sheeting acting as tension reinforcement.

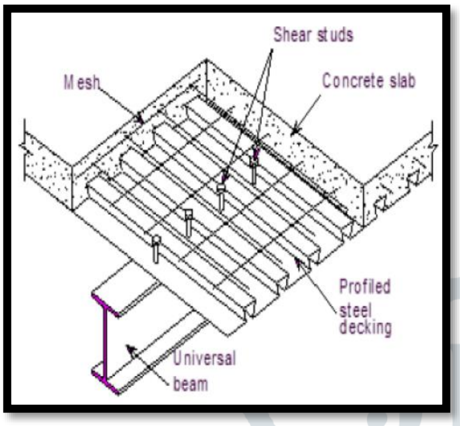

Figure 1 typical profile deck slab beam arrangement

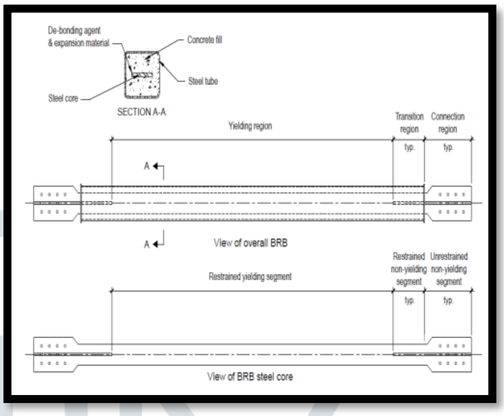

Figure 2 Common BRB assembly

1.2 BUCKLING RESTRAINED BRACES:

- The idea of buckling restricted braces evolved in Japan with the aid of using NIPPONS STEEL in 1980`s.
- Buckling restrained braces (BRBs) are a relatively recent development in the field of lateral load resisting structure. Buckling restrained braces (BRBs) are one of a new type of seismic structural system and are actively used for seismic design and renovation of building structures in highly seismic areas.
- Components of BRBs: -
  Steel core
  Steel tube
  De-bounding material
- The main components of BRBs consist of a steel core, which is encased by concrete which is shown in figure 3.
  The metal center is split into 3 regions:
  • The yielding domain
  • The transition domain
  • The connection domain
- De-bonding substances are epoxy resin, silicon resin, vinyl tapes, silicon rubber sheets, polythene sheets, etc.

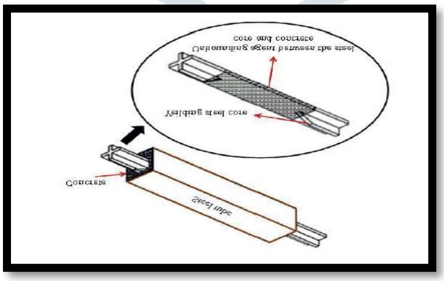
Figure 3 Schematic diagram of the BRB components

- It can be easily connected to the structural system by means of a bolted or pinned connection to gusset plate.
- BRB gusset end connections come in three common configurations:
  • Bolted connection
  • Welded connection
  • Pin connection

Figure 4 Bolted connection

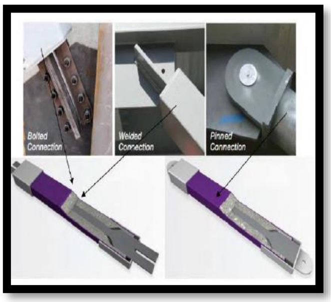

Figure 5 BRB connections

1.3 BRB

The basic behavior of conventional braced frame and BRBF system is shown in the figure 6. and Figure7 shows the hysteresis behavior of the brace. BRB have a stable force-deformation curve during tension and compression cycle while concentric brace performs well during tension cycle and experience buckling during the compression cycle. After the buckling of the brace, the brace losses its strength and leads to the fracture of the brace in the subsequent cycle. Low compression cycle capacity lads to the low energy dissipation and deformation ductility of the brace when compared to the BRB.

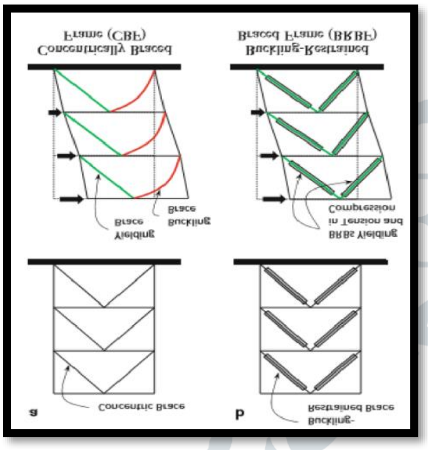

Figure 6 Behaviors of braces

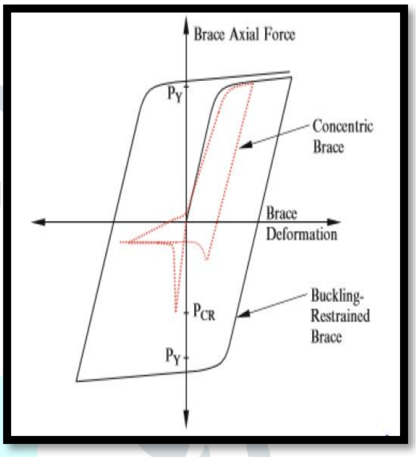

Figure 7 BRB have full balanced hysteresis loops with compression and tension yielding behaviors

BRBs have been used on many types of structures such as office building, hospitals, retail, car parks, multi-story residential, schools, religious, stadiums and arenas, as well as non-building and industrial structures.

- How the effectiveness of BRB is evaluated with static analysis or response spectrum analysis?
- Two models are analyzed with static and response spectrum analysis and check the effectiveness of BRB provided in same frame building.
  1. G+7 frame without BRB
  2. G+7 frame with BRB
  - For the same column section, same beam section and same dimension are provided with same seismic zone.
  - BRB provided only outer edge in the G+7 frame with BRB and Check the advantages.

1.4 OBJECTIVES:

- Buckling restrained brackets (BRBs) have become one of the most efficient earthquake resistant structural systems of the new type and are active for seismic design and recovery of building structures.
- The main following objectives of the as per my work.
- To study the different effects on the performance of composite structures containing BRBs under different story heights, using different braking configuration systems.
- To analyze story displacement, time span, roof displacement, story flow using BRB. Offering different configurations with better performance.

II. RESEARCH METHODOLOGY

- Modeling of Composite structure in ETABS software. Static and dynamic analysis of the building is done as per IS 1893 :2016. Comparison of various bracing in different bays.
- Initially a building plan is selected and modeled in ETABs setting preliminary units, Dimensions, according to Indian standards codes.
- Assigning preliminary sizes for composite column, steel beam, deck slab and BRB.
- Assign the fixed supports condition as required for the building.

- The diaphragms are added and are assigned to each floor of the building.
- Calculating loads such as dead, live, and wind loads as per is 875-part 1, 2, 3.
- Assigning dead and live load on to the shell and wind load on to the diaphragms.

2.2 MODEL CONFIGURATIONS

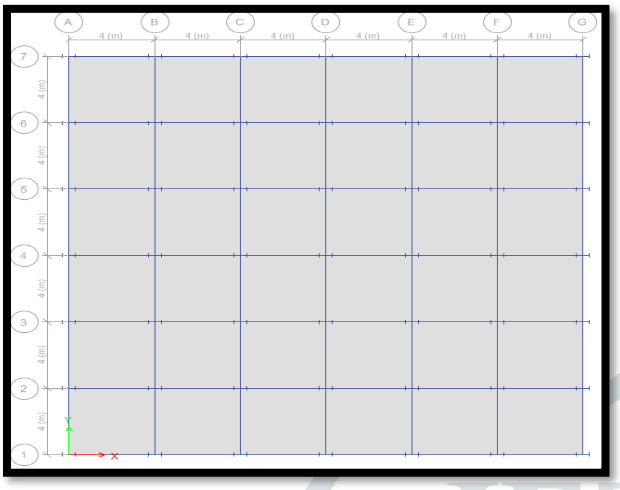

Figure 7 plan of problem

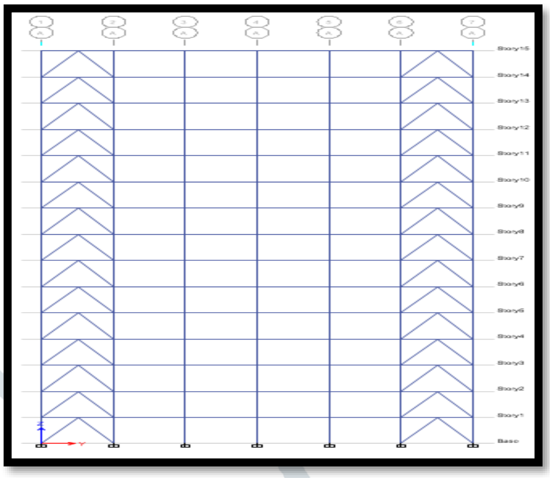

Figure 8 Elevation of problem

Table 1 Problem validation

No. of stories	G+7	Live load	3 KN/m2
Floor height	3m	Dead load	1.5 KN/m2
Total height	21m	Location	Ahmedabad
Plan area	30m*30m	Seismic zone	III
Deck slab thickness	140mm	Seismic zone factor	0.16
Concrete grade	M30	Basic wind speed	39 m/s
Wall thickness	230mm	Terrain category	Class 3
Steel grade	Fe350	Structure class	B
Size of beam	ISMB 400	Risk factor k3	1
Size of column	Composite Structure 450*450 ISMB 350	Cp	1

2.3 CALCULATION BRB:

The BRBs are modeled by a truss element characterized by a cross section with an equivalent area Aeq equal to

$$A_{eq} = \frac{A_c}{\frac{L_j}{L_w}\frac{A_c}{A_j} + \frac{L_t}{L_w}\frac{A_c}{A_t} + \frac{L_c}{L_w}}$$

Were,
Lc = The length of the yielding core
Lt = The length of the restrained non – yielding segment
Lj = The length of the unrestrained non – yielding segment
Lw = The length of the whole brace
Ac = The area of the yielding core
Aj = The area of the restrained non – yielding segment
At = The area of the unrestrained non – yielding segment
Area of yielding core,

$$A_c = \frac{V}{2 F_y \cos\alpha}$$

Were,
V = Story shear
Fy = yielding stress of the BRBs core
α = angle of inclination of the brace with respect to the longitudinal beam axis

At = 2 Ac

.: At = 2 Ac

Aj = 3.33 Ac

.: Aj = 3.33 Ac

In accordance with common application of BRBs, the length of the yielding core is supposed to be equal to 0.5 Lw in V type of bracing and 0.65 Lw in diagonal type of bracing.

Lj = 0.65m

Lt = 0.5 (Lw – Lc - Lj)

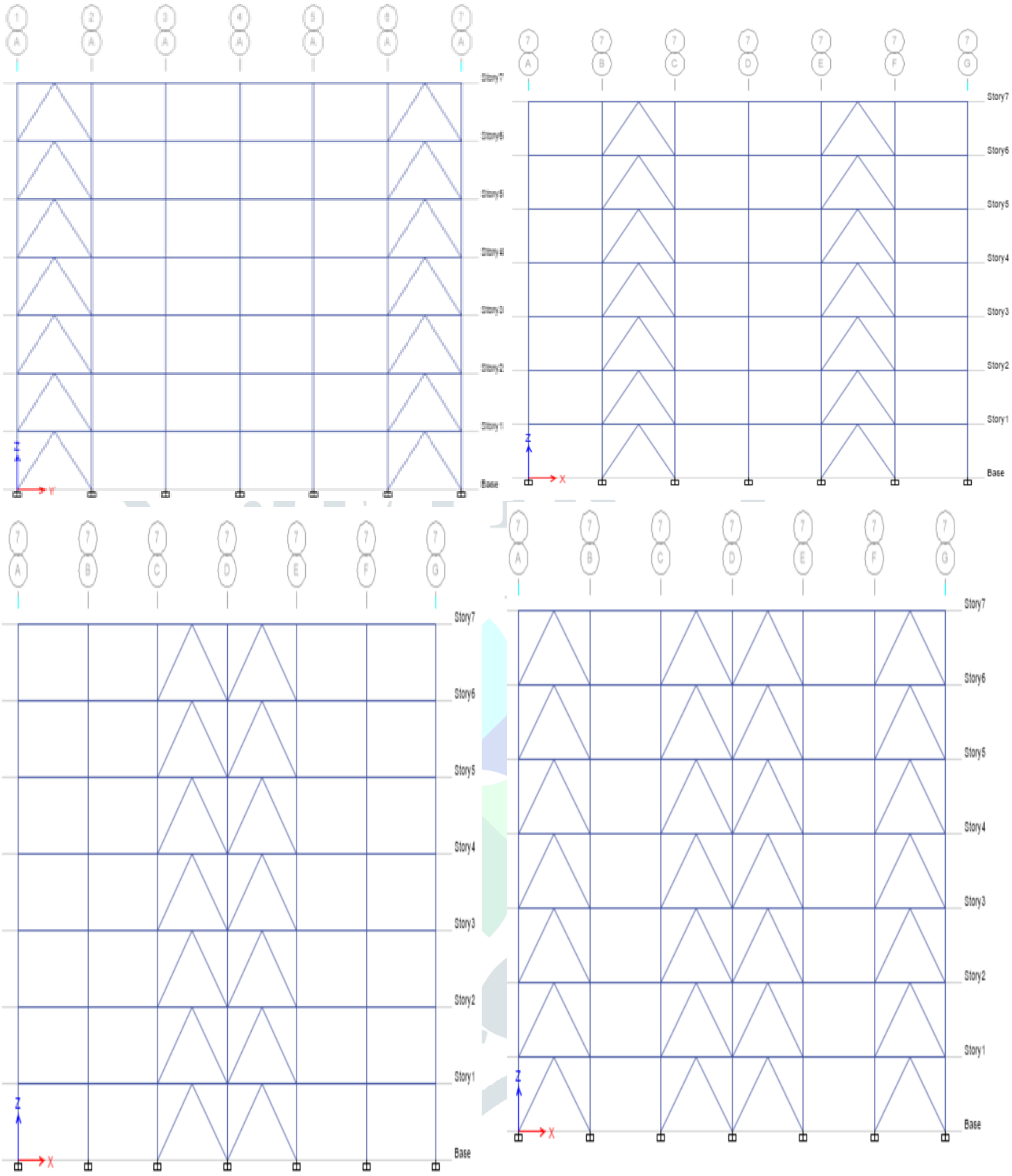

Figure 10 providing BRB in different bays

III. Result:

3.1 Story drift G + 7

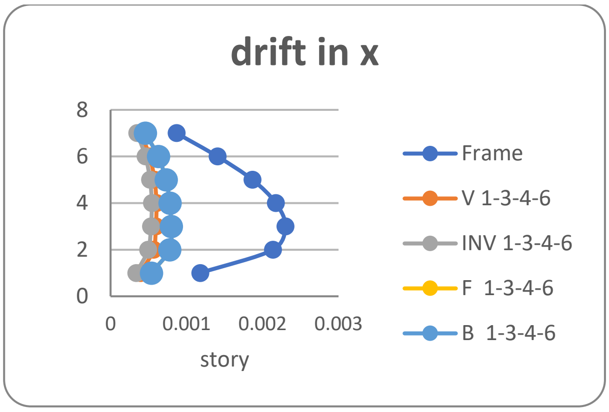

Figure 11 Story drift in Inverted bracing in X direction

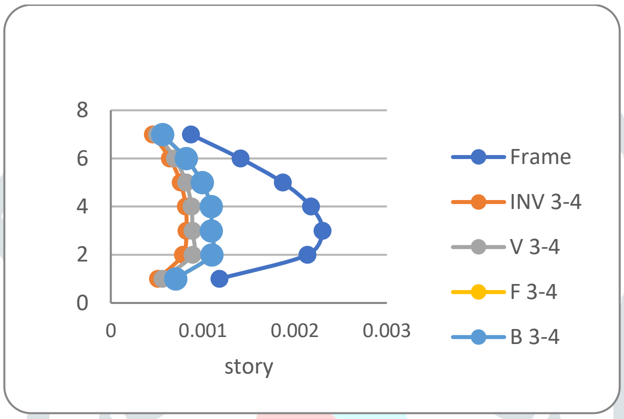

Figure 12 Story drift in Inverted bracing in Y direction

3.2 Displacement G + 7

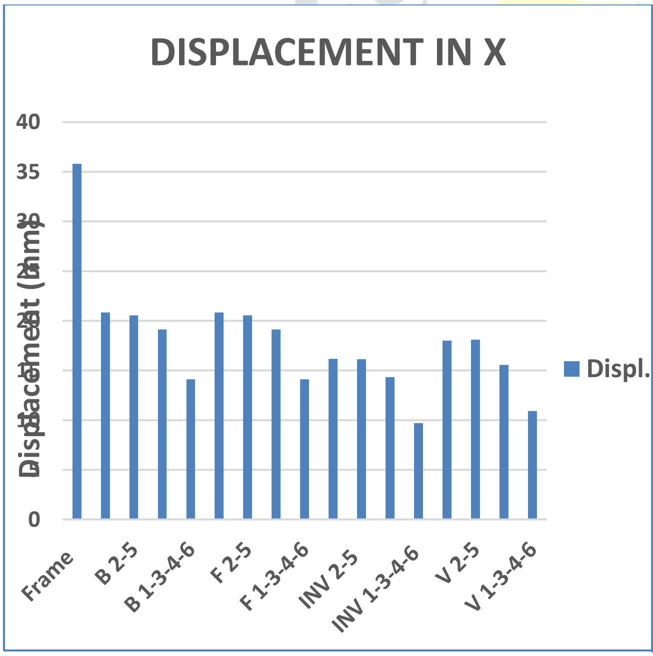

Figure 12 Max displacement in X direction

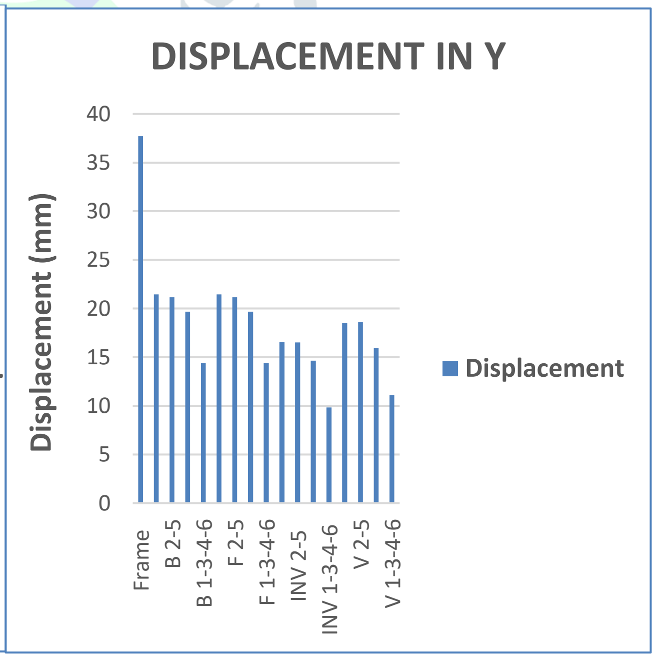

Figure 13 Max displacement in Y direction

3.3 TIME PERIOD

TIME PERIOD(SEC)			
FRAME	1.507	V 1-6	0.968
B 1-6	1.056	V 2-5	1.012
B 2-5	0.236	V 3-4	1.023
B 3-4	1.089	V 1-3-4-6	0.896
B 1-3-4-6	1.050	INV 1-6	0.856
F 1-6	0.983	INV 2-5	1.025
F 2-5	1.023	INV 3-4	0.877
F 3-4	1.099	INY 1-3-4-6	0.987
F 1-3-4-6	0.896	INV 1-3-4-6	0.856

IV. CONCLUSION

- It is evident that the perimeter frame of the joint structure is significantly improved after the use of 2 and 4 bays.
- The period of providing BRB in 2 bays was reduced by 40% and also the period for providing BRB in 4 bays was reduced by approximately 45%
- The use of Brackets in BRBF is the most efficient in the inverted V geometry. Better than any other type of composite

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