REVIEW ON BASE ISOLATED STRUCTURES

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Abstract - *Seismic isolation, commonly referred to as base isolation, is a design concept that presumes a structure can be substantially decoupled from potentially damaging earthquake ground motions. By decoupling the structure from ground shaking, isolation reduces response in the structure that would otherwise occur in a conventional, fixed-base building. Alternatively, base-isolated buildings may be designed for reduced earthquake response to produce the same degree of seismic protection. Isolation decouples the structure from ground shaking by making the fundamental period of the isolated structure several times greater than the period of the structure above the isolation system. The potential advantages of seismic isolation and the advancements in isolation system products led to the design and construction of a number of isolated buildings and bridges in the early 1980s.*

Seismic isolation is a technique to shift the fundamental natural period of a structure to the long period range, e.g., two to four seconds, by placing horizontally flexible isolation devices at the base of the structure to physically decouple it from the ground shown in Figure 3.1. For earthquake excitation this period shift translates into reduced floor acceleration and inter-story drift demands on the superstructure (structure above the isolation system) by comparison to the equivalent non-isolated structure. The reduced demands allow the superstructure to remain elastic, or nearly elastic, following a design level event.

Keywords:- Base isolation, inter-story drift

1. INTRODUCTION

The concept of base isolation system had been suggested in last few decades and the available technologies and the knowledge of base isolation system are getting mature and well established. Seismic isolation systems are more effective when applied to high stiffness, low-rise buildings, owing to their abilities to alter the characteristic of the building from rigid to flexible. An increasing number of structures to be isolated reflect the fact that base isolation system is gradually becoming accepted as a proven technology in earthquake hazard mitigation. Base isolation is an anti-seismic design strategy that can reduce the effect of earthquake ground motion by uncoupling the superstructure from the foundation.

In recent years, considerable progress has been made in the area aseismic protective systems for civil engineering structures. Aseismic protective systems, in general consist of passive systems, active systems and semi active systems. There are three basic elements in any practical seismic isolation system. These are:

I. A flexible mounting (support) so that the period of vibration of the total system is lengthened sufficiently to reduce the force response.
2. A damper or energy dissipator so that the relative deflections between building and ground can he controlled to a practical design level.
3. A means of providing rigidity under low (service) load levels such as wind and minor earthquakes.

- Flexibility

Bridge structures, for many years, have been supported on elastomeric bearings, and as a consequence have already been designed with flexible mounts. It is equally possible to support buildings on elastomeric bearings, and numerous examples exist where buildings have been successfully mounted on pads. To date, this has been done primarily for vertical vibration isolation rather than seismic protection. More than 100 buildings in Europe and Australia have been built on rubber bearings to isolate them from vertical vibrations from subway systems. By increasing the thickness of the bearing, additional lateral flexibility and period shift for seismic isolation can he attained.
While the introduction of lateral flexibility may be highly desirable, additional vertical flexibility is not. Vertical rigidity is maintained by constructing the rubber bearings in layers and sandwiching steel reinforcing plates between each layer. The reinforcing plates, which are bonded to each layer of rubber, constrain lateral deformation of the rubber under vertical load, resulting in vertical stiffnesses several hundred times the lateral stiffness.

- Energy Dissipation

One of the most effective means of providing a substantial level of damping is through hysteretic energy dissipation. The term "hysteretic" refers to the offset in the loading and unloading curves under cyclic loading. Work done during loading is not completely recovered during unloading and the difference is lost as heat. Many engineering materials are hysteretic by nature, and all elastomers exhibit this property to some extent. By the addition of special purpose fillers to elastomers, it is possible to increase their natural hysteresis without unduly affecting their mechanical properties. Such a technique gives a useful source of damping, but so far it has not been possible to achieve the same level of energy dissipation as is possible with a lead-rubber elastomeric bearing.

Friction is another source of energy dissipation which is used to limit deflections. However, it can be a difficult source to quantify, and reliable systems tend to be of a magnitude more expensive than either of the above mechanisms. A further disadvantage is that most frictional devices are not self-centering, and a permanent offset between the sliding parts is a real possibility after an earthquake.

- Rigidity for Low Lateral Loads

While lateral flexibility is highly desirable for high seismic loads, it is clearly undesirable to have a structural system which will vibrate perceptibly under frequently occurring loads such as minor earthquakes or wind loads.
Lead-rubber bearings (and other mechanical energy dissipators) provide the desired low load rigidity by virtue of their high elastic stiffness. Some other seismic isolation systems require a wind restraint device for this purpose—typically a rigid component designed to fail under a given level of lateral load. This can result in a shock loading being transferred to the structure due to the sudden loss of load in the restraint. Nonsymmetrical failure of such devices can also introduce undesirable torsional effects in a building. Further, such devices will need to be replaced after each failure.

2. LITERATURE REVIEW

Donato Cancellara, et al (2016) have studied the dynamic nonlinear analysis of different base isolation systems for a multi-storey RC building irregular in plan. Two base isolation systems were analyzed and their seismic behavior is compared with reference to a multi-storey reinforced concrete building. A comparative analysis is presented for evaluating the behavior of a base isolated irregular building subject to seismic events. Two base isolation systems have been considered, the High Damping Rubber Bearing (HDRB) actuated in parallel with a Friction Slider (FS) and the Lead Rubber Bearing (LRB) was actuated in parallel with a Friction Slider (FS). A dynamic nonlinear analysis is performed for the three-dimensional base isolated structure. A comparative study is conducted on behavior of the structure isolated by the two considered base isolation systems and the corresponding behavior of the traditional fixed base structure.

Athanasios et al (2016) have conducted a study on response simulation of hybrid base isolation systems under earthquake excitation .Investigated the response of a hybrid base isolation system under earthquake excitation. The base isolation system consists of high damping rubber bearings and low friction sliding bearings. Two separate models are employed for the numerical simulation of the high damping rubber bearing component, namely a bilinear and a trilinear system, both in parallel with a linear viscous damper. A series of numerical simulations are carried out to study the behavior of the considered hybrid base isolation system under different excitation and site conditions.

Fabio De Angelis et al (2016) conducted a study on nonlinear dynamic analysis for RC structures with hybrid base isolation systems in presence of bi-directional ground motions.The work analyzed three different hybrid base isolation systems in order to protect reinforced concrete structures with regards to bidirectional ground motions. The Elastomeric Spring Dampers operated in parallel with Friction Sliders, the Lead Rubber Bearings operated along with Friction Sliders and the High Damping Rubber Bearings operated in parallel with Friction Sliders are the three hybrid base isolation systems considered. A comparative analysis is made for the three base isolated composite structures by reporting the base acceleration, the base shear, base displacements and of the inter-storey drifts and the peak values of the base shear. Finally a comparative analysis is presented between the base isolated structure with the three considered base isolation systems and the fixed base structure.

N Murali Krishna et al (2016) studied the nonlinear time History Analysis of Building with Seismic Control Systems. Asymmetric buildings have been taken for the study to control the seismic response of the structure. The study was on the nonlinear time history analysis, considering the effect of use of shear wall and base isolation system. The RCC moment resisting frame is subjected to nonlinear time history analysis (NLTHA). The storey drifts, base shear, torsional moment and storey displacement of the structure were studied. The results indicate that significant effect of the base isolation was observed on the storey drift, storey shear, storey displacement and torsional moment of low rise asymmetric buildings and significant effect of the shear wall was observed on the same responses of high rise asymmetric buildings.

Radmila B. Salic et al (2008), in this paper the authors have demonstrated the effect of dynamic response of the seven-story residential building under the earthquake ground motions. Mode shapes, natural frequencies and damping ratios of the existing fixed-base building are obtained by ARTeMIS (Ambient Response Testing and Modal Identification Software). The fixed base model represents the dynamic behavior of the structure and seismic isolated model representing the dynamic behavior of the structure isolated by lead rubber bearing seismic isolation system. Dynamic analysis of both models has been performed by ETABS (Nonlinear version 9.0.4). The finite element model was chosen to satisfy the needs of this analysis. The Dynamic responses of fixed base and seismic isolated models have been calculated for four types of real earthquake time histories of different frequency characteristics whose value is determined based on the detailed site response analysis. The authors have showed that increase of natural period of structure increases flexibility of the same structure. In seismic isolated model, base shear force is highly reduced. Increased flexibility of the system led to increase of the total displacements due to the elasticity of the existing isolation. Implementation of the isolation system resulted into the reduction of the interstory drifts. Analysis of seismic isolated model has shown significant reduction of the story accelerations.

Juan C. Ramallo, et al (2008) . In this paper authors have investigated the effects of using controllable semi-active dampers, such as magneto-rheological fluid dampers, in a base isolation system. A two degree of freedom model of a base isolated building is used. The fundamental concept is to isolate a structure from ground, especially in the frequency range where the building is most affected. The goal is to reduction in inter-storey drifts and floor accelerations to limit damage to the structure and its contents in a cost-effective manner. This paper investigates the improvements that may be achieved by replacing supplemental linear viscous damping devices in base isolation with semi-active dampers. A linear, two degree of freedom (2DOF), lumped mass model of a base-isolated building is used as the test bed for this study. The system model is used in this test is a single degree-of freedom model that has mass and fundamental modal frequency and damping ratio. In this study passive linear viscous damper, active damper and semi-active damper have been used. Generalized semi-active as well as magneto-rheological fluid dampers was used in seismic protection system. Authors have concluded that the semi-active damper was able to accomplish nearly as much as the fully active damper. With the semi-active damper, the peak base drifts were decreased as compared to the optimal passive linear damper. This study suggests that semi-active dampers, such as magneto-rheological fluid dampers, show significant promise for use in base isolation applications with greatly reduced power requirements as compared to the active systems.

J. C. Ramallo1, et al (2008) have presented an innovative base isolation strategy and shows how it can effectively protect the structures against extreme earthquakes without sacrificing performance during the more frequent, moderate seismic events. This innovative concept includes base isolation system with semi-active or controllable passive dampers for seismic response mitigation. In this method the structure is modeled as a single degree-of-freedom system representing the fundamental mode. When the isolation layer is added, the augmented model is a two degree-of-freedom system. Test has been shown experimentally that the linear behavior of low-damping rubber bearings can extend to shear strains above 100%. Lead-rubber bearings are considered as the baseline against which the smart damping strategies are compared. The rubber isolation in these two systems is identical. The various ground excitations are used for modal excitation. A family of controllers that decreases base drift and absolute accelerations (compared to the LRB) is obtained for a controllable smart damper. The base isolation system, comprised of low-damping elastomeric bearings, and controllable semi-active dampers, was shown to have superior performance compared to several passive base isolation designs using lead-rubber bearings.

Minal Ashok Somwanshi (2015) et al carried out a study on Seismic Analysis of Fixed Based and Base Isolated Building Structures. The work deals with modeling and analysis of 13-storey rigid jointed plane frame for two cases. First case is fixed base and second case is base isolated. Modeling and analysis is done using E-TABS software for Bhuj earthquake ground motion records. Maximum vertical reaction is obtained from analysis in E-TABS software. Using this vertical reaction and total mass of structure lead rubber bearings are designed manually. Time-history analysis is carried out in order to evaluate floor response, accelerations and displacements during a ground motion. This paper intends to demonstrate how an isolation system can be efficient, evaluating its effectiveness for the building in terms of maximum shear force, maximum bending moment, base shear, storey drift and storey displacement reductions. From analytical results, it is observed that base isolation technique is very significant in order to reduce the seismic response of both symmetric as well as asymmetric models as compared to fixed base building and control the damages in building during strong ground shaking.

Dr Manjunath N Hegde et al (2016), In this research an attempt is made to study the results for building with fixed base, base isolator (rubber isolator), and damper and shear wall. Here irregular plan building of (G+7) floor is taken for analysis. For seismic zone IV by considering type II (medium) soil using ETABS Software. Analysis is carried out by both equivalent static method and response spectrum method. Results like time period, displacement, storey drift and base shear are compared for building with base isolator and shear wall with fixed base building. Building provided with base isolator has more displacement than compared to fixed and shear wall. When compared to fixed base building base shear is reduced in base isolated building, thus seismic response of building with base isolator is better than fixed base.

Sonali Anilduke et all (2012), This paper present three dimensional nonlinear time history analysis is performed on r/c building by the use of computer program SAP 2000 v12.0.0. The dynamic analysis of the structure has been carried out and the performance of the building with and without isolator is studied. The main objective here is to make seismic response control by providing Isolators and comparing between the fixed based and isolated base building. Rubber bearing and Friction pendulum bearing are used. Basic concept of base isolation are very well studied .Base Isolators controls structural response in which the building or structure is decoupled from the horizontal component of the earthquake ground motion. A base-isolation system reduces ductility demands on a building, and minimizes its deformations. From the result, By conducting the nonlinear time history analysis it was shown that base isolation increases the flexibility at the base of the structure which helps in energy dissipation due to the horizontal component of the earthquake and hence superstructure's seismic demand drastically reduced as compared to the conventional fixed base structure.

Yang et al (2006), in this paper two aseismic hybrid control systems are proposed for protecting building structures against strong earthquakes. The hybrid control system consists of a base-isolation system connected to either a passive or active mass damper. The base-isolation system, such as elastomeric bearings, is used to decouple horizontal ground motions from the building; whereas the mass damper, either active or passive, is used to protect the safety and integrity of the base-isolation system. The performance of the proposed hybrid control systems is investigated, evaluated, and compared with that of an active control system. It is shown from the theoretical/ numerical results that the proposed hybrid control systems are very effective in reducing the response of tall buildings under strong earthquakes. Likewise, the practical implementation of such hybrid control systems is easier than that of an active control system alone.

3. CONCLUSIONS

From the above literatures it is find out that the use of base isolation considerably reduces the response of the structure due to earthquake loading. Base isolation is very promising technology to protect different structures like buildings, bridges, airport terminals and nuclear power plants etc. from seismic excitation.

The significant characteristic of base isolation a system affect the superstructure to have a rigid movement and as a result shows the relative story displacement & story drift of structural element will decrease and consequently the internal forces of beams and columns will be reduced.

Due to decrease in lateral loads to stories, the accelerations of the stories are reduced. This results in the reduction of inertia forces. Story overturning moment and story shear are also reduced in base isolated building.

From the above points, it is concluded that the performance of isolated structure is efficient in the Earthquake prone areas.

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