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Parametric Study to Compare Different Configurations of Buckling Restrained Braces and Conventional Braces in RC Building

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Abstract: **The RC frame with bracings is an efficient and economical method to resist the lateral forces acting on the structure. Under the seismic loading, the conventional steel bracings buckle due to compression. Buckling restrained braces are the innovative bracing systems which show same load deformation behaviour under both compression and tension. Aim of this study is to compare the conventional steel braces and buckling restrained braces considering a 10 storey RC frame for different configuration of braces. The analysis is performed using commercially available software ETABSv2016. For different configuration of braces the response spectrum analysis is performed and the parameters such as storey drifts and base shear are evaluated for all type of bracing configuration. From the study it is concluded that BRB with the X bracings arranged in central bay perform better during earthquake event.**

Keywords**: Base shear, Buckling Restrained Braces, Conventional Steel Braces, ETABS v2016, Response Spectrum Analysis, Story drift.**

I. INTRODUCTION

Buckling restrained braces (BRB) are the new type of lateral force resisting systems in modern building designs. The energy dissipation capacity of ordinary steel braces in a frame subjected to earthquake loading is limited due to buckling of braces under compression. The idea of buckling restrained braces was borne to enhance the compressive capacity of braces in order to get the symmetric hysteresis response without affecting its tensile capacity. Buckling restrained braces consists of three major components steel core, bond- preventing layer, and casing. The steel core resists full axial force coming on the bracing. It consists of the yielding zone in the middle length which is designed to yield in-elastically during design level earthquake and rigid i.e., non yielding zones at both end which remains elastic. The bond preventing layer decouples the core from the outer casing and allows the steel core to take the entire axial load coming on the bracing. The outer casing is made of steel tubes which provide lateral resistance for steel core buckling. Figure 1 shows typical section of BRB.

The buckling restrained brace system is innovative concept which meets two design requirements, namely axial strength provided by the steel core, avoids material failure and flexural rigidity by the outer casing which prevents buckling of the core member. Fig 2 shows the concept of BRB under axial loading.

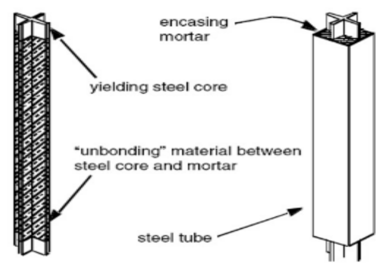

Fig 1 Typical section of BRB [2]

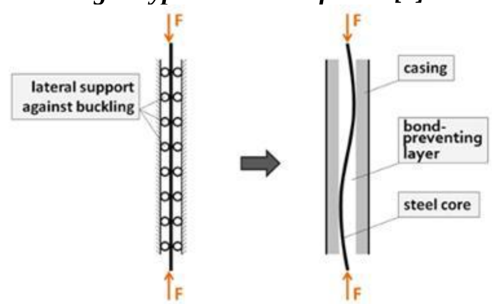

Fig 2 Concept of BRB under axial loading [3]

Experimental and analytical study by Kalyanaram et.al., [3] have shown that a well beyond the yield strain, without buckling of strut, the core can undergo compressive strain provided that the sleeve has adequate elastic buckling strength under the compression loading. [4] The parametric studies considering BRB in multi-storey buildings have shown better performance under earthquake loading, which has made BRB a better option in earthquake resistant building.

Generally BRB braces arranged concentrically to form Buckling Restrained Braced Frames (BRBF). The initial BRBF was developed by Nippon Steel Corporation 30 year ago in Japan with the product name Unbonded Brace. Presently there are at least three manufacturers developing and promoting BRBF application in new and retrofit building design.

II. BEHAVIOUR OF BRBF

The axial force coming on the brace is transferred directly to the steel core, which may consists of rod, plate, single or double angle. Core portion of the brace yields both in tension and compression under the earthquake loading. The outer casing prevents the lateral deformation of the core under compression loading as the casing does not experience any axial force due to inert bond preventing layer between them. As long as the buckling strength of core is greater than its compressive yield strength, the outer casing remains unaffected to the buckling under compression. Unlike the conventional braces, the BRB yields both in tension and compression, and absorb considerable amount of energy. [2] Fig 3 shows the hysteresis curve for conventional steel brace and buckling restrained brace.

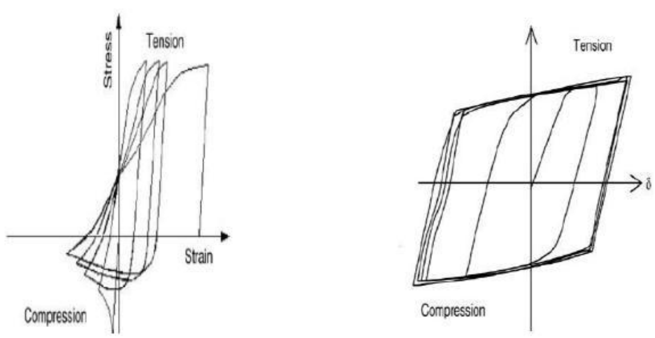

Fig 3 Hysteresis curve for conventional steel brace and buckling restrained brace [5]

III. NEED OF BRB IN RC FRAMES

The normal moment resisting frames have failed to perform in high seismic zones. So to increase the performance of structure to desired life span bracing systems are used in frames to give more stiffness and stabilize the structure. The brace location and the configuration also play an effective role in resisting the lateral loads. In the present study, the commercially available software ETABSv2016 is used to compare conventional steel braced frames and buckling restrained braced frames for four different configurations.

IV MODEL AND ANALYSIS

A ten storey three-bay frame was selected and four different bracing configurations for Chevron and X type bracing pattern were chosen. 3D frame was modelled with bay width of 6m and storey height of 3m. Detail description of building is given in the table 1.

Plan	18X18m
Beam size	0.3X0.45 m
Column size	0.45X0.45 m
Slab thickness	0.15 m
Steel brace size	ISMB450
BRB size	StarBRB_5.0
Live load	2 k N/m
Floor finish	1.5 k N/m
Concrete grade	M30
Steel grade	Fe 250
Rebar	Fe 415
Seismic zone	IV
Soil type	II
Importance factor	1
Response reduction factor	8
Damping ratio	5%

Details of the frame

The frames with conventional steel braces are classified as A, B, C and D with four different configurations. Similarly, frames with BRB are classified as A1, B1, C1 and D1. Figure 4 shows the plan view of all the frames. Figure 5 shows the different configuration location of bracings for both types of braces.

ISMB 450 section is used as conventional bracing system. The properties of I section are defined as per Indian Codal provisions. StarBRB_5.0 is adopted as the Buckling restrained brace and its properties are taken from Star Seismic provisions as follows:

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Area of yielding	32.3 cm^2
Total depth	30.48 cm
Total width	20.32 cm
Total weight	8.247 k N
Length of yielding	426.72 cm
Length of elastic segment	171.62 cm

Plan of the RC 3D frame is symmetric in both X and Y direction also the size of columns and beams are same throughout all stories.

Parametric study different configurations of buckling restrained braces and conventional braces Different load cases are defined for dead, live, floor finish and earthquake loadings. To perform response spectrum analysis, special load cases RSx and RSy are defined to generate response spectra in zone IV. The analysis gives the behaviour of steel and BRB braces in different configurations.

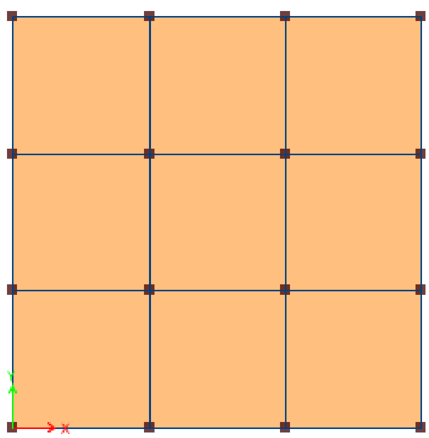

Fig 4 Plan view of the building

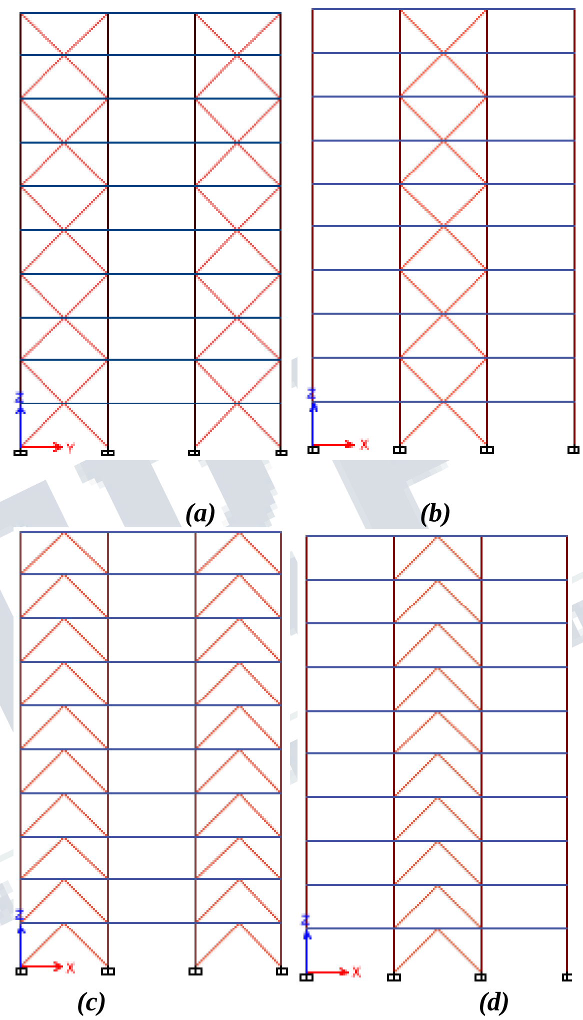

Fig 5 shows different bracing configurations and locations (a) X bracing at corners (b) X bracing atcentre (c) chevron bracing at corners (d) chevron bracing at centre.

V. RESULTS AND DISCUSSIONS

5.1 Results

From the response spectrum analysis performed for the frames with varying configuration following results are obtained. In this study the parameters like base shear and storey drift are analysed.

5.1.1 Base shear for the bracings arranged in central bay

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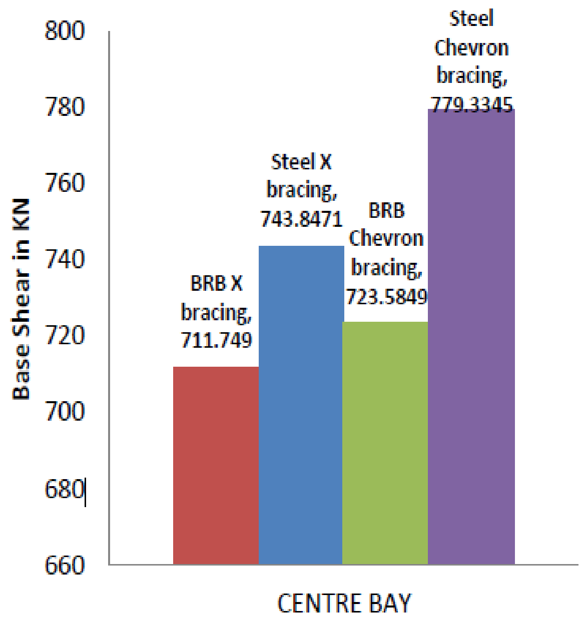
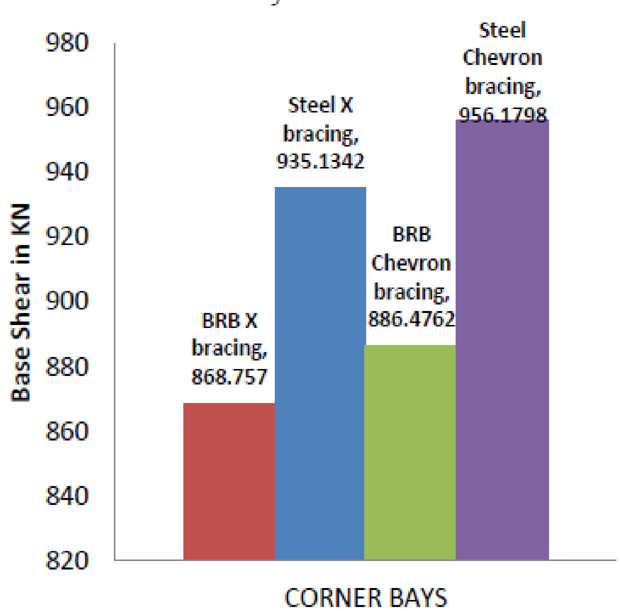
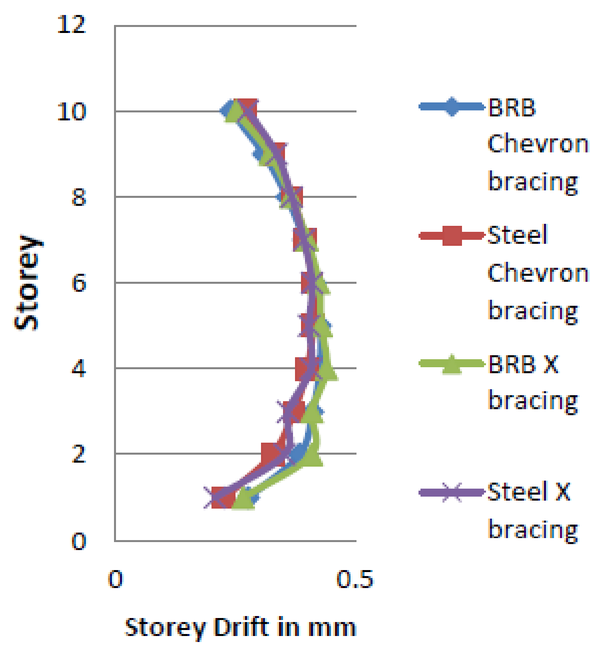


5.1.2 Base shear for the bracings arranged in corner
bay

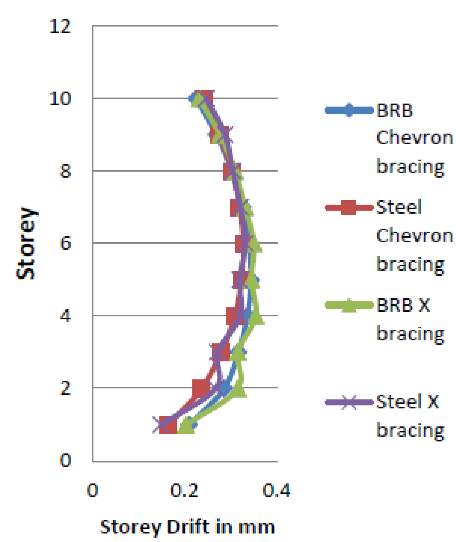


5.1.3 Storey v/s Storey Drift for bracings in central

bay



5.1.3 Storey v/s Storey Drift for bracings in corner
bays



The response of the frames is plotted for only in one direction i.e., X direction since the plan of the building is square. Results of base shear and storey drift are plotted separately for bracings arranged in central bay and bracings in corner bays.

5.2 Discussions

The response of the frames with four different configurations of braces for each type of bracing system i.e., BRBF and Conventional bracing system are analysed under the earthquake loading. Two parameters are plotted and discussion is made out as follows.

The Buckling restrained braces with X pattern shows lower values of base shear in both the cases of bracing arrangement i.e., in central bay and corner bays. In both case of bracings arrangement, steel chevron bracings give higher values of base shear. Comparing the above values of base shear, BRB frames with X pattern of bracings perform better during the earthquake event.

The storey v/s storey drift plot for both cases shows BRB arranged in X and chevron pattern shows higher values of drift at the bottom stories whereas at top storey level it shows lower vales compared to other bracing pattern. Drift values of conventional steel braced frames are almost similar to the BRB braced frames but slightly higher value at top storey level. This shows that the drift decreases with increase in height of the building.

VI. CONCLUSIONS

From the above parametric study comparing all the configuration and pattern of both the bracing system of frames, the Buckling restrained brace with X pattern arranged in central bay gives better results with lower base shear and lower drift values at the top storey level. Thus BRB with x pattern is stable compared to other bracing pattern. When conventional braces are compared with BRB braces for all type of bracing arrangement, frames with BRB are safe for utility than the conventional braced frames.

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