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A Review Paper on Analytical Study on Seismic Response Control of Multistory RC Building Frame Using Various Types of Bracing Systems

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Abstract: *Earthquake induces lateral forces on the parent element of building. Columns are the primary lateral load resisting element of building, so to reduce the effect of earthquake on building structure bracing systems are effectively used now a days as bracing system is lateral force resisting system. The lateral forces on columns is transmitted to braces through beam column joints axially. Bracing members descends the lateral deflection of the building by buckling and yielding during axial compression and tension respectively. Braces can be installed within frames in various configurations like diagonal, X, V (chevron), inverted V and K. This paper presents a review of the previous work on seismic response control of multistory RC building using various types of bracing system.*

Keywords: *RCC Frame Structure, Multi Storey, Bracing System, Non linear Dynamic Time History Analysis.*

I. Introduction

The multi-storied edifice were susceptible against natural hazards like earthquake which was life threatening for the residents. With the advancement in engineering practices, researchers developed systems which reduced the effects of seismicity on the engineered structures. One such evolution which is added to the buildings is bracing system. The modern structural protective system is categorized into three major categories: Seismic Isolation System, Passive Energy Dissipation Devices and Semi Active and Active Energy Dissipation Devices. These energy dissipation devices When gets installed inside any structure curtails response due to the seismicity of earthquake ground motion. All these devices have their advantages and disadvantages but prove to be effective in improving response of structure.

Bracing system are of two type

1) Concentric Bracing
2) Eccentric Bracing

1) Concentric Bracing

Concentric brace frame are those in which the centerline of member that meet at a joint intersect at a same work point to form a vertical truss system that resist lateral forces. The type of concentric bracing include X-Bracing, V-Bracing, Inverted V-Bracing, K-Bracing, Diagonal Bracing etc.

2) Eccentric Bracing

Eccentric brace frame are those in which the members are not connected to joint to joint & bracing connect to separate work point on beam/girder. The type of eccentric bracing include X-knee bracing, V and Inverted V-knee bracing, knee diagonal bracing system.

Following are the modern structural protective system which is categorized into three major category.

1) Seismic Isolation System
2) Passive Energy dissipation Device
3) Semi active & Active Energy Dissipation device.

II. Litrature Review

Moghaddam H. - A methodology for optimization of the dynamic response of concentrically braced steel frames subjected to seismic excitation, based on the concept of uniform distribution of deformation. In order to obtain the optimum distribution of structural properties, an iterative optimization procedure has been adopted. In this approach, the structural properties are modified so that inefficient material is gradually shifted from strong to weak areas of a structure. This process is continued until a state of uniform deformation is achieved. It is shown that the seismic performance of such a structure is optimal, and behaves generally better than those

designed by conventional methods. In order to avoid onerous analysis of the frame models, an equivalent procedure is introduced for performing the optimization procedure on the modified reduced shear-building model of the frames, which is shown to be accurate enough for design purposes.

Hjelmstad K. D. and Popov E. P. - Researched on the eccentrically braced steel frames for efficiently reducing the structural damages during seismic disturbances. The two experimentally validated their research. For that they have chosen two building of three and six storey. But prior to their field experimentation the duo implemented the suit on a single storey single bay frame. For the simple system, the lateral stiffness can be expressed in terms of the relative bending, shear, and axial stiffness of the members (EI, GA', and EA, respectively, in which E and G = elastic modulus; I = the moment of inertia; A = the total area; and A' = the shear area) and the topological parameters e/L and h/L. They concluded that eccentrically braced frames are more efficient in meeting drift control requirements than moment resisting frames. As a consequence, the bending moments imposed by the beams on the columns are also smaller, resulting in less expensive connections and the possible elimination of doubler plates in the column panel zones. Since the link beams limit the axial forces that may develop in the braces, the possibility of their buckling can be eliminated. This gives eccentrically braced frames a considerable advantage over concentrically braced frames.

Maheri M. R. and Sahebi A. -Investigated the use of steel bracing in concrete-framed structures. The research is carried out through a series of tests conducted on a number of model frames. The objective of the tests was to determine the degree of effectiveness of different diagonal bracing arrangements to increase the in-plane shear strength of the concrete frame and to observe the relative behaviour of tension and compression braces. Due importance was given to the connection between the steel braces and the concrete frame. The test results indicate a considerable increase in the in-plane strength of the frame due to steel bracing. As an overall conclusion it is noted that, with proper connection between the brace and the frame, the steel bracing could be a viable alternative or supplement to shear walls in concrete framed buildings in seismic areas**.**

Qiu C.-X. And Zhu S. - Investigated seismic-resisting, multi-story steel frames with self-centering braces (SCBs) numerically through pushover and incremental dynamic analyses. The seismic performance of self-centering braced frames (SC-BFs) is systematically compared with that of buckling-restrained braced frames (BRBFs), with emphasis on high-mode effect. The concentration of inter-story drift in the upper part of the buildings is more significant in SC-BFs than in BRBFs as a result of this effect. This high-mode effect strengthens with the increasing intensity of ground motions. Parametric studies indicate that increasing the post-yield stiffness ratio and/or energy dissipation capacity can successfully improve the seismic performance of SC-BFs, particularly in terms of limiting the high-mode effect. SC-BFs with enhanced post-yield stiffness and energy dissipation capacity exhibit relatively uniform inter-story drift ratios and reduced record-to-record variability in seismic performance.

Youssef et al. - Worked on the performance evaluation of reinforced concrete frame building with steel bracing system. An experimental investigation evaluated the performance of metallic X brace element. Two RC frames were modeled one with moderate ductility and other with braces in accordance with International Building Code (IBC) and ACI 318 - 02. Two cyclic load tests were conducted on moment resisting frame and braced frame. The RC frame had four stories in it. The braces were connected to the RC frame with the help of gusset plate welded together. A pushover analysis was conducted on the cast specimen and the results revealed that bracings reduced ductility demands on the primary structural members. Bare frame starts yielding at a load of 45 kN and failed at 55 kN load. Whereas the braced frame yielded at a load of 105 kN and failed at a load of 140 kN. The experimental work should have been carried out with V, Inverted V and K bracing system to find the effective bracing system.

Sarno and Elnashi - Studied the seismic performance of steel moment resisting frame and frame with bracing system. Three types of bracing system used are Special Concentrically Braces (SCBF's), Buckling Restrained Braces (BRB's) and Mega Braces (MBF's). A nine storey steel building was modeled with insufficient lateral stiffness so that the code drift limitations in high seismicity zone are not satisfied. Retrofitting of the structure was carried out with the help SCBF's, BRB's and MBF's. An inelastic time history analysis was carried out to access the performance of the modeled structure. Comparative results were accessed in the form of plastic rotation of the member, inter storey drift and roof storey displacement. Results concluded that the roof storey displacement of the Mega Brace Frame is 70% lower than Moment Resisting frame and 50% lower than Special Concentrically Brace Frame. Further investigation stated that Buckling Restrained Mega Brace Frame is superior than Mega Brace Frame. To find the yield point and formation of hinges pushover analysis should also be carried out.

Valente - Numerically investigates performance of new type of bracing system in area of high seismicity. Proposed bracing system by researcher consist of a ductile shear panel attached to the 'I' section short bracing at the four corner of shear plate by bolted connections. The braces are not designed to show the ductile behavior but the shear plate provides adequate ductility. An energy based design procedure is adopted for designing the frames with shear panels and concentric X bracing system. To measure the effectiveness of the bracing system a

four storey RC frame was designed only for gravity loads. Nonlinear dynamic analysis was carried out imposing seven accelerogram on the designed structure. Results were concluded in the form of top storey displacement, interstorey drift and energy dissipation capacity. Conclusions of the results were in favour of shear panel bracing system. There was a reduction in displacement of top storey and also the inter storey drift. Dissipation of energy increased in case of shear panel bracing system in comparison to the bare frame. For accessing the sequence of plastic hinge formation pushover analysis should be carried out.

Bahey and Bruneau - Applied the structural fuse concept to retrofit reinforced concrete bridge bents. Objective of investigation aimed at keeping the bridge piers elastic by the inelastic deformation of the structural fuse. This innovative technique could be applied on new construction as well as to the old structure for retrofitting purpose. Buckling restrained braces of mild steel were used as structural fuse element. Nonlinear dynamic time history analysis was carried out to analyze the modeled structure. Graphical representation were used to find admissible solution and shows that as the frame strength increases larger fuse element is required to achieve effective structural fuse concept. Different bracing system could be used to enhance the concept of metallic fuse.

Moghaddam et al. - Researched on a new concept of optimizing the dynamic response of concentrically braced steel frame subjected to the seismic excitation based on the concept of uniform distribution of deformation. In this procedure the modification of structural properties occurs in such a manner that the inefficient material is shifted from strong zone to the weak zone and this procedure is continued till uniform deformation is achieved. For the sake of carrying out analysis three steel buildings were modeled with storey variation of 5, 10 and 15 with concentric steel braces. The building was assumed to be located seismic zone 4 of UBC with a PGA of 0.44g and all connections are considered to be simple. Nonlinear static and dynamic analysis was carried out with the help of DRAIN - 2D programming software. Four ground motion records were imposed on to the building. Results concluded that optimization procedure based on the concept of uniform distribution of deformation reduced the deformation demand for the optimum model considered compared to conventional model. For steel buildings eccentric type of bracing system is more robust than concentric type.

III. Conclusion on Literature

Various researchers investigated on concept of metallic fuse and carried out experimental and analytical investigation using metallic damper, bracing system and buckling restrained braces as metallic fuse element. The buckling restrained braces are the types of braces that do not buckle during while mitigating with axial compressive force. Almost all researchers have used either pushover procedure or nonlinear dynamic time history analysis for the evaluation of concept. It is necessary to use both procedures for verifying the performance of the building structure. Non linear analysis is essentially performed because linear analysis does not give full insight of the structure whereas performing non linear analysis enables researchers to have a broader view with what is happening to the structure when the induced earthquake exceeds the elastic limit of the structure.

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