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ANALYTICAL STUDY ON COMPOSITE BUILDING WITH DIFFERENT CONFIGURTION BUCKLING RESTRAINED BRACING UNDER LATERAL LOAD USING ETABS

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Abstract - *Composite building combines the good properties of both steel and concrete. Buckling restrained braced are primarily used as seismic-force resisting systems for buildings in seismically-active regions. Buckling Restrained Braces have become one of the most efficient earthquakes-resistant structural systems. From this analytical 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. ETABS software will be used for the analysis of story drift, story displacement, time period, roof displacement etc. with different bracing configuration.*

***Key Words*: BRB, Response spectrum analysis, composite structure, Etabs**

1. INTRODUCTION

In the past for the construction, the choice was usually between a concrete structure and a masonry structure. Failure of many masonry buildings and multistoried RCC buildings because of earthquake has necessitated structural engineers to look for the different method of construction. Due to significant potential in improving the overall performance through rather modest changes in construction technology, use of composite structure is of interest.

During an earthquake, seismic ground forces have the result 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 avoid 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 building do not meet the lateral strength requirements of current seismic codes because of the design of building only gravity load, change in the use of building and strength deterioration because of gravity load, change in the use of building and strength failure because of aging or previous earthquake. Such buildings are collapse in the event of future earthquake. Decrease these damages on the existing structure by introducing new elements like shear wall or conventional steel bracings.

Conventional steel braces have been used in seismic strengthening of buildings in seismically- actively regions. They can be added fast installed than other strengthening techniques and they do not add much weight to the structure.

Buckling Restrained Braced Frame (BRBF) is a technically advanced type of Concentrically Braced Frame (CBF) that integrates the effect of lateral forces subjected on to the structure.

1.1 Composite Structure

Steel and concrete may be arranged to produce an ideal combination of strength with steel efficient in tensile concrete in compression.

Components of composite structure: -

- Steel beam: - Composite beam consists of a steel beam, over which a reinforced concrete slab is cast 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 normally 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 get better 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.

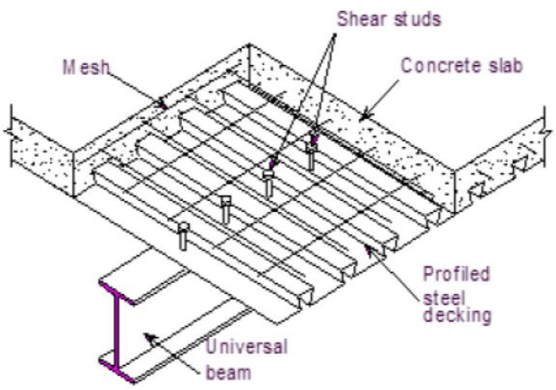


Fig-1: Typical profile deck slab beam arrangement

1.2 Buckling Restrained Braces:

The concept of buckling restrained braces developed in Japan by NIPPONS STEEL in 1980's.
Buckling restrained braces (BRBs) are a relatively recent development in the field of lateral load resisting structure.

What is BRB?

Buckling Restrained Braces are one of the newer types of seismic force- resisting structural systems and have been actively applied to seismic design and retrofit of building structure in seismically high active regions.

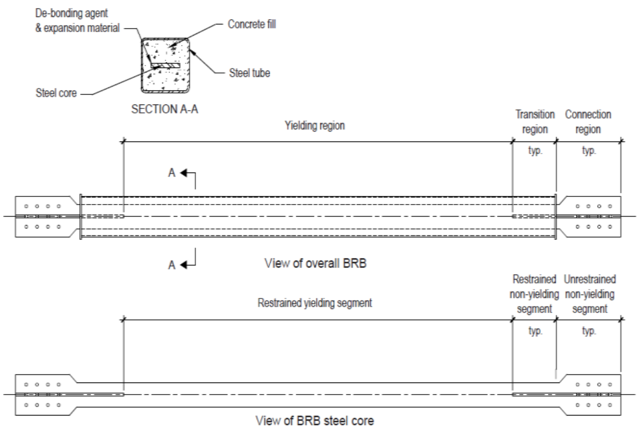


Fig-2: Common BRB assembly

The main components of BRBs consist of a steel core, steel tube, and de-bounding material. The steel core is divided into three regions: 1.The yielding region 2.The transition region 3.The connection region.

The space between the tube and brace is filled with a concrete like material and special coating is applied to the brace to prevent it from bonding to the concrete. So, that the brace can slides with respect to the concrete-filled tube. De-bonding materials are epoxy resin, silicon resin, vinyl tapes, silicon rubber sheets, polythene film sheets, etc. the concrete filled tube provides the required confinement during cycling loading.

The main load resisting element in BRB is the steel core, and the overall buckling of the core steel is resisted by the restrained mechanism provided by the outer casing.

There are three common configurations for BRB end connection with gusset plate is bolted connection, welded connection and pin connection.

Why BRB?

In a serve earthquake, the braces are subjected to extreme loading with repeated cycle of stress, which exceed the elastic limits of the brace. The braces will then yield in compression and tension to absorb and stop the build-up of energy in the structure.

The basic behavior of conventional braced frame and BRBF system is shown in the fig 3.

BRB shows symmetry in the response during the action of lateral loads and BRB is designed in such a way that the buckling during the compression cycle avoided.

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.

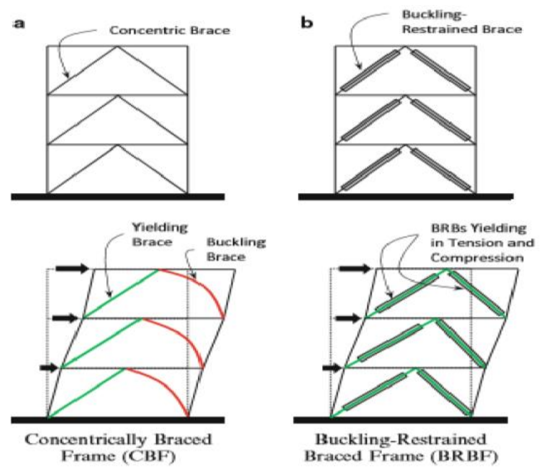


Fig-3: Behavior of braces

1.2 Objectives:

The main objectives for present work are as follows:

- To study the various effects on performance of composite structure having BRB under different story height, using different bracing configuration system.
- To analyze the story displacement, time period, roof displacement, story drift using BRB.

- Proposing the various configurations which have better performance.

2. RESEARCH METHODOLOGY AND MODELING

Firstly a building plan is selected and modeled in ETABS. Setting preliminary units, Dimensions according to Indian standards codes. Assigning the preliminary size of 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 every floor of the building. Calculating loads such as dead, live, and wind loads as per is 875-part 1, 2, 3.

2.1 Model configuration

Table -1: model configuration

No. of stories	G + 18
Floor height	3m
Total height of building	54m
Plan area	30m x 30m
Deck slab thickness	140mm
Concrete grade	M30
Steel grade	Fe350
Density of wall	20N/m^2
Wall thickness	230mm
Size of beam	ISMB 450
Size of column	Composite structure 600x600 mm encased with ISMB 450
Live load	3KN/m2
Location	Ahmedabad
Basic wind speed	39m/s
Terrain category	Class 3
Structure class	B
Risk factor	1
Topography factor k3	1
Cp	As per Is 875:2002

2.2 Calculation of BRB:

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

$$Aeq = \frac{Ac}{\frac{Lj\,Ac}{Lw\,Aj} + \frac{Lt\,Ac}{Lw\,At} + \frac{Lc}{Lw}}$$

Where,

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,

$$Ac = \frac{V}{2\,fy\,\cos\alpha}$$

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

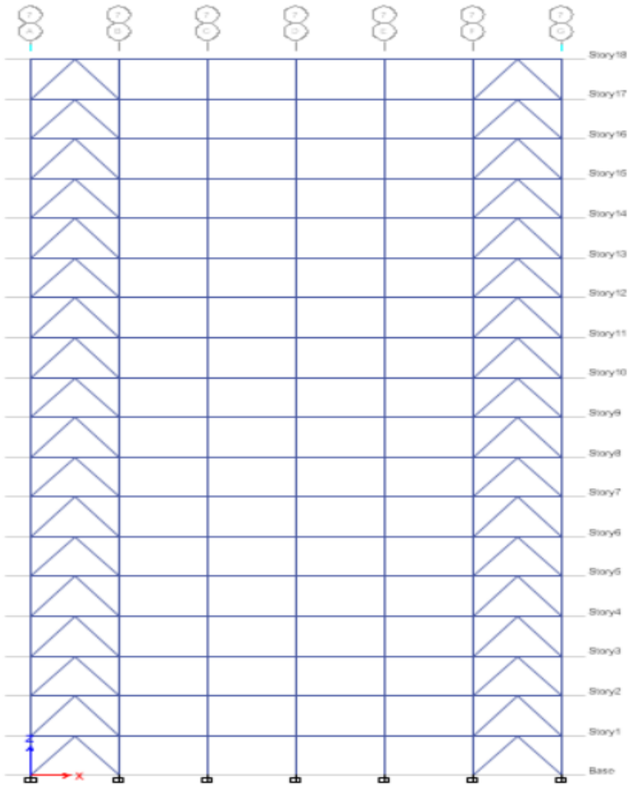
At = 2 Ac
Aj = 3.33 Ac

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.

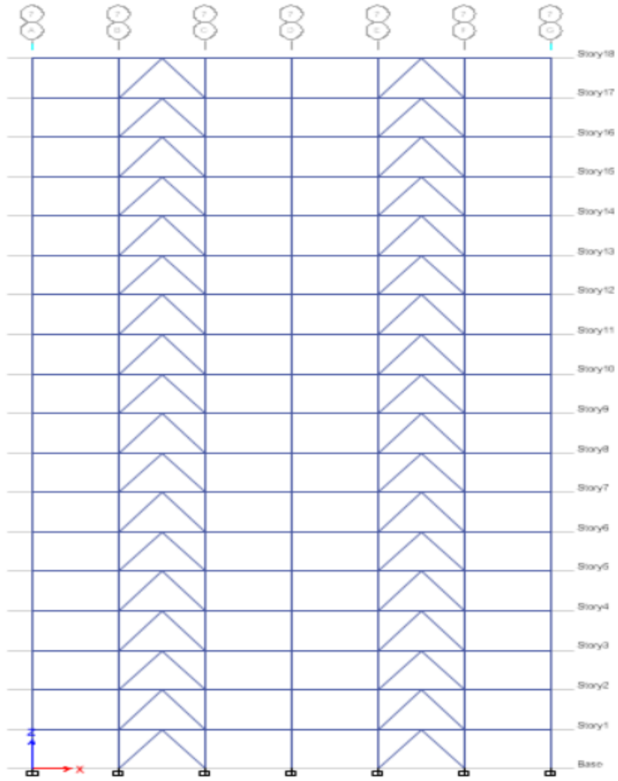
Lj = 0.65m
Lt = 0.5 (Lw – Lc - Lj)

Figure show the BRB providing in Inverted V type of bracing. Same as provided in Backward, Forward and V type of bracing.
Different bracing configurations are in outer edges, in inner edges, in center, in between outer and center
Providing BRB bracing in,

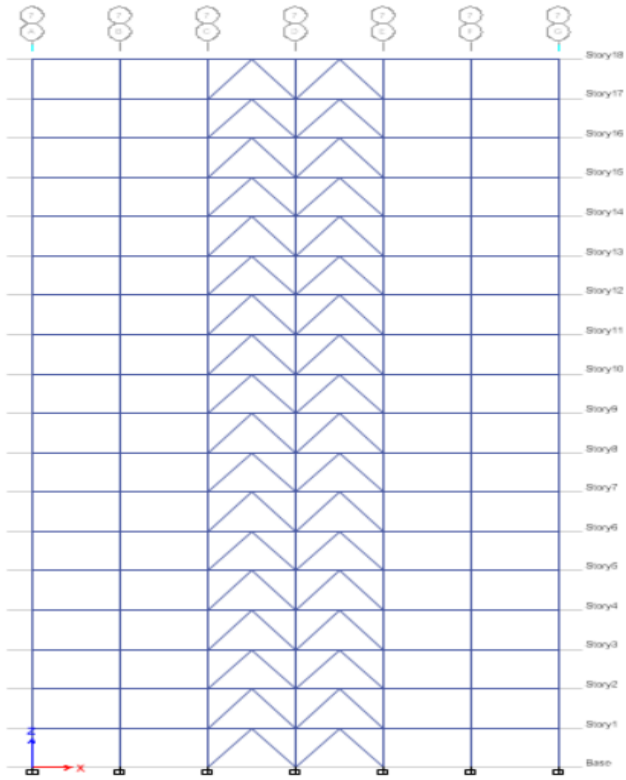
- Bay 1 and 6
- Bay 3 and 4
- Bay 2 and 5
- Bay 1,3,4 and 6



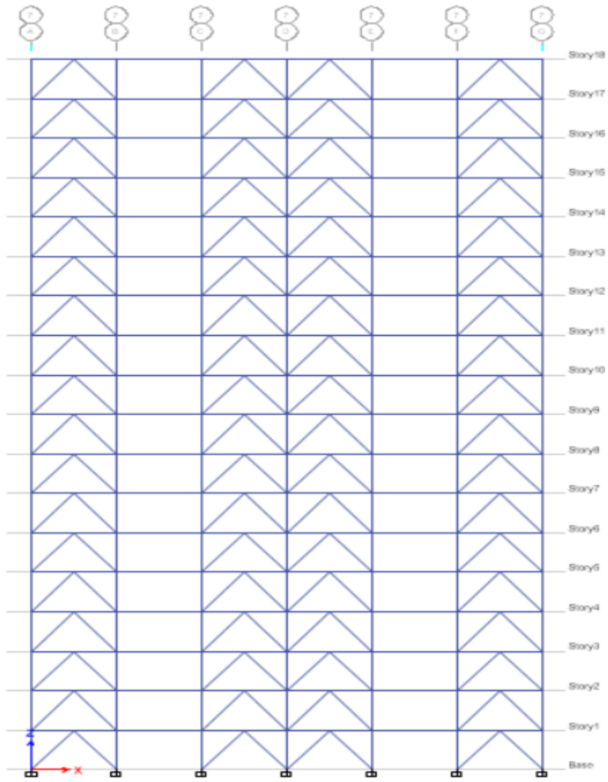
Bay 1 and 6



Bay 2 and 5



Bay 3 and 4



Bay 1, 3, 4 and 6

Fig-4 model of different bracing provision

3. RESULT:

The selection of BRB place of the building with different configurations are modeled and compared to each other suitable configuration. Here in order to comparison has been made and leads to which type of system gives the improved performance with all type of BRBs.

1. Story drift

Shown in the figure 5 &6 it can be observed that the story drift in with BRB has less value as compared to the without BRB. From the above four different type of BRB model, Bay 1,3,4,and 6 type of BRB showed to have less story drift as compared to other configuration model.

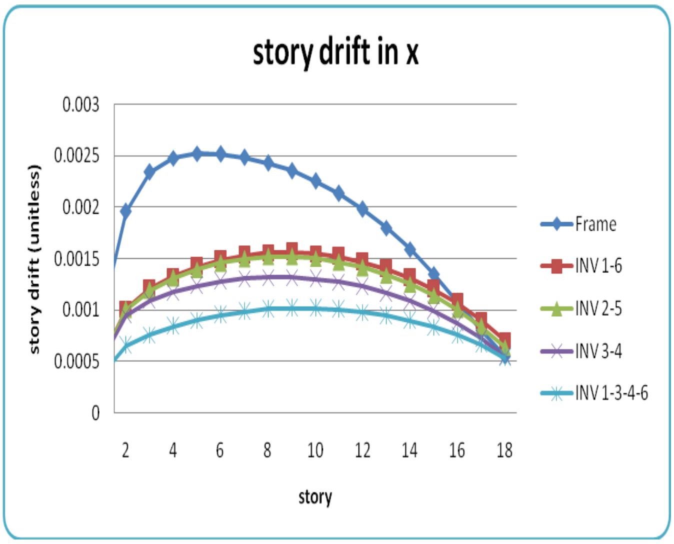


Fig-5 Story drift in x direction

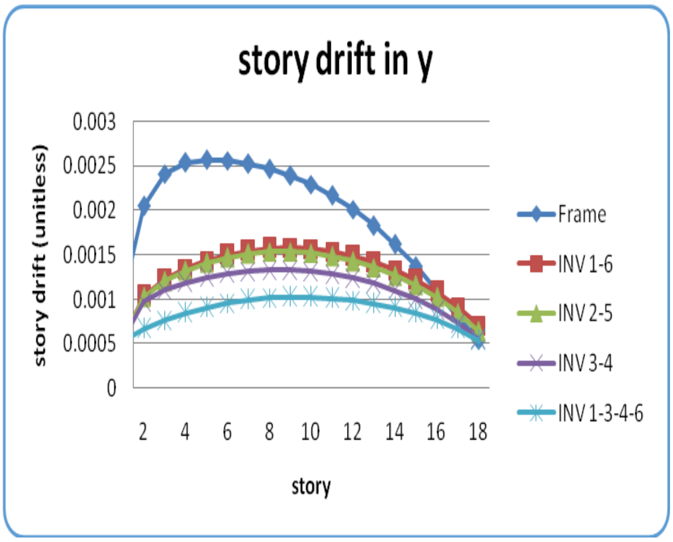


Fig-6 Story drift in y direction

2. Roof displacement

Shown in the figure 7 & 8 it can be observed that the Story displacement in with BRB has less value as compared to without BRB. Providing BRB in bay 3 and 4 is better than the providing BRB in bay 2 and 5 or 1 and 6. When BRB provided in 4 bays, the displacement is more reduced as compare to any other type of configuration.

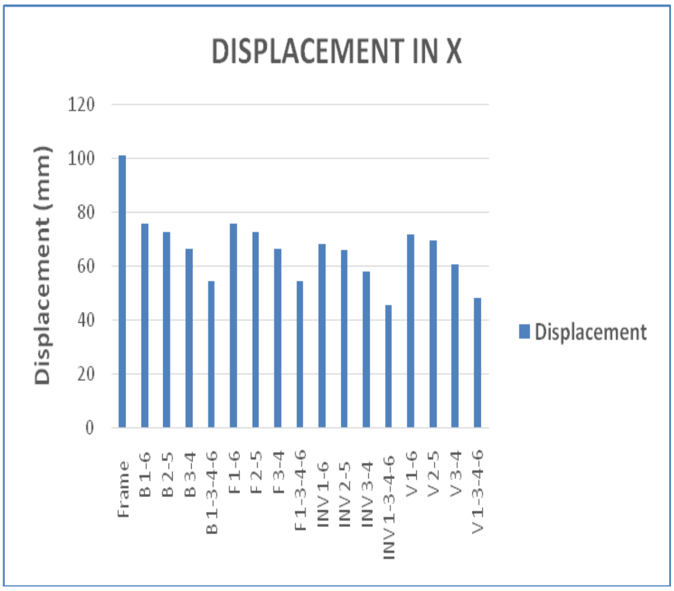


Fig -7 Roof displacement in x

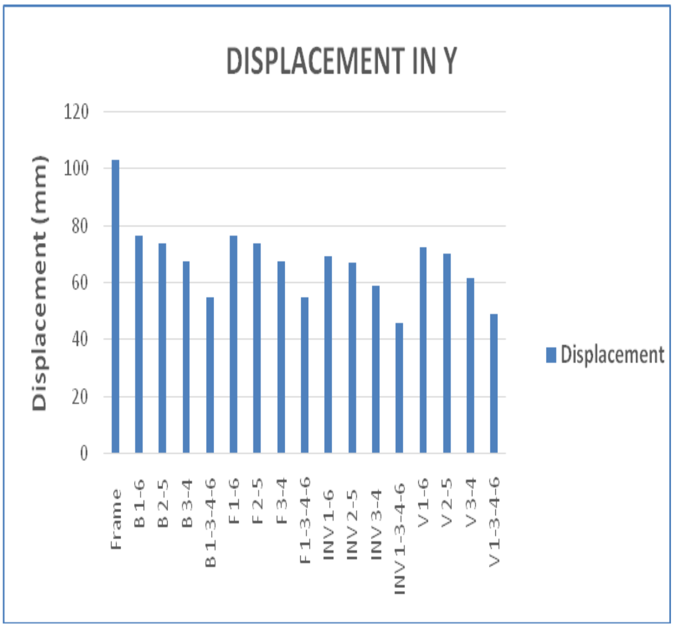


Fig-8 Roof displacement in y

3. Time period

Shown in the table 2, it can be observed that the time period of the structure of the frame model without BRB is more as compared to model with BRB.

Table 2- : Time period of structure

Time period	
Model	G+7
Frame	1.438
B 1-6	1.045
B 2-5	1.041
B 3-4	1.007
B 1-3-4-6	0.842
F 1-6	1.045
F 2-5	1.041
F 3-4	1.007
F 1-3-4-6	0.842
INV 1-6	0.922
INV 2-5	0.921
INV 3-4	0.878
INV 1-3-4-6	0.711
V 1-6	0.976
V 2-5	0.979
V 3-4	0.915
V 1-3-4-6	0.756

4. CONCLUSIONS

- The use of BRBs in two and four bay in each of the perimeter frames of the composite structure, results in a significant improvement.
- The story drift decreased by 74% for providing BRB in four bays and decreased by 64% for providing BRB in two bays.
- The story displacement decreased by 73% for providing BRB in four bays and decreased by 60% for providing BRB in two bays.
- The Time period decreased by 50% for providing BRB in four bays and decreased by 39% for providing BRB in two bays.
- In BRBFs, braces act more effective in inverted V geometry than in any other form in composite structure.

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