Available online: www.ijsrmes.com

International Journal for Scientific Research in Modern Engineering and Science

International Journal for Scientific Research in Modern Engineering and Science, 3(5): 69- 75 (2022)

A REVIEW ON PERFORMANCE OF STRUCTURE WITH AND WITHOUT BASE ISOLATION

Aakriti Singh [1]*, Vijay Kumar Shukla [2], Vivek Kumar Mishra [3]

[13]M. Tech Student, Department of Civil Engineering, Vishwavidhyalaya Engineering college Ambikapur-CSVTU Bhilai.
[2]Assistant Professor, Department of Civil Engineering, Vishwavidhyalaya Engineering college Ambikapur-CSVTU Bhilai.

Abstract

The structures constructed with good techniques and machines in the recent past have fallen prey to earthquakes leading to enormous loss of life and property and untold sufferings to the survivors of the earthquake hit area. Base isolation concept was coined by engineers and scientists as early as in the year 1923 and thereafter different methods of isolating the buildings and structures from earthquake forces have been developed world over. Controlling seismic behaviour is possible only through faithful design that ensures all behavioral actions considered in buildings during analysis. In keeping with the key characteristics of buildings, structural design of buildings can be stiffness-based, strength-based, deformation-based and energy based. In this paper a review has been done for the base isolated structure with different techniques, parameters and components.

Keywords: *Earthquake, Base isolation, Stiffness, Deformation.*

** Corresponding author*

1. INTRODUCTION

The destruction caused by an earthquake is highly unpredictable and sometimes beyond repair. Though it is not possible to avert this natural disaster, but it is possible to minimize and reduce the effect caused by it. Innovative methods of seismic analysis of structures play an important role in its mitigation. The loss of life and damage to property due to the disaster can be reduced by adoption of improved prevention and preparedness measures. This is usually accomplished by using permanent controls i.e.; structural or non- structural designed and developed [Housner, G.W. et al, 1997] in advance of the disaster or by using temporary measures. One of the most widely implemented and accepted seismic protection systems is base isolation. Seismic base isolation [Skinner et al. 1993; Naeim and Kelly 1999] is a technique that mitigates the effects of an earthquake by essentially isolating the structure and its contents from potentially dangerous ground motion, especially in the frequency range where the building is most affected. The goal is to simultaneously reduce interstory drifts and floor accelerations to limit or avoid damage, not only to the structure but also to its contents, in a cost-effective manner. Base isolation concept was coined by engineers and scientists as early as in the year 1923 and thereafter different methods of isolating the buildings and structures from earthquake forces have been developed world over. Countries like US, New Zealand, Japan, China and European countries have adopted these techniques as their normal routine for many public buildings and residential buildings as well. Hundreds of buildings are being built every year with base isolation technique in these countries. As of now, in India, the use of base isolation techniques in public or residential buildings and structures is in its inception and except few buildings like hospital building at Bhuj, experimental building at IIT, Guwahati, the general structures are built without base isolation techniques. Many significant advantages can be drawn from buildings provided with seismic isolation. The isolated buildings will be safe even in strong earthquakes. The response of an isolated structure can be ½ to 1/8 of the traditional structure. Since the super structure will be subjected to lesser earthquake forces, the cost of isolated structure compared with the cost of traditional structure for the same earthquake conditions will be cheaper. The seismic isolation can be provided to new as well as existing structures. The buildings with provision of isolators can be planned as regular or irregular in their plan or elevations.

Base Isolation Techniques The seismic energy forces entering the structure can be controlled by two basic approaches: a) Structural Design that can accommodate the input seismic energy. b)Isolate the seismic energy to reduce or divert it, before it enters the structure. Seismic isolators function based on the second approach, in which energy is limited by using energy absorbing or dissipating devices. These devices isolate only horizontal forces. These isolators come in various shapes, forms and sizes (The Hartford loss control department, 2002). Seismic isolated structures are currently difficult to analyze, design and implement due to complex code requirements. Base isolation is an approach to earthquake-resistant design that is based on the concept of reducing the seismic demand rather than increasing the earthquake resistance capacity of structure. This technology was first developed for bridge construction to protect against thermal movement in the bridge deck. Isolators are of many types depending upon their sizes, shapes and advantages. They can be elastomeric based systems, high damping natural rubber systems and sliding systems etc. The isolation mechanisms are designed so that only a small portion of the energy of the earthquake is left to be dissipated by the super-structure. Elastomeric bearings and frictional sliding mechanisms installed in the foundations of seismically isolated structures are some of the examples of seismic isolation systems which protect the structures from strong earthquakes through a reduction of stiffness and an increase in damping. The purpose of this paper is to provide a brief overview of many new technologies that are rapidly becoming more prevalent in the seismic design of structures. All these technologies involve the use of specific devices to alter or control the dynamic behavior of buildings.

2. LITERATURE REVIEW

A detailed literature review of semi-active control systems Michael D. Symans et. al (1999) provides references to both theoretical and experimental research but concentrates on describing the results of experimental work. Specifically, the review focuses on descriptions of the dynamic behavior and distinguishing features of various systems which have been experimentally tested both at the component level and within small scale structural models. The semi-active systems which are reviewed include stiffness control devices, electro rheological dampers, magnet orheological dampers, friction control devices, fluid viscous dampers, tuned mass dampers and tuned liquid dampers.

T.T. Soonga et. al (2002) studied about passive systems encompass a range of materials and devices for enhancing structural damping, stiffness and strength. Also for a specific level of seismic intensity, a designated performance level of the structure is proposed by Fabio Mazza, Alfonso Vulcano (2008) which assumes the elastic lateral storey-stiffness due to the braces proportional to that of the unbraced frame, is combined with the Direct Displacement-Based Design, in which the design starts from a target deformation. Various studies has been done by Fabio Mazza, Alfonso Vulcano on base isolated structure in which they have studied different parameters eq. studied the two and multi-degree-of-freedom systems, representing medium-rise base-isolated framed buildings according to Euro code 8 assuming ground types A (i.e., rock) and D (i.e., moderately soft soil) in a high-risk seismic region. The overall isolation system, made of inparallel high-damping laminated- rubber bearings (HDLRBs) and supplemental viscous dampers, is modeled by an equivalent viscoelastic linear model.

Fabio Mazza and Alfonso Vulcano (2011) analyzed that the insertion of steel braces equipped with viscoelastic dampers (VEDs) is a very effective technique to improve the seismic or wind behaviour of framed buildings. Overview of the present state of base isolation techniques with special emphasis and a brief on other techniques developed world over for mitigating earthquake forces on the structures is discussed by S.J.Patil1, G.R.Reddy (2012) in which dynamic analysis procedure for isolated structures is briefly explained. The provisions of FEMA 450 for base isolated structures are highlighted. The effects of base isolation on structures located on soft soils and near active faults are given in brief by Gordon P. Warn et. al. (2012) and summarizes current practices, describes widely used seismic isolation hardware, chronicles the history and development of modern seismic isolation through shake table testing of isolated buildings and reviews past efforts to achieve three-dimensional seismic isolation. The review of current practices and past research are synthesized with recent developments from full-scale shake table testing to highlight areas where research is needed to achieve full seismic damage protection of buildings.

Fabio Mazza, Alfonso Vulcano et. al. (2012) studied design of baseisolated structures located in a near-fault area, base-isolated five-storey r.c. framed buildings with elastomeric bearings acting alone or combined in parallel or in series with sliding bearings (“Base Isolation and in-Parallel Sliding”, BIPS, or “Base Isolation and in-Series Sliding”, BISS, systems). C C Patel, R S Jangid (2012) examined the dynamic response of two adjacent single-degree-of-freedom (SDOF) structures connected by viscous damper under base acceleration. The base acceleration is modeled as harmonic excitation as well as stationary white noise random process. The governing equations of motion of the coupled structure are derived and solved for relative displacement and absolute acceleration responses. The viscous damper is found to be effective for response control of adjacent structures by connecting with appropriate damping coefficient of damper.

Fabio Mazza and Mirko Mazza (2012) designed a six and twelve storey r.c. spatial frames according to the provisions of the Italian seismic code, considering horizontal and vertical seismic loads in a high-risk seismic region and assuming low and high ductility classes. The nonlinear dynamic response of the test structures is studied with reference to the horizontal and vertical components of nearfault records. The occurrence of a directivity effect at arbitrary orientations is checked rotating the horizontal components of the selected motions, rather than considering only fault-normal and fault-parallel orientations.

Fabio Mazza, Alfonso Vulcano (2013) focused on the modeling and nonlinear seismic analysis of framed structures equipped with friction, metallic yielding, viscoelastic and viscous dampers. A design procedure is proposed for proportioning damped braces in order to attain, for a specific level of seismic intensity, a designated performance level of the structure. Faramarz Khoshnudian et. al. (2013) studied a four-story building with different eccentricities supported on elastomeric isolators with different vibration periods and damping ratios as well as three different records is used to study the effects of vertical component of earthquakes on the seismic behavior of asymmetric steel isolated structures. Andre Filiatrault1et. al. (2014) review paper summarizes current knowledge on the seismic design and analysis of nonstructural building components, identifying major knowledge gaps that will need to be filled by future research. Furthermore, considering recent trends in earthquake engineering, the paper explores how performance based seismic design might be conceived for nonstructural components, drawing on recent developments made in the field of seismic design and hinting at the specific considerations required for nonstructural components.

Manuela Cecconi et. al. (2014) presents a paper on application of the seismic design method named “Direct Displacement Based Design” (DDBD), first introduced in 1990s in the field of earthquake structural engineering, and gaining due attention in the recent years with considerable discussion on its applicability to flexible earth retaining structures in coarse grained-soils. Particular attention is given to the evaluation of the equivalent damping ratio of the wall/soil system, since it sensibly affects the results of the procedure. A simplification of the design process is proposed in order to provide a seismic demand curve, in terms of active/passive thrust, which is dependent on the system ductility. A numerical example of application of the method is also provided in the paper.

Stefano Sorace, Gloria Terenzi (2014) presented a study on the evaluation of seismic response of statues exhibited in art museums, and a base-isolated floor strategy for their enhanced protection. Attention is particularly focused on statues made of small tensile strength materials, whose behaviour is simulated by a smeared-crack finite element approach. Angelo D’Ambrisi, Marco Mezzi (2014) studied a paper on energy-based method for nonlinear static analysis that allows to overcome these assumptions. Fabio Mazza, Alfonso Vulcano (2014) also analyzed expressions of the equivalent damping which obtained considering the energy dissipated by the HYDBs and the framed structure. Also, they studied a displacement-based design procedure for proportioning hysteretic damped braces (HYDBs) in order to attain, for a specific level of seismic.

Intensity, a design at the performance level of a reinforced concrete (r.c.) in-elevation irregular framed building which has to be retrofitted. George D., Hatzigeorgiou et.al. (2014) examines the inelastic response behaviour of structures with supplemental viscous dampers under near-source pulse-like ground motions. Amir Soltani et. al. (2014) introduces a simple approach to determine optimum parameters of a nonlinear viscous damper for vibration control of structures. A MATLAB code is developed to produce the dynamic motion of the structure considering the stiffness matrix of an SDOF frame and the non-linear damping effect. Fabio Mazza, Alfonso Vulcano (2015) studied Displacement-Based Design (D.B.D.) procedure which is adopted for the retrofit of framed structures by inserting hysteretic damped braces (HYDBs) Julián M., Londoño et.al. (2015) examines the effects of amplifying the displacements transferred to a non-linear damper, to increase the effectiveness of the damper in a range of situations commonly encountered in civil engineering structures. These include, (i) the ability to ‘‘fine tune’’ the required damping for a particular size damper, (ii) the ability to have a set of the same size dampers, but with different amplification factors to achieve a specific damping task, and (iii) to increase the sensitivity of the damper to small movements which effectively extends the range over which the damper works.

Mehdi Ezati Kooshki et.al. (2015) studied an effective way to protecting of structures against grand motions by new method (semi base isolation system). In the new way structures isn't completely decouple of bases and it changed natural frequency of structures due earthquake by changing horizontal stiffness. The proposed semi base isolation (SBI) system were applied to a one story frame and compared with end fixed frame and the time history analysis was conducted on record of Kobe earthquake (1995), San Fernando (1971) and Santa Barbara (1978), by used finite element software (ABAQUS 6-10-1). The analysis results can show that the efficiency reduced the floor acceleration and displacement and velocity. This study shows that (SBI) system has great potential in future application of seismic isolation technology. Alaa Barmo et. al. (2015) examined the response of buildings isolated using isolation system hybrid consisting of Lead-Rubber Bearings (LRB), Flat Sliding Bearings (FSB), with the addition of Rotation Fiction Damper (FD) at the base, then compare the results with buildings that have traditional foundation, in terms of the (period, displacement and distribution shear force and height of the building).

3. CONCLUSION

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 affects 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.

REFERENCES

[1] Andre Filiatrault and Timothy Sullivan, "Performance-based seismic design of nonstructural building components: The next frontier of earthquake engineering", Earthq Eng & Eng Vib (2014) 13: 17-46 .

[2] Branz Study Report, "Base Isolation of Low Rise Light And Medium Height Buildings", 10th World Conference on Seismic Isolation, Energy Dissipation and Active Vibrations Control of Structures, Istanbul, Turkey, May 28-31, 2007.

[3] C C Patel, R S Jangid , " Optimum Parameter of Viscous Damper for Damped Adjacent Coupled System", Journal of Civil Engineering and Science, JCES Vol.1 No. 1 2012 PP.22-30.

[4] Deb, Sajal Kanti," Seismic base isolation – An overview", Department of Civil Engineering, Indian Institute of Technology, Guwahati, India, Current Science, vol.87, 2004.

[5] Fabio Mazza, Alfonso Vulcano, "Displacement-Based Design Of Dissipative Braces At A Given Performance Level Of A Framed Building", The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China

[6] Fabio Mazza, Alfonso Vulcano, " Nonlinear Response of RC Framed Buildings with Isolation and Supplemental Damping at the base Subjected to Near-Fault Earthquakes", Journal of Earthquake Engineering, 13:690–715, 2009.

[7] Fabio Mazza and Alfonso Vulcano ,"Control of the earthquake and wind dynamic response of steel-framed buildings by using additional braces and/or viscoelastic dampers", Earthquake Engineering And Structural Dynamics,2011; 40:155–174

[8] Fabio Mazza and Mirko Mazza, " Nonlinear Modeling and Analysis of R.C. Framed Buildings Located in a Near-Fault Area", The Open Construction and Building Technology Journal, 2012, 6, 346-354.

[9] Fabio Mazza, Alfonso Vulcano et. al. " Nonlinear Dynamic Response of RC Buildings with Different Base Isolation Systems Subjected to Horizontal and Vertical Components of Near-Fault Ground Motions". The Open Construction and Building Technology Journal, 2012, 6, 373-383

[10] Faramarz Khoshnudian et. al. , " Seismic Response of Asymmetric Steel Isolated Structures Considering Vertical Component of Earthquakes", KSCE Journal of Civil Engineering (2013) 17(6):1333- 1347..

[11] Fabio Mazza, Alfonso Vulcano, "Design of Hysteretic Damped Braces to Improve the Seismic Performance of Steel and R.C. Framed Structures", Research Gate, Anno XXXI – N. 1 – gennaio-marzo 2014.

[12] Gordon P. Warn et. al., "A Review of Seismic Isolation for Buildings: Historical Development and Research Needs" 2012, 300-325.

[13] Housner, G.W., Bergman, L.A., Caughey, T.K., Chassiakos, A.G., Claus, R.O., Masri, S.F., Skelton, R.E., Soong, T.T., Spencer, B.F., and Yao, J.T.P., "Structural control: past, present and future," Journal of engineering Mechanics, Vol 123, No 9, pp 897-971,1997.

[14] H. Gavin, C. Alhan, "Parametric analysis of passive damping in base isolation", 16th ASCE engineering mechanics conference, 2003.

[15] K.K.Walsh and Makola M. Abdullah, "Adaptive base isolation of civil structure using variable amplification", Earthquake Engineering and engineering vibration, vol.5, 2006

[16] Michael D. Symans et. al," Semi-active control systems for seismic protection of structures: a state-of-the-art review", Engineering Structures 21 (1999) 469–487.

[17] M.C. Costantinou ; M.Eeri; A.M. Reinhorn; A.Mokha and R.Watson, "Displacement Control Device for Base isolated Bridges", Earthquake spectra, Vol.7 , No.2, 1991.

[18] M. D. Symans, A.M. ASCE; F.A.Charney, F.ASCE, A. S. Whittaker, M.ASCE, M. C. Constantinou, M.ASCE, C. A. Kircher, M.ASCE, M. W. Johnson, M.ASCE, and R. J. McNamara, F.ASCE, "Energy Dissipation Systems for Seismic Applications:Current Practice and Recent Developments", Journal of structural engineering, vol.134, 2008.

[19] Naeim Farzad and M.Kelly james," Design of seismic isolated structure: From theory to practice", Jons Wiley & sons, Inc., 1999.

[20] S.J. Patil, G.R.Reddy, "State Of Art Review -Base Isolation Systems For Structures" International Journal of Emerging Technology and Advanced Engineering , ISSN 2250-2459, Volume 2, Issue 7, July 2012.

[21] Skinner, I.R., Robinson, W.H., and McVerry, G.H., An Introduction to Seismic Isolation, John Wiley & Sons, 1993.

[22] T.T. Soonga et. al," Supplemental energy dissipation: state-of-the-art and state-of-the practice", Engineering Structures 24 (2002) 243–259.