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SEISMIC PERFORMANCE OF BUILDING WITH BASE ISOLATION, DAMPER AND BRACED SYSTEM:A REVIEW

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ABSTRACT:*Non-structural components are sensitive to large ground motion which produces floor accelerations, velocities, and displacements. During an earthquake, the building produces this motion, resulting in peak floor accelerations higher than the peak ground acceleration. Thus earthquake ground motion can cause significant or severe structural damages. Therefore the needs of structural response control system increase worldwide. These paper deals with review of structures with some most worldwide used structural system such as base isolation, damper and bracing. Paper also comprises recent development in these control systems with their structural reduction efficiency.*

KEY WORDS: *Seismic performance, base isolation, damper, bracing, time history analysis, pushes over analysis*

I. Introduction

For seismic design of building structures, the traditional method, i.e., strengthening theStiffness, strength, and ductility of the structures, has been in common use for a long time. Therefore, the dimensions of structural members and the consumption of material are expected to be increased, which leads to higher cost of the buildings as well as larger seismic responses due to larger stiffness of the structures. Thus, the efficiency of the traditional method is constrained. To overcome these disadvantages associated with the traditional method, many vibration-control measures, called structural control, have been studied and remarkable advances in this respect have been made over recent years. Structural Control is a diverse field of study. Structural Control is the one of the areas of current research aims to reduce structural vibrations during loading such as earthquakes and strong winds.

In terms of different vibration absorption methods, structural control can be classified into active control, passive control, hybrid control, semi-active control. Base isolation is a passive vibration control system that does not require any external power source for its operation and utilizes the motion of the structure to develop the control forces. Theapplication of this technology may keep the building to remain essentially elastic and thus ensure safety during large earthquakes. Since a base-isolated structure has fundamental frequency lower than both its fixed base frequency and the dominant frequencies of ground motion, the first mode of vibration of isolated structure involves deformation only in the isolation system whereas superstructure remains almost rigid.

Viscous dampers are hydraulic devices that dissipate the kinetic energy of seismic events and cushion the impact between structures. They are versatile and can be designed to allow free movement as well as controlled damping of a structure to protect from wind load, thermal motion or seismic events.

The development of bracing made theconstruction of the skyscraper possible. Bracings are strong in compression. Bracing with their surrounding frames has to be considered for increase in lateral load resisting capacity of structure. When bracings are placed in Steel frame it behaves as diagonal compression strut and transmits compression force to another joint. Variations in the column stiffness can influence the mode of failure and lateral stiffness of the bracing.

II. Literature review

A) Review on base isolation

S.M. Kalantari [1] Investigated the effect of using two different types of seismic isolators in decreasing the base shear and story shears of structure. Four structural models with 2, 5, 8 and 12 stories for three cases including fixed-base, lead-rubber isolator and friction pendulum isolator with different stiffness have been modeled. All models have been analyzed under earthquake characteristics of Manjil, Naghan, Tabas and Elcentro using a nonlinear finite element program. The results indicate that by using lead-rubber isolators, maximum displacements of stories in low-rise structures have been increased in comparison with fixed-base model. In contrast, in majority of cases, applying the FPS isolators doesn't guarantee the displacement requirement. Also by using isolators, number of cycles related to displacement response would be decreased especially in models with lower stories. In short base isolated structures, the decrease in plastic hinge formation percent of elements was much more than in fixed-base structures.

C.P. Providakis [2] Performed nonlinear time history analyses using a commercial structural analysis software package to study the influence of isolation damping on base and superstructure drift. Various lead-rubber bearing (LRB) isolation systems were systematicallycompared and discussed for aseismic performances of two actual reinforced concrete (RC) buildings. Parametric analysis of the buildings fittedwith isolation devices was carried out to choose the appropriate design parameters. The efficiency of providing supplemental viscous damping forreducing the isolator displacements while keeping the substructure forces in reasonable ranges was also investigated.

Franco Braga [3] had done experimental studies on a series of dynamic snap-back tests. This test was carried out on a residence building in southern Italy at Rapolla (Potenza–Basilicata).Theaim ofthe research was to investigate the seismic behavior of low-rise base isolated structures mounted on rubber bearingsonly, or with a hybrid isolation system (sliding bearings for isolation and steel rubber bearings to have a re-centering force).

AbdolrahimJalali [4] carried out investigation on the effect of superstructure characteristics on performance of multi-story buildings isolated with lead-plug laminated rubber bearings.the superstructure characteristics considered at this research were superstructure mass, superstructure stiffness and superstructure damping, which were varied in the range that was compatible with engineering practice. Comparing the study results it has been observed that, there is optimum amount for each of the dynamic properties of the superstructure which will make design criteria achievable in seismic base-isolation of multi-story buildings. To this purpose, five reinforced concrete moment resisting frame buildings with two, five, nine, fourteen and twenty stories were considered. They were designed according to UBC97, in fixed-base form and base-isolated form. Five different amount for superstructure base-mass were assigned and 25 related models were created. Variations in superstructure stiffness and superstructure damping were considered in the same manner. All of 85 model buildings were subjected to five ground motion records which have been scaled to have PGA = 0.4g. Nonlinear time-history analyses of created models were conducted by using ETABS 8.5.0. Fundamental periods, modal participation factors and base-shears were studied for all of the model buildings. Comparing analysis results in term of base shear variations for different parameters considered, it was concluded that, superstructure characteristics have considerable effect on performance of isolated systems and optimal performance of base isolated multi-story buildings was achievable by modifying superstructure characteristics.

B) Review on dampers

Liya Mathew [5] studied reinforced concrete buildings with and without fluid viscous dampers. A parametric study for finding optimum damper properties for the reinforced concrete frames was conducted.Nonlinear time history analysis was done on a symmetrical square building. Analysis was carried out using SAP2000 software and comparisons were shown in graphical format.

ChaoYinglu [6] carried out case study on Pangu Plaza, located at Beijing close to 2008 Olympic main stadium, 191 meter, 39-story steel high-rise building, was analyzed under earthquake and wind loads by us, with both Fluid Viscous Dampers (FVD) and Buckling restrained braces (BRB or UBB), as the seismic protection system. A repeated iteration procedure of design and analysis was finished for the optimization. The complete seismic response on the horizontal and vertical directions was shown the Fluid Viscous Dampers are highly effective to reduce the structural response, as well as the secondary system response.

A.K. Sinha [7] discussed the use and effectiveness of fluid viscous dampers, for response control of structures and to reduce damping demand on structural system. In his paper he conducted anon-linear time history analysison a 3D model of a 12 story RCC MRF building using 3-directional synthetic accelerogram. Two different cases of building models with and without supplemental damping have been analyzed using ETABS. The story responses in terms of absolute maximum displacement and story drift have been compared. Time history response plots for the two models have also been compared for various responses viz. roof displacement and acceleration, base shear and story shear forces, along with the various energy components and damping behavior. The results of the time history analysis are in close conformation with previous investigations and represent the effectiveness of dampers in improving the structural response as well as damping demand on structural systems.

D B Raijiwala [8] investigated the influence of mechanical control on structural systems through strategically applying reliable dampers that can modulatethe response of building. SAP2000 nonlinear time history analysis program was applied to investigate the effects onbuilding such as normalized base shear, tip displacement, normalized acceleration and energy dissipation of damperelement by varying different important parameters namely Earthquake time histories, location of dampers, dampingcoefficient, damper stiffness, no of story of building. Comparison study is also presented between building installed withdampers, building installed with diagonal bracing, combination of both and simple building to show importance ofdamping system for reduction of seismic quantities.

C) Review on bracings

A Kadid [9] had done research on the seismic behavior of RC buildings strengthened with different types of steel braces, X-braced, inverted V braced, ZX braced, and Zipper braced. Static nonlinear pushover analysis has been conducted to estimate the capacity ofthree story and six story buildings with different brace-frame systems and different cross sections for the braces. It was found that adding braces enhances the global capacity of the buildings in terms of strength, deformation and ductilitycompared to the case with no bracing, and the X and Zipper bracing systems performed better depending on the typeand size of the cross section.

A. Ghobarah [10] studied The seismic performance of a low-rise nonductile reinforced concrete (RC) building rehabilitated using eccentric steel bracingA three-story office building was analyzed using various ground motion records. The effectiveness of the eccentric steel bracing in rehabilitating the building was examined. The effect of distributing the steel bracing over the height of the RCframe on the seismic performance of the rehabilitated building was studied. The behavior of the nonductile RC frame members isrepresented by a beam–column element capable of modeling the strength deterioration and the effect of the axial force on the yieldmoment and the deformation capacities at peak strength of the members. The link behavior was modeled using tri-linear momentand shear force representations. The performance of the building is evaluated in terms of story drifts and damage indices.

JensakKochanin [11] conducted experimental studies to examine the seismic behavior of a large-scale non-ductile RC specimen strengthened with BRBs. For the analytical study, a large number of dynamic analyses of non-ductile systems that were strengthenedusing ductile elements with varying strength were conducted to investigate the overall response behavior.Finally, a practical strengthening design method was presented. The method was based on the modifiedperformance-based plastic design approach. A design example was presented. Nonlinear pushoverand nonlinear time history analyses were conducted to evaluate the performance of a non-ductile RCframe strengthened with BRBs. Both the test and analysis results indicated that BRBs significantlyincreased the stiffness, lateral force capacity and energy dissipation.

Pooja Desai [12] investigated Behavior of concrete and steel X braces with varying storey height. Author of paper summarizes the seismic behavior of four structures with 5, 10, 15 and 20 story's and plan dimension of 25m x 15m. This structure was analyzed using equivalent static load method and response spectrum method in ETABS. Parameters such as base shear, displacement and natural time period were compared and presented in form of graph. It was observed that on adding bracings the seismic response of the structure was improved.

III. Conclusion

Based on studies of various research paper following conclusions are drawn

- Lead rubber isolators generally increase the maximum displacement of structures in low rise buildingscompared with fixed base structures but in high rise buildings the difference is negligible.
- In low-rise buildings, simple base-isolation has good performance and there is no need to modify the superstructure characteristics. Indeed, these modifications cannot have positive effect on isolation performance.
- In middle-rise buildings we can reach better isolation by assigning additional base-mass and increasing the damping of superstructure.
- In high-rise buildings, stiffening superstructure and increasing the damping will cause an effective base-isolation.
- The located dampers can play important role in reducing the located response, i.e. four dampers can reduce the top acceleration on the top cantilever truss obviously.
- Even though the FVDs have significantly reduced the responses, the damping demand of structure can be further reduced by optimum selection and installation of FVDs at various critical locations.
- Comparison between Building with dampers and Building with braces showed that dampers are more significant to reduce seismic quantities withsame direction of placement as brace.
- Eccentric bracing exhibited lower deformation and damage when subjected to earthquake ground motions as compared to the behavior of the concentric bracing case.
- The energy dissipation of the frame strengthened with BRBs could be as much as 10 times higher than that of the RC bare frame.
- The BRBs significantly reduced the possibility of having the soft-story mechanism present in the existing frame.

IV. Critical remark

- The research can be taken to next level and seismic response of reinforce concrete structure with different height with base isolation; damper and bracing can be analyze.
- Effectiveness of base isolation, damper and bracing can be check by analyze steel structures with these seismic response resisting systems.

- The efficiency of base isolated building, braced building and building with damper can be analyze with building located at different earthquake zone.

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