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# Earthquake Resistant Buildings Techniques: A Review

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**Abstract:- For over 35 years now, field of earthquake engineering has existed in our country. There have been significant contributions to seismic safety of several important structures in our country by Indian engineers. It is also seen that due to lack of awareness amongst practicing engineers about provisions that needs to be followed in designing earthquake resistant buildings, the result has been less satisfactory for normal structures during past Earthquake in India. To prevent the buildings from earthquake excitations there are several techniques that are used nowadays such as base isolation, dampers, bracings, etc. This paper is a review on various researches carried out by various researchers and engineers on such systems. The paper consists of a short review on the tests and investigations on systems for earthquake resistance in buildings done by professors, students, etc of various universities from all over the globe and also focuses on the result they obtained.**

## I. INTRODUCTION

Disasters have always caused huge damage to humans ever since our existence. They are unexpected, unpredictable. In counter activities, there have been several attempts to alleviate the catastrophic effects of these disasters. Since ancient times, earthquake is one of nature's greatest hazards on our planet which have caused immense damage to human life. What makes it even worse is its sudden and unexpected nature. Bringing down the damage caused due to untimely earthquake excitations is a major concern for many parts of the world. Since they are unpredictable, the only way left to prevent structures from earthquake is to design earthquakes resistant buildings. Considering this concern, there have been several attempts in this direction globally. The outcome of such attempts are motivating in developed countries while on other hand in developing countries results have been terrible including ours too. This can be proved as there were less loss of life and damage in developed countries compared to developing countries, due to earthquake excitations. Earthquake being a natural phenomenon, it cannot be stopped but all that humans can do is construction of safe structures to mitigate the death toll and damage. Only if the buildings are built earthquake resistant, just as it is made in USA and Japan, the developed countries, we will be able to bring down the damage and death toll and provide a safe environment for humans to live on and carry out their daily activities peacefully without any fear of losing life to earthquake.

## II. LITERATURE REVIEW

A brief review on earthquake resistant techniques by some of the researchers is given below:

- **Lin Su et al (1991)**: In this paper Lin Su, Goodarz Ahmadi and Iradj G. Tadjbakhsh, discusses about the analysis on a new combination of base isolator resulted after combination of the properties of electricity de France (EDF) base isolator and resilient base isolator(R-FB1) device, and new isolator formed i.e. sliding resilient base isolation system (SR-F). A curve is generated which is than compared with the one by EDF and RFB1 system called as Isolator Response Spectra. The outcome is then compared with fixed base isolation system. Different outcome from this different earthquake records were then compared with SR-F newly proposed isolator. Peak response of all earthquakes for EDF and R-FB1 were recorded and obtained results are compared to the SRF system. Therefore, maximum responses almost ended without large base displacement and the peak response of this isolator was also not too much serious in frequency and amplitude content.

- **H.W. Shenton et al (1993)**: In this paper, Shenton and Lin compared and analyzed relative results of fix based and base isolated structure. Referring the concrete fix base structure was designed according to the Structural Agencies Association of California (SEAOC), and comparison was done with a fixed base response. According to the SEAOC recommendation, the base shear was varying. Three various type of time history, post-earthquake record were chosen for the performance of nonlinear dynamic analysis for fixed base and base isolated structure. Comparisons of the results were done to 25% and 50% of the specified lateral force by SEAOC and the building's performance was checked for various lateral forces.

- **Todd W Erickson et al (2010):** In this paper, Erickson and Altoontash discuss the response of the industrial structure. It is shown that the response of industrial structure was presented under seismic forces and according to the IBC code, the building was designed. The current study signifies that three industrial buildings rest on one isolation slab. All problems related to analyses, design, placement of isolator are examined comparatively.

- **SM Kalantari:** SM Kalantari who for decreasing the base and storey shear of structure investigated effect of using two various types of seismic isolators. Four models of 2, 5, 8 and 12 stories had been created for cases of fixed base, lead rubber and friction pendulum isolator with varying stiffness. All this four models were analyzed under earthquake characteristics of Electro, Naghan, Tabas and Manjil by use of non linear finite element program. The outcome showed that use of LRB had more displacements in lower storey of building compared to fixed base model. While in most number of cases was seen that using FPS isolators didn't guarantee displacement requirement.

- **Franco Braga:** Franco Braga carried out some experimental study on series of dynamic snap back tests. The test was conducted on Potenza Basilica, a residential building in south Italy. The study aimed towards investigation of seismic behavior of low rise base isolated buildings on rubber bearings only.

- **Alex Y Tuan and GQ Shang (2014):** In their paper "Vibration control in a 101 storey building using a TMD" an investigation was carried out on effects of TMD on structural dynamic responses of Taipei 101 tower. A detailed dynamic analysis was conducted for evaluation of structural behavior.

- **Mr Ashish A Mohite, Prof. G.R. Patil (2015):** In his paper "Earthquake analysis of tall building with tuned mass damper", a software study on TMD was conducted. In which TMD is placed on the top of the building and storey drift, storey displacement and base shear was analyzed with and without TMD on ETAB. The analysis was done by investigating seismic behavior of $10^{th}$, $12^{th}$, $14^{th}$, $16^{th}$, $18^{th}$ and $21^{st}$ floor and excitations of Bhuj earthquake were applied using time history analysis. They concluded that the TMD should be placed at top floor for best control of the first mode and also proper implementation is necessary.

- **Balakrishna G.S et al (2014):** In his paper, it is presented that by using passive energy absorbing devices, seismic response of the building in earthquake prone areas can be improved. By use of SAP2000 v14, a 6 storey building was analyzed with provision of Viscous Fluid Dampers (VFD), Tuned Mass Damper (TMD), and without any damping devices and non linear time history analysis was conducted by applying equivalent to Bhuj earthquake.

- **Thakur VM et al (2012):** This paper comprises of explanation of use of TMD in soft storey form constructed at the top of building. A six storey building, rectangular in shape was considered and analyzed using SAP2000 software by using direct integration approach. Percentage mass of TMD used were 2% and 3%. Comparison between buildings with TMD and without TMD was done by applying three different recorded time histories of past earthquakes for analysis.

- **Liya Mathew:** Liya studied a reinforced concrete building, one with fluid viscous damper and other without it. A study was conducted to find the optimum damper properties for reinforced concrete frames. A symmetrical square building was analyzed using SAP2000 software for nonlinear time history and graphical format was used for showing comparison.

- **AK Sinha:** AK Sinha talked about the use and efficacy of fluid viscous dampers for response control of structures and to minimize the damping. In this paper, a nonlinear time history analysis was performed by him on a 3D model of 12 story RCC MRF building with help of 3D synthetic accelerogram. Two various cases of building models were analyzed one with supplemental damping and other without, it using ETABS. Absolute maximum displacement was compared and Time history response plots were also compared for various responses i.e. base shear and story shear forces, damping behavior and roof displacement and acceleration for both the models. The outcome of time history analysis was that the use of dampers improved the structural response as well as damping demand and proved to be effective.

- **Tomasz Falborski, Robert Jankowski**: The present paper is a report on outcome obtained from the experimental study of determining the effectiveness of elastomeric polymer bearings (EPB) in suppressing structural vibrations during different dynamic excitations. Analysis on single storey model one with fixed base and one with EPB was done and the response of the same was noted. It was seen that there was significant improvement in dynamic properties by use of EPB which reduces the structural vibrations.

## III. CONCLUSION

*A.* Simple base isolation system in low rise structure performs better and gives better outcome which means there is no need to modify the characteristics of superstructure as modification might not have a positive impact on performance of isolators.

*B.* By increasing damping of superstructure and allocating additional base mass, better isolation can be achieved in middle rise buildings.

*C.* By increasing the damping and making the superstructure stiff, we can reach effective base isolation in high rise buildings.

*D.* Although fluid viscous dampers reduces the response, it can be further reduced by proper selection and installing the fluid viscous dampers at various crucial locations.

*E.* It was seen that base shear can be reduced by about 10-35% while storey displacement can be reduced to 10-25 % effectively by providing 3% TMD. The drift of each

floor can be reduced to 1.2 % in a building frame by provision of Viscous Fluid Dampers (VFD).

*F.* It can be understood from this research that efficiency of isolated base and fixed base structure depends primarily on the type of soil upon which the structure rests. Response is satisfactory for hard strata but acceleration increases for soft soil strata thereby decreasing the energy dissipation of the structure and increase in frequency.

*G.* The efficiency of isolators varies with varying height of buildings. For buildings with low to medium height efficiency of isolators is good. The response of the structure is different because of the different types of changes due to the changes in physical properties of an isolator.

*H.* Recently, the seismic control systems have been used widely what is important is selecting best suitable damper and its installation in buildings for minimizing the structural vibrations when subjected to seismic loading. As passive control systems doesn't require any external power and are reliable, TMD is used as it is one of the best passive dampers.

*I.* On testing the structure using shake table there was seen significant decrease in structure with EPB. There was 58% reduction during sine sweep test and 40% reduction in peak lateral acceleration during dynamic tests. As it can be seen from the result, free vibration test showed considerable increase in damping of structure. The use of EPB was effective in reducing the structural vibrations.

*J.* Going through all these research paper we conclude that earthquake vulnerability can be greatly reduced by application of earthquake resistant techniques thereby providing safe living conditions and safer environment too. The success of such techniques is largely attributed to the development of such devices and proper planning.

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