

# A Review of Behaviour of Building under Earthquake with or without Base Isolation

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**Abstract** – Seismic isolation systems are widely used to protect reinforced concrete (RC) structures against the effects of strong ground motions. The building provides a good opportunity to study and assess the contribution of isolation systems to seismic performance of RC structures. In the current research project, to compare the effectiveness of base Isolation in plan irregular and vertical multi-storied RC frame building. For this study, no of Storied R.C frame building is considered and time history analysis is carried out using ETABS Software. The isolated structure was subjected to four earthquake records with increasing intensity. The performances of the isolated structure were compared with those of the fixed-base structures in terms of lateral inter-storey drifts, peak absolute floor accelerations, and residual drifts. The laminated rubber bearings, the high damping isolation devices, composed of rubber bearings and viscous dampers, and the hybrid isolation system of rubber bearings and friction pendulum bearings were analysed. The effectiveness of the three base isolation systems considered in enhancing structural performance was investigated. The results show the level of improvement attained in seismic response by each system. They also illustrate that the rubber bearings coupled with friction pendulum bearings produce best drift control without causing excessive horizontal displacements at the base level and without adversely affecting floor accelerations.

## 1. INTRODUCTION

Base isolation concept was coined by engineers and scientists as early as in the year 1923 and consequently different method of isolating the buildings and structures from earthquake forces have been urbanized world over. Country like US, New Zealand, Japan, China and European countries have adopted these techniques as their standard routine for many public buildings and residential building as well. Hundreds of buildings are being built each year with base isolation technique in these countries. This paper describes the development of base isolation technique and other techniques developed approximately the world. 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, investigational building at IIT, Guwahati, the general structures are built without base division techniques. National level guidelines and codes are not available presently for the reference of engineers and builders. Engineers and scientists have to accelerate the pace of their research work in the direction of developing and

constructing base isolated structures and come out with solutions which are simple in design, simple to build and cost effective as well.

Many significant advantages can be drawn from building provided with seismic isolation. The answer of an isolated structure can be  $\frac{1}{2}$  to  $\frac{1}{8}$  of the traditional structure. Since the super structure will be subjected to lesser earthquake forces, the cost of out-of-the-way 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

## 2. LITERATURE REVIEW

**2.1.1.** Mithranjali N. A. & Mathew C. George, “Study On Rc Building With Friction Pendulum Base Isolation System – A Review”, *International Journal for Research in Applied Science & Engineering Technology*, Vol. 5, 2017.

Buildings are very important after the natural hazards such as earthquake. Introducing base isolation techniques to improve the performance of buildings. Friction pendulum or Friction bearing is one of the best base isolation techniques. The main aim of these papers investigates the seismic response of multi story buildings with friction pendulum base isolation. FPS with different radius and co-efficient of friction are included in each papers. There different past recorded earthquake are used for time history analysis and SAP 2000 software is used for modeling and analysis.

**2.1.2.** Vasu A. Shah, et.al. “Comparative Study of Base Isolation in Multistoried R.C Irregular Building”, *International Journal of Advance Engineering and Research Development*, Vol. 4, 2017.

Now a day’s architects and engineers are required to plan and design the structures, which can withstand against the seismic loads. Therefore it became necessity to provide passive control device “base isolation” to resist large horizontal and vertical load which leads the structure to collapse. Base isolation is one of the promising and widely accepted passive control devices to resist these forces by isolating the super structure from the sub structure, in this research paper the response of Base isolated building and

fixed base building are evaluated for high rise building having irregularity in plan at Storey level. Response spectrum analysis and time history analysis carried out in terms of Storey Displacement, Base shear, Time period and Storey drift using ETABS software.

**2.1.3.** Asst Prof. Noor Mohammed, Mohammed Huzaifa Yaman & Shaik Mohammed Siddiq, “**Non-Linear Pushover Analysis of RCC Building with Base Isolation system**”, *International Journal of Engineering Sciences & Research Technology*, 2016.

Buildings are designed as per the code regulations meeting all specific requirements of code and assuming a linear elastic behaviour for the structural members. Moreover, it is also necessary to know the behaviour of a building that were designed with older codes or which may not have been designed for earthquake forces. During the seismic excitation the building responds well beyond its elastic and linear capacity and enters into non-linear stage. So, the present work is intended to provide a systematic procedure to assess the behaviour of a structure during the seismic excitation. For studying the behaviour a non-linear static analysis procedure known as pushover analysis is used. The literature pertaining to pushover analysis is reviewed. A Nine storey residential building located in the Hyderabad city, which was designed and constructed for gravity loads alone, was considered for analysis. The present structure is studied using the evaluation procedures provided in ATC-40 and FEMA-273 documents. Under detailed evaluation a target displacement for Immediate Occupancy, Life Safety, Collapse Prevention was given and the performance is checked in accordance with IS 1893:2002.

**2.1.4.** H. Sugihardjo, Tavio & Y. Lesmana, “**Behavior of A Base-Isolated Residential House in A Highly Seismic Region**”, *International Journal of Applied Engineering Research*, Vol. 11, Pp. No. 8253-8258, 2016.

A base isolation system is an effective engineering method for reducing seismic impacts by isolating an upper structure from soil vibration due to seismic motion. The primary concept of a base isolation system is the extension of the natural period of a building. However, the production of isolators is very expensive, particularly when an isolator is employed as a residential house's base isolator. To alleviate the issue, a low-cost rubber base isolation system is proposed. The proposed low-cost bearing system uses the perforated thin steel plates instead of solid thick ones. The study is the initial step of research on low-cost base isolation systems for residential houses in highly seismic regions. A nonlinear time history analysis (NLTHA) that is based on seven scaled-earthquake records is implemented in one-and two-storey isolated reinforced concrete (RC) residential houses by considering the influence of the isolation ratio. The results indicate that the houses with isolation systems achieved better performance with regard to ductility

demand and natural period due to seismic loads. The house with the higher isolation ratio achieved lower ductility demand.

**2.1.5.** M. Vijayakumar, Mr. S. Manive & Mr. A. Arokiaprakash, “**A Study On Seismic Performance Of RCC Frame With Various Bracing Systems Using Base Isolation Technique**”, *International Journal of Applied Engineering Research*, Vol. 11, Pp. No. 7030-7033, 2016.

Acceleration due to natural calamity is inevitable in tall structures. The taller of the building capture a higher rate of the acceleration than the ground floor due to gravity and resulting in structural damage. Various types of studies are in progress so as to put forward a successful model that withstands the natural calamity that effect the state of the building structure. Structural engineering plays a vital role in providing a solution that safe guards the structure as such. Bracings are used to provide stability and resists lateral loads were the base isolation technology provides passive structural vibration control. X, V and Chevron bracings provided in different sides of building and the effect of base shear in building columns is absorbed for steel bracing with and without using lead rubber bearing as base isolator. The force impact on the structure with X, V and Chevron Bracings is measured for the simulated model for different cases using SAP2000 v18 software.

**2.1.6.** K. Sugantha Priya, et.al. “**A Study On Review Of Literature Of Asymmetrical Building With Bracings**”, *International Journal for Research in Applied Science & Engineering Technology*, Vol. 3, 2015.

An emerging demand for earthquake resistant structure provokes new trends in seismic analysis. In present days a new challenge of constructing asymmetrical building has higher thirst compared with symmetrical buildings. It has been proved for these buildings were able to sustain stiffness and flexibility. Bracings a vital finding enhances the resistances to lateral loads. This paper deals with a study on literatures assembling the need of steel braces over asymmetrical buildings. The author's suggestions were discussed and possible ways to persuade the types of bracing over asymmetric building were framed in this paper. It has been concluded from findings of literatures that initiating the usage of bracings on asymmetric building can effectively reduce the deflection due to lateral loads.

**2.1.7.** Vinodkumar Parma & G. S. Hiremath, “**Effect Of Base Isolation In Multistoried RC Irregular Building Using Time History Analysis**”, *International Journal of Research in Engineering and Technology*, Vol. 4, 2015.

Base isolation (BI) is a technique that has been used around the world to protect the building structures from the

damaging effects of earthquake. The installation of isolator in building at base level significantly increases the time period of the structure, which means it reduces the possibility of resonance of the structure giving rise to better seismic performance of the building. The study is performed to compare the effectiveness of base isolation in plan irregular and vertical irregular multi-storied RC frame building. For this study, 15 storied R.C frame building is considered and Time History analysis is carried out using ETABS 2013 software. The Lead Rubber Bearing (LRB) is designed as per UBC 97 code and the same was used for analysis of base isolation system. The results obtained from the analysis were time period and base shear. Time period for the base isolated structures are higher than that of the fixed base structure. Due to the presence of isolator, Base shear is significantly reduced in each direction (X and Y direction) as compared to fixed base building. It has been found that when compared to plan irregular base isolated building the vertical irregular building gives better performance in high seismic prone area by using isolators at the base of the building.

**2.1.8.** S. K. Sabu, H. S. Chore & S. B. Patil, “**Effectiveness of Lead Rubber Base Isolators, For Seismic Resistance of Buildings, Supported On Different Soil Stratas**”, *International Journal of Electrical, Electronics and Computer Systems*, Vol. 2, 2014.

Seismic Base-isolation of building is an innovative technique used in recent years, for reducing seismic energy transmitted to buildings, in highly seismic prone areas. The basic principle behind the base-isolation system is to introduce a flexible interface between the base of a structure and the foundation. Laminated Rubber Bearings are the most widely used technology in seismic base isolation, because of their technical and economic effectiveness and reliability. Even though base isolation method is extensively used for over 8000 structures internationally, this method is very rarely used in India in spite of the fact that India has so many highly seismically active zones. A case study comprising of the seismic analysis of a sample building, in seismic zone V of India, with lead rubber bearings at the base is done in this paper. Linear static and nonlinear dynamic analysis is performed for both isolated and non-isolated buildings under code mandated bi-directional earth quake. A comparative seismic parametric study is also done with conventional design. Parametric comparison is done for the building with three types of founding soil strata. The study reveals that for medium rise building construction, isolation can significantly reduce seismic response. The reduction in seismic responses is more in harder soil founding strata. In seismic vulnerable areas where the main concern is the mitigation of the seismic instability with the support of critical components, the study shows the effectiveness of the base isolation system in terms of reduced structural responses under seismic loading.

**2.1.9.** Chauhan Kalpesh M. & Dr. B. J. Shah, “**Excel Spreadsheet for Design of Lead Rubber Bearing Uses For Seismic Isolation of Bridges**”, *International Journal of Advanced Engineering Research and Studies*, Vol. 2, Pp. No. 60-62, 2013.

This paper presents the design methodology of Lead Rubber Bearing used for seismic isolation of bridges. Bearing is one of the important components of bridges. Instead of using traditional bearings like PTFE-POT bearing LRB is found to be effective in high seismic region and it is used in many developed countries. However it is not started in our country because of its high cost. These devices are placed in between super-structure and sub-structure. EXCEL spreadsheet is widely used in design office for various design related activities. EXCEL spreadsheet is prepared considering design criteria prescribed by AASTHO, so optimum size can be carried by doing different trials.

**2.1.10.** Mehmet Komur, Turan Karabork & Ibrahim Deneme, “**Nonlinear Dynamic Analysis of Isolated And Fixed-Base reinforced Concrete Structures**”, *Gazi University Journal of Science*, Vol.24, Pp. No. 463-475, 2011

Earthquakes are a major threat to human lives and to the integrity of the infrastructures in seismic regions. Structures are the worst hit with the phenomenal damages due to ground motions resulting from earthquakes. Recent research and studies have led to new techniques to reduce the damages caused by earthquakes on structures and these techniques are applied for innovative structural design. One of the techniques is the base isolation method, which is used to design structures against earthquake damages by using seismic isolators to change the dynamic characteristics of a structure. In this study, three bay 4- and 8-storey reinforced concrete structures are designed as isolated and fixed-base. Lead-rubber bearing (LRB) is used as an isolation system. Nonlinear behavior of both isolation system and super-structure are considered in the modeling. The behaviors of designed models under dynamic loads are analyzed using Ruaumoko computer software. Erzincan, Marmara and Duzce Earthquakes are chosen as the ground motions. At the end of analysis, period, storey accelerations, inter-storey deformations, base shear forces, plastic hinge locations and weighted damage histories are compared for isolated and fixed-base structures. As a result, the advantages of isolated reinforced concrete structures against fixed-base structures under earthquake are shown.

**2.1.11.** H Wang and G Song, “**Lmi Based Fault Detection and Isolation on Base Isolation System Model**”, *Earth and Space*, 2010.

Fault detection and isolation (FDI) in engineering systems can provide early warnings of faulty sensors and actuators in order to prevent events that lead to catastrophic failures. The main objective of this paper describes the use of FDI and

fuzzy fault tolerant control techniques on base separation systems. Thus, this paper presents a Linear Matrix Inequality (LMI) based filter design theorem and approach of fixed-order FDI. The needed and sufficient conditions for the existence of a solution to detecting and isolating faults using  $H_\infty$  formulation is provided in the planned filter design. Furthermore, a Fuzzy Fault Tolerant Controller (FFTC) for base isolation structure model based on the FDI filter is designed to preserve the pre-specified performance of the system in the presence of faults. Simulation and experimental results demonstrate that the designed filter can successfully detect and isolate faults including displacement sensor and accelerometer, while maintaining excellent performance of base isolation technology in faulty conditions.

**2.1.12.** J. C. Ramallo, E. A. Johnson, A. M. ASCE and B. F. Spencer Jr., M.ASCE, “**Smart** Base Isolation Systems”, *Journal of Engineering Mechanics*, Vol. 128, Pp. 1088-1099.

A “smart” base isolation strategy is proposed and shown to effectively protect structures against extreme earthquakes without sacrificing performance during the more frequent, moderate seismic events. The proposed smart base isolation system is composed of conventional low-damping elastomeric bearings and “smart” controllable semi active dampers, such as magnet archeological fluid dampers. To demonstrate the advantages of this approach, the smart isolation system is compared to lead-rubber bearing isolation systems. The effectiveness of the isolation approaches are judged based on computed responses to several historical earthquakes scaled to various magnitudes. The limited performance of passive systems is revealed and the potential advantages of smart dampers are demonstrated. Two- and six-degree-of-freedom models of a base-isolated building are used as a test bed in this study. Smart isolation is shown to achieve notable decreases in base drifts over comparable passive systems with no accompanying increase in base shears or in accelerations imparted to the superstructure. In contrast to passive lead-rubber bearing systems, the adaptable nature of the smart damper isolation system provides good protection to both the structure and its contents over a wide range of ground motions and magnitudes

### 3. CONCLUSIONS

Base isolation systems are widely used to improve seismic performance of reinforced concrete structures. It is based on the concept of decoupling superstructure from ground shaking, thereby limiting the transfer of seismic induced energy to the structure. Three different types of base isolation systems were investigated in the current research project, consisting of a rubber isolation system, high damping isolation devices that are composed of rubber isolators and viscous dampers, and a hybrid isolation system consisting of rubber bearings and friction pendulum

bearings. The effectiveness of these isolation systems on seismic performance of reinforced concrete frame buildings were assessed considering a model with and without base isolation.

Their performance of with base isolator is best than without base isolator building, it can be used for general purposes or initial cost of structure increases tremendously. Base isolation is a technique developed to prevent or minimize injury to buildings during an earthquake. But safety it should be providing at such as hospitals, police station, & public places etc. it should be provided. It is observed that in case of without base building it is not possible to achieve the Intermediate occupancy and Life Safety performance level but it is possible in with base isolated building.

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