SEISMIC PERFORMANCE OF FRAMED STRUCTURE WITH BUCKLING RESTRAINED BRACES & DAMPERS- A REVIEW

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Abstract
Many existing RC buildings & Steel Frames do not meet the lateral strength requirements of current seismic codes and are vulnerable to significant damage in the event of future earthquake. The seismic performance assessment of steel moment-resisting frame (SMRF) was carried out by nonlinear time history analysis. The lateral strength of structure was improved by using Energy Dissipating Devices (EDD) these devices either alone or in combination. The Viscous Fluid Damper (VFD) is found to be a good EDD as it significantly improves the performance of the RCC & Steel frame at all levels of seismic analysis.

Keywords: steel moment-resisting frame; viscous fluid damper; buckling-restrained brace; passive energy dissipation devices;

I. INTRODUCTION

Steel moment-resisting frame (SMRF) with open first storey (Soft Storey) is known to perform well as compared to the reinforced cement concrete (RCC) frames during strong earthquake shaking (FEMA 2000).

RCC framed structures are more durable and have less maintenance, but they have a disadvantage of being less ductile in lateral direction. It is found that RCC columns and beams fail in bending and torsion which causes exposure of steel during earthquake. Occupant's functional needs for parking vehicles, provision of shops on ground floor etc. are the reasons due to which provision for open first few stories in high rise building.

In High Rise building parking floor cannot be avoided. But, in Multistoried buildings with soft storey are vulnerable to collapse due to earthquake loads. From literature, it can be observed that the current practice of multi-storied building with a soft first storey for earthquake forces is without consideration in reduction of stiffness at first floor.

The sudden reduction in stiffness is the most important part of the building analysis as it affects the concentration of forces (Magar Patil and Jangid 2012)

II. LITERATURE REVIEW

Dia Eddin Nassani, Ali Khalid Hussein, Abbas Haraj Mohammed (ELSEVIER 2017) [1]

In this paper a comparison of the seismic response of steel frames is carried out using different types of bracing systems namely X-braced frames, V braced frames, inverted V braced frames, Knee braced frames and zipper braced frames. The steel frames are modeled; nonlinear static and dynamic analysis is carried out in four different height levels. The frames consist of three bays and steel braces were inserted in the middle bay of each frame. The structural responses of frames are studied in terms of capacity curve, drift ratio, global damage index, base shear, storey displacements, roof displacement time history and plastification. The results showed a good improvement in the seismic resistance of frames with the incorporation of bracing. The results revealed that the bracing elements were very effective in diminishing drifts since the reduction of inter-storey drifts with respect to unbraced frames were on the average 58%. Also steel braces considerably reduced the global damage index.

Hamdy Abou-Elfath , Mostafa Ramadan, Fozeya Omar Alkanai (ELSEVIER 2016) [2]

This study evaluates the seismic upgrading of a 6-story RC building using single diagonal buckling restrained braces. Here seismic evaluation study is carried out using static pushover analysis and time history analysis. Ten ground motions with different PGA levels are used in the analysis. The mean plus one standard deviation values of the roof-drift ratio, the maximum story drift ratio, the brace ductility factors and the member strain responses are used as the basis for the seismic performance evaluations.

The results obtained in this study indicate that strengthening of RC buildings with buckling restrained braces is an efficient technique as it significantly increases the PGA capacity of the RC buildings.

The results also indicate the increase in the PGA capacity of the RC building with the increase in the amount of the braces

H.R. Magar Patil* and R.S. Jangid (Taylor & Fransis 2015) [3]

In this paper the seismic performance assessment of modified steel moment-resisting frame (SMRF) was carried out by nonlinear timehistory analysis. The basic bare SMRF was reduced in strength first and then enhanced by installing passive energy dissipating devices (EDDs) to develop modified frame. Passive EDDs comprise both rate-dependent and rate-independent devices. Viscous fluid damper (VFD) is a rate-dependent device whereas buckling-restrained brace is a rate-independent device. The lateral strength of structure was improved by using these devices either alone or in combination.

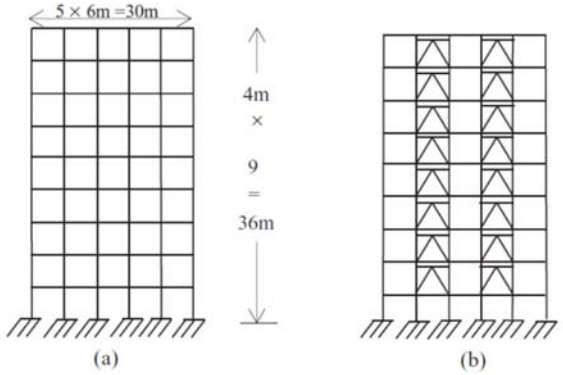

Figure 1.Structural models: (a) SMRF; (b) MSMRF installed with EDD.

Seven-scaled time-history records were used for incremental dynamic analysis. The stiffness effect on the stories is demonstrated through the lateral displacement profile of the building. The VFD is found to be a good EDD as it significantly improved the performance of the frame at all levels of seismic analysis.

Hector Guerrero a, Tianjian Ji a, Amador Teran-Gilmore b, J. Alberto Escobar c (ELSEVIER 2016) [4]

This paper proposes a method for preliminary Performance-Based Seismic Design (PBSD) of low-rise structures provided with Buckling-Restrained Braces (BRBs). It is assumed that a frame structure protected with BRBs, termed as a dual structure, is rationally represented by a dual single-degree-of freedom (SDOF) oscillator whose parts yield at different displacement levels. The formulation of the method is presented for SDOF structures.

Here this simplification is validated using a case study example. Comparison of the responses between conventional and dual structures shows that, when designing dual structures, the common practice of using conventional design spectra may lead to biased designs. One of the main advantages of the method is that, during its application, information useful for preliminary and quick assessment of structures is generated, facilitating the application of the PBSD philosophy.

A case study example is conducted to show its applicability and its potential for preliminary assessment of structures. Here main limitation is that this method is valid for low-rise regular buildings with rigid in-plane diaphragms, and whose dynamic response is controlled by their fundamental mode of vibration.

Sh. Hosseinzadeh, B. Mohebi (ELSEVIER 2016) [5]

In this paper All-steel buckling restrained braces (BRBs) are a newly developed main variation is that here ordinary BRBs characteristics such as weight and curing of core mortar are enhanced. In this study Finite element (FE) models of all-steel BRBs with varied geometries were subjected to cyclic analyses. The satisfactory brace geometries that minimized instability of the core section while maximizing energy dissipation capacity were then identified.

Bilinear FE-derived back-bone curves of the selected BRBs were subsequently used in the representative truss elements to retrofit three 4-, 8-, and 12-story frames.
The advantages of these braces were highlighted by drawing performance comparisons against ordinary braces. Nonlinear static and dynamic responses of the frames with all-steel BRBs were also assessed in terms of parameters such as maximum inelastic deformation demand.

Jiulin Bai , Jinping Ou (ELSEVIER 2016) [6]
In this study, a performance-based plastic design (PBPD) method for dual system of buckling-restrained braced reinforced concrete moment-resisting frames (RC-BRBFs) is developed. Trilinear force–deformation relationship of the dual RC-BRBF system was approximated as the bilinear capacity curve to derive the yield displacement. The design base shear was determined based on the energy balance equation which accounted for the energy dissipation capacity quantified by Large Takeda model. Plastic design procedure was presented to derive the section internal forces.

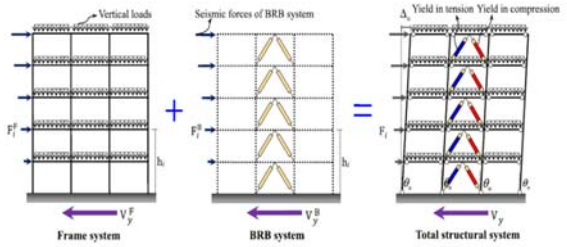

Figure.2. Schematic of RC-BRBF system yielding in a global mechanism under gravity and seismic loads

The proposed methodology was verified through a 5- and 10-story RC frame structures with chevron-configured BRBs. Numerical model was established and validated to assess the seismic performance through nonlinear static pushover analysis and time history analyses using FEMA P695 recommended ground motions.
The analytical results show both RC-BRBFs can achieve the intended performance levels in terms of capacity curves, yield mechanism, story drift ratio distribution, residual drift, maximum ductility and cumulative ductility demands. Furthermore, the developed design procedure can be easily extended to other BRB configurated dual structural systems to achieve the desired seismic performance.

Ozgur Atlayan a, Finley A. Charney b (ELSEVIER 2014) [7]
This paper introduces a new structural steel system called hybrid buckling-restrained braced frame (BRBF). The “hybrid” term for the BRBF system comes from the use of different steel materials, including carbon steel (A36), high-performance steel (HPS) and low yield point (LYP) steel in the core of the brace.
In this study Variety of BRBF models are analyzed with Nonlinear static pushover and nonlinear incremental dynamic analysis and comparison is carried out with seismic behavior of standard and hybrid BRBF systems.
Results shows that Hybrid BRBF systems are shown to have a significant improvement over standard BRBF systems in terms of various damage measures including a significant reduction in the problematic residual displacements of the standard BRBFs.

Quan Gu , Alessandro Zona , Yi Penga, Andrea Dall Asta (ELSEVIER 2014) [8]
This paper illustrates the derivation of response sensitivities for a hysteretic model specifically developed for buckling-restrained braces (BRBs) in order to provide a tool that can be used to evaluate the effect of BRB constitutive parameters on structural response as well as a tool in gradient-based methods in structural optimization, structural reliability analysis, and model updating.
Results for a case study consisting of a steel frame with BRBs subjected to seismic input are reported to illustrate the influence on global and local structural response quantities of the BRB constitutive parameters. In addition, the derived response sensitivities are used in a simulated finite element model updating problem to show the efficiency of DDM over FDM.
This work opens the way to many applications and potentialities such as sensitivity analysis of complex BRB design solutions, performance-based selection of optimal BRB properties, development and use of optimization-based design procedures.

Mingming Jia, Dagang Lu, Lanhui Guo, Lin Sun (ELSEVIER 2013) [9]

In this paper the pseudo-static tests (PSTs) of one 1/3 scale 2-story 1-bay buckling-restrained braced composite frame (BRBCF) system consisting of concrete-filled circular hollow section (CHS) steel columns, steel beams and BRBs were tested in Harbin Institute of Technology, a same bare composite frame (CF) was tested to compare with BRBCF.

The test BRBCF exhibited excellent performance and sustained no strength or stiffness degradation during the significant drift demands imposed by the subsequent quasi-static cyclic test, which possessed good ductility and energy dissipation capacity. Compared with CF system, the stiffness load-bearing capacity and energy dissipation capacity of BRBCF system increased evidently. The welded splices beam–column-BRB connections are cheap joints and are convenient to install BRBs in construction site, the experiment demonstrated their ability to withstand major ductility demands.

The BRBs didn't show global buckling, local buckling and fracture of inner cores. Test also found the damage in beam–column–BRB connections region, including fractures of the gusset and beam welds, local buckling of flanges and webs of beams and enforced loops due to frame and brace action forces, which should be considered in the design of BRBCF.

For frames using the proposed gusset connection, the maximum frame drift prior to failure will be governed by the rotational capacity of the beam to- column connection, not the axial deformation of the BRB. The fracture and buckle of CHS steel tubes at the first story base indicated the thickness of CHS steel tube of composite columns in BRBCF should be enlarged to avoid the early failure of composite columns.

III. CONCLUSIONS

From this review we conclude that due to lateral force that is generated due to seismicity or wind structures may damage to reduce this lateral force in the steel & RCC frames we use different types of Bracing systems and Dampers. Either of these types of system provided in the building to reduce storey drift, displacement and base shear. Recently combination of VFD and Buckling Restrained Bracing Systems are installed in the building and performance of the structure is studied. It is found that they perform well as compared to buildings provided with only Buckling Restrained Braces. This type of system can either be used in soft storey or can also be used for existing structures.

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