Design And Development Of Buckling Restrained Braces Using Matlab.

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Abstract: Earthquake forces on structure are of great concern to the engineers. To minimize the effects of an earthquake and lateral loads, the steel braced frames are used. It is one of the systems which plays an effective role in resisting the lateral loads the new type of bracing system called buckling restrained braces are introduced to overcome the drawbacks of conventional bracing system. The project work is to study buckling restrained braces. The analysis is done using MATLAB. In the present study, a code for a building model is developed to analyze the behaviour of the structure without BRB. Time history method is used to determine the dynamic response of the structure. A mathematical model was created to perform modal time history analysis. Time stepping was performed using Newmark's Beta modified for linear acceleration. The response parameters such as Base Shear, Story displacement, Time period, Inter-story drift are evaluated to study the structural performance. The same model results are validated in ETABS v16. Further, a code will be developed for a building structure with BRB to compare the response of both structures.

Index Terms— Buckling restrained brace, Base shear, Displacement, MATLAB, Story Drift Time-period, Time history analysis.

1 INTRODUCTION

There are various technology and equipment's which are used for the construction of a structure. Despite of these technologies a structure may be influenced by an earthquake. Ultimately leading to loss of property and human life in the area where earthquake has occurred. Thus, it has become essential for engineers to consider the earthquake effect and to construct a structure to resist earthquake forces. The earthquake in the past have provided the engineers with sufficient information for its considerations, leading to the development of different techniques. Normally during an earthquake, the ground movement to the structure. Resulting into damage of structure

A braced frame is a structural system commonly used in structures subject to lateral loads such as wind and seismic pressure. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression.

Buckling restrained braces are widely used all around the world to strengthen structure against seismic load, it was first implemented in Japan in late 20th century such as those in Japan, USA, Taiwan, China, Turkey, and New Zealand. There are many of approaches available in various codes although they don't necessary consider all aspects

Buckling Restrain Braced frame is an effective type of LLRS to increase seismic performance of the building. It is designed so that the building resists cyclic lateral loadings, typically induced due to earthquake one. If the BRBF designed carefully it provides advantage to a system by which the inherent ductility of a mild steel can be translated in to system ductility which there by controls the seismic response of the structure to a harmful earthquake and presents an effective alternative to conventionally braced frames.

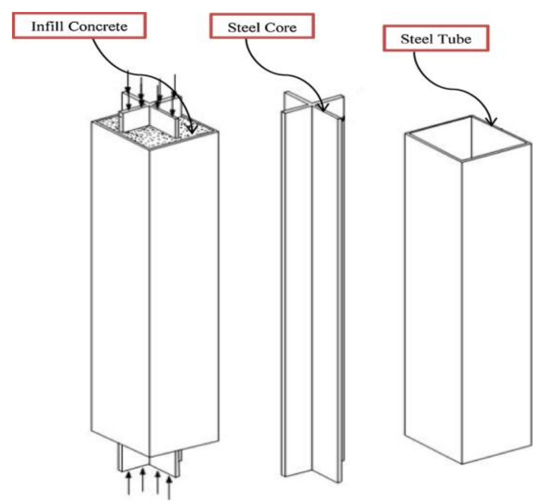

Fig. 1. Components of BRB

The core is designed for resisting axial force developed on the brace. Its area is much lower than regular brace, since its restrained against buckling. The core designed for yielding inelastically in during design earthquake. Increased area of the non-yielding section makes sure that it remains elastic, and thus plasticity is concentrated in the middle part of the core.

The bond preventing layer ensures decoupling between casing and core to prevent interaction between them. For this purpose, air gaps, special chemical or tapes can be used. The layer allows the steel core only to resist axial force developed.

The metal casing is provided with concrete infill which provides lateral support against flexural buckling of core. The casing is typically made of steel tubes. The design for casing is such that it provides adequate rigidity for resisting the core buckling.

The objective of this study is to study different approaches to design Buckling restrained Braces, develop a code to perform

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seismic analysis of a structure and compare the behavior of structure with and without BRB.

2. Research Methodology

The analysis of seismic response of a G+6 for validation purpose and G+10 storied building is done using MATLAB which gives the output in form of Time period, Frequency, Mode Shapes, Displacement, Base Shear, Storey Shear, Intra story Drift, etc. The structure was designed and checked for serviceability. The input requirements are seismic weight and lateral stiffness of each floor of the structure. The demand for lateral load was calculated by time history analysis by Newmark's modified method.

A. Seismic analysis of Building-

The MDOF system is analysed using Modal analysis. The equation of motion for MDOF system is given by:

$$[m]\{\ddot{u}(t)\} + [c]\{\dot{u}(t)\} + [k]\{u(t)\} = -[m]\{r\}\ddot{u}_g(t) \qquad \ldots(1)$$

where,
[m]= Mass matrix (n x n);
[k] =Stiffness matrix (n x n);
[e] =Damping matrix (X):
{r}=Influence coefficient vector (nx1);

Normalizing the uncoupled equation (1) by expressing the mass matrix [m] and expressing in terms of damping ratio ζ and frequency ω it can be written as,

$$\ddot{u}(t) + 2\zeta\omega_i\dot{u}(t) + \omega_i^2 u(t) = -\Gamma\ \ddot{u}_g(t) \qquad \ldots.(2)$$

Mode shapes, Frequency, Displacements, etc for undamped system are obtained by using the equation:

$| [k]-w^2 [m] | = 0$

Where,
k = Stiffness of floor
m= Mass on Each floor
w= Natural frequency

B. Design of Buckling Restrained Brace.

The story shear from each floor is used for the demand for design of BRB.

$$Area_{brb} = (Pu * Cos^2\theta) / (\phi * Fysc)$$

Where,
Pu = Storey shear.
θ= Angle of brace with respect to x-axis

Ø = 0.9, Strength reduction factor.

Stiffness of provided BRB is K_{br} =1.3(A*E)/L

C. Modelling

A G+10 storey RC frame with 4 bays is considered for analysis without buckling restrained braces. The Frame has 4 bays of 5m. The storey height is 3m for all floors. The seismic analysis is done by time history analysis by applying El Centro and Bhuj ground motion data.

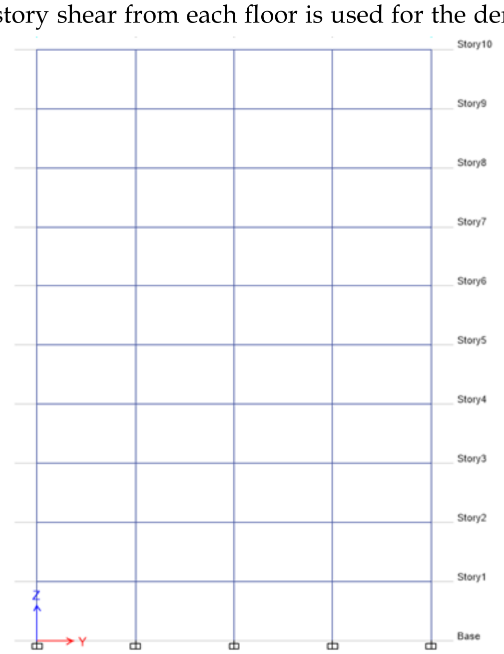
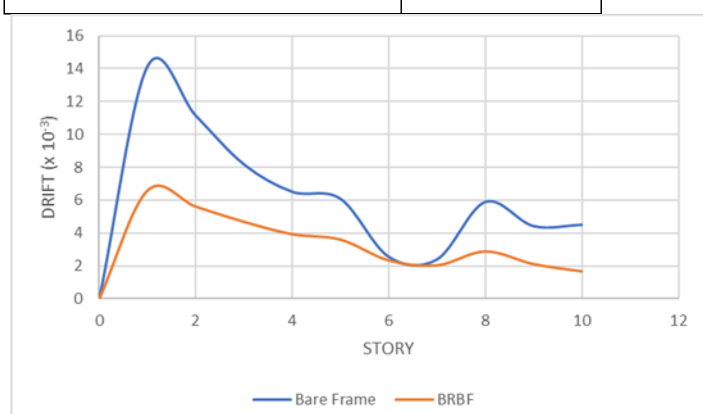


Fig. 2 Elevation of Structure

Table 1.
Material Properties And Section Details

Parameter	Value
Grade of Concrete Used	M25
Elastic Modulus of Concrete	25000 Mpa
Unit Weight of concrete	25 kN/m³
Lateral Stiffness of each floor	33092.2kN/m
Seismic Mass of each Floor	72843 Kg
Damping Ratio	2%
Size of columns	230 x 450 mm
Size of beams	230 x 400 mm
Response Spectra Data	El Centro



For validation, a code for G+6 storey building is developed in MATLAB and the results are compared with a similar model in ETABS. Seismic response results of the structure obtained from both software are follows.

TABLE 2. ETABS RESULT

Parameter	ETABS	Newmark's Modified
Maximum Displacement at top floor	42mm	46mm
Time Period	0.480sec	0.539sec

3. RESULTS.

A. Base shear

Application of buckling restrained braces showed an increase in base shear of building the results are as below.

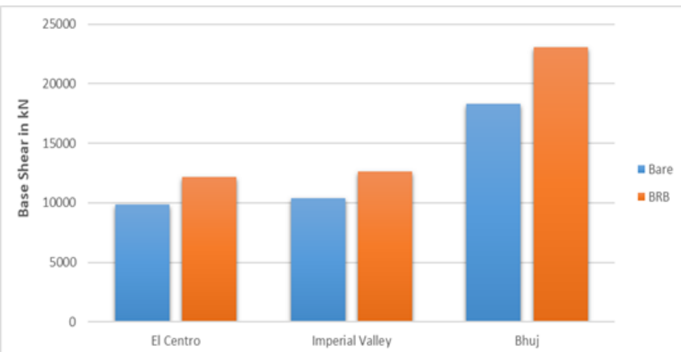


Fig. 3 Comparison of Base shear.

B. Story Drift

Installation of BRB shows a considerable amount of reduction in inter-story drift. The maximum observed reduction was 42%.

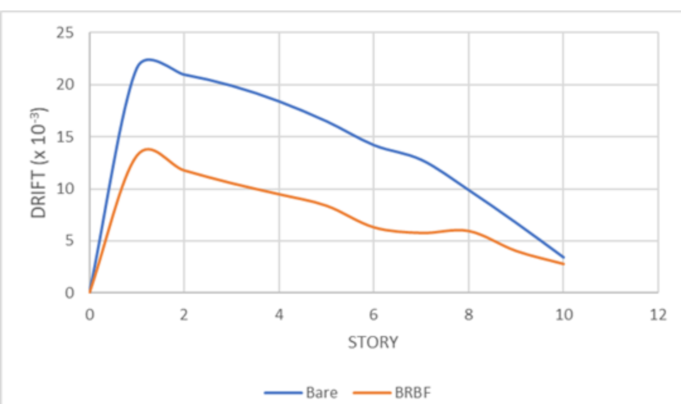


Fig. 4 Story Drift for Bhuj.

Fig. 4 Story Drift for El Centro

C. Story Displacement.

For both frames the displacement is maximum at top level. Hence only displacement at roof level is compared. Story displacement of braced frame is less than bare frame. Comparing the story displacement, it is observed that there is a decrease in the displacement of BRB frame by 45.8%

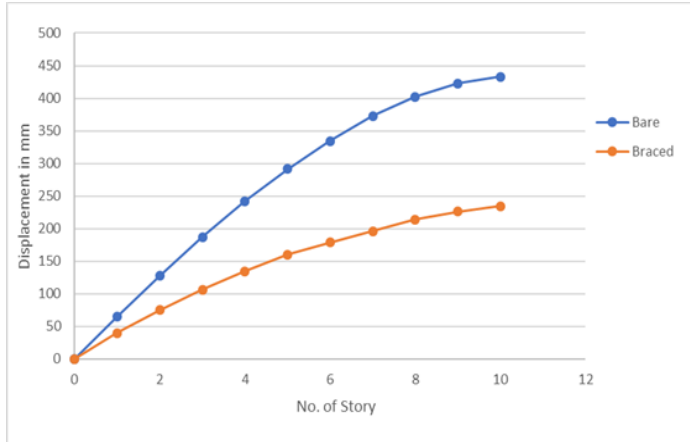


Fig. 5 Story Displacement for Bhuj.

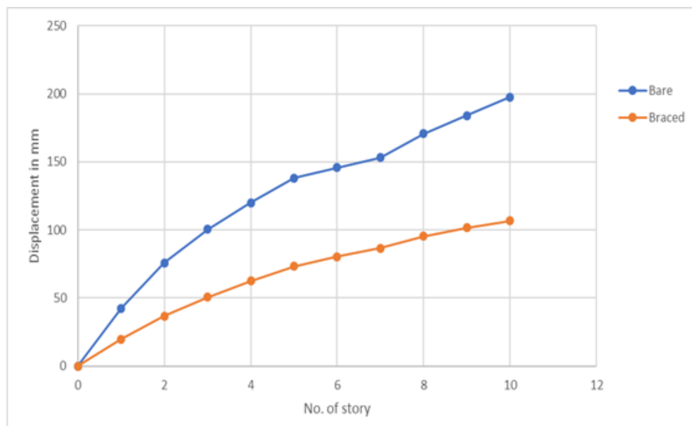


Fig. 6 Story displacement for El Centro

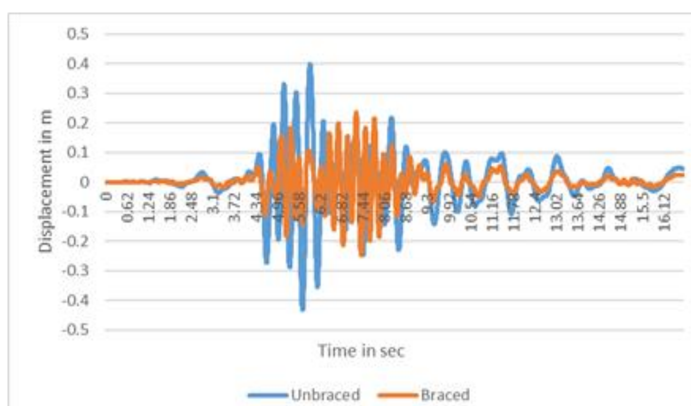


Fig. 8. Top story displacement response for Bhuj

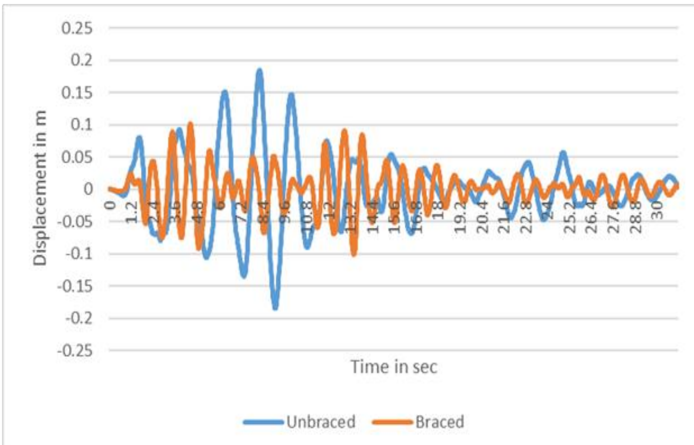


Fig. 9. Top story displacement response for El Centro

4. Conclusion.

In this study of RC building with and without BRB the seismic performance was observed as follow

- After the application of there was a increase of 26% in the base shear
- The inter story drift was decreased by 42%.
- Displacement was decreased by 45.8% as compared to bare frame structure.
- Buckling restrained brace provided control over seismic performance of structure

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