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# Study of Base Isolation Technique for Design of Earthquake Resistant Structures

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***Abstract:*— Conventional seismic design attempts to make buildings that do not collapse under strong earthquake shaking, but may sustain damage to non-structural elements and to some structural members in the building. Non-structural components may consist of furniture, equipment, partitions, curtain wall systems, piping, electrical equipment and many other items. There are mainly three main categories: architectural components, mechanical and electrical equipments, and building contents. This may render the building non-functional after the earthquake, which may be problematic in some structures, like hospitals, which need to remain functional during the earthquake. Non-structural components are sensitive to large floor accelerations, velocities, and displacements. When a building is subjected to an earthquake ground motion, the building induces motion, resulting in floor accelerations higher than the ground acceleration. Hence, it is present need and also a duty of civil engineers to innovate earthquake resisting design approach to reduce such type of structural damages. Special techniques are required to design buildings such that they remain practically undamaged even in a severe earthquake. The idea behind base isolation is to detach (isolate) the building from the ground in such a way that earthquake motions are not transmitted up through the building, or at least greatly reduced.**

***Key word:*-- Base Isolation, Earthquake Resistant Structures, Strong Ground Motions.**

## I. INTRODUCTION

Special techniques are required to design buildings such that they remain practically undamaged even in a severe earthquake. There are two basic technologies used to protect buildings from damaging earthquake effects. An earthquake is the result of a sudden release of energy in the Earth's crust that creates seismic waves. This results in enormous seismic vibrations that travel through bedrock. As the energy of the earthquake travels in waves through the ground, certain frequencies of vibration retain more energy than others depending on the mechanical properties of the surrounding soil. Every building has a fundamental frequency (usually between 5 and 0.833 Hertz) that often falls within the range of seismic frequencies. During a seismic event floor accelerations and inter-storey drifts are caused in a structure. The basic dilemma in providing superior seismic resistance of a building is the difficulty in minimizing inter-storey drift and floor accelerations simultaneously. Large inter-storey drifts also causes damage to non-structural components. Inter-storey drifts can be minimized by stiffening the structure, but this leads to amplification of the ground motion, which leads to high floor acceleration, causing damage to structural components. Inter-storey drifts can be minimized by stiffening the structure, but this leads to amplification of the ground motion, which leads to high floor acceleration, causing damage to structural components. Making the system more flexible can reduce floor acceleration, but this leads to large inter-storey drifts. The only practical way of reducing inter-storey drift and floor acceleration simultaneously is to use base isolation, which provides the necessary flexibility, with the displacements concentrated at the isolation level.

### *A. Conservation of Energy-*

During an earthquake, a finite amount of energy is input into the structure. This input energy is transformed into both kinetic and potential (strain) energy, which must either absorbed or dissipated through heat. Following equation shows the conservation of energy in a structure during earthquake.

$$E = E_k + E_s + E_n + E_d$$

Whereas,
E- Absolute energy input from earthquake motion i.e., represents the work done by total base shear force at the foundation,
Ek – Absolute kinetic energy,
Es – Recoverable elastic strain energy,
En – Irrecoverable energy dissipated by structural system through inelastic or other forms of action and
Ed – Energy dissipated by supplemental damping device.

***B. Behaviour of Base Isolated System Against Fixed Base System-***

As an earthquake shakes the soil laterally, the foundation moves with the soil and the seismic waves are transferred throughout the structure over time. If the earthquake has natural frequencies with high energy that match the natural frequencies of the building, it will cause the building to oscillate violently in harmony with the earthquake frequency. The earthquake energy loses as it moves a structure, is proportional to the stiffness of the structure. Thus, in a nonisolated state, the building itself becomes an outlet for the energy of the earthquake because in all of its structural components it has to provide tremendous resistance (force) to the seismic motion. For the above equation of conservation of energy of a structure during seismic events, magnitude of energy component En is very high and is the primary reason for failure of structure. However, if the natural frequency of the building can be changed to a frequency that does not coincide with that of earthquakes, the building is less likely to fail. This is exactly what a base isolator does. The base isolator reduces the stiffness of the structure and thereby lowers its natural frequency. In this condition, the building's superstructure will respond to the vibrations as a rigid unit instead of resonating with the vibrations. Simply put, the building's foundation moves with the ground and the base isolator flexes to reduce the ground motion from affecting the superstructure. Lateral displacements caused are concentrated at isolation interface limiting the inter-storey drifts. Seismic isolation is characterized by flexibility and energy absorption capability. The flexibility alone is insufficient to defeat away a major portion of the earthquake energy so that inelastic action does not occur, i.e., En is minimized by means of energy dissipation in the isolation system and Ed is then useful in limiting the displacement response and in avoiding resonance. However, Structures are normally not isolated from vertical earthquake motions. Vertical ground motions are smaller in magnitude than horizontal motions. In addition structure is basically designed to resist static gravity loads they are inherently strong and stiff in vertical directions, making isolation in vertical direction of secondary importance.

## II. SCOPE AND OBJECTIVES

Seismic isolation enables the reduction in earthquake forces by lengthening the period of vibration of the structure. The typical period of isolated building is generally kept as 2.0 seconds. Therefore the significant benefits obtained from isolation are in structures for which the fundamental period of vibration without base isolation is short, less than 1.0 second. Buildings with comparatively higher natural period attract low earthquake forces even without seismic base isolation.Base isolation is a technique developed to prevent or minimize damage to buildings during an earthquake.A fixed –based building (built directly on the ground) will move with an earthquake's motion and can sustain extensive damage as a result.When a building is built away (isolated) from the ground resting on flexible bearings or pads known as base isolators, it will only move a little or not at all during an earthquake.

Base isolation of high-rise buildings has been growing in popularity Japan , yet it is uncommon in most of the world. While tall buildings already have long periods and thus lower input accelerations, the addition of isolation can decrease inter store y drifts and greatly decrease floor acceleration, protecting building content. By protecting building content, high-rises can be kept fully operational and occupiable after earthquakes. The Japanese design code has clearly outlined procedures for designing isolated high-rises in Japan. A base isolates structure is supported by a series of bearing pads, which are placed between the buildings and building foundation. Base isolation has become a widely accepted method for earthquake resistant design of structures. Initially, base isolation was a very suspect process for design of earthquake resistant structures, and engineers were wary of its applications; however, it has since become a widely accepted approach.The goal of base isolation is to reduce the energy that is transferred from the ground motion to the structure by buffering it with a bearing layer at the foundation which has relatively low stiffness. One of the important properties of a base-isolation system is that although it is designed to be significantly more flexible than the elements of the superstructure, it must still be stiff enough to resist typical wind loadings and similar low-amplitude horizontal forces.

Buildings of base isolated houses involves various steps from the design to completion, ranging from technical works such as ground survey and structural calculation, to practical works including material supply, construction and installation. In building a base –isolated house, it is necessary to conduct a ground survey or the like. Since the building moves horizontally in an earthquake, there are various precautions to be observed such as securing a horizontal clearance and attention to be paid to piping.

## III. LITERATURE REVIEW

There have been numerous papers and books published regarding base isolation of structures. However, the three –dimensional performance of these structures has been generally overlooked in the literature.

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Abe, et al (2004-a) performed tests on various bearing materials to determine their properties such as stiffness and multi-directional behaviour. The experiments performed by him suggest that the vertical force acting through the bearings affects their stiffness and damping properties.

James M. Kelly is an influential researcher in the area of base isolation. His book, Earthquake Resistant Design with Rubber (1996), discusses the theory and application of base isolation in detail.

The PhD dissertation of Ahmad El-Hajj (1993), published at the University of Pitsburgh developed a multi-dimensional approach to base isolation. .

Mostaghel and Khodaverdian(1988) wrote a paper on the dynamic response of base isolated structures which formed a skeleton for many of the derivations presented in this study.

Ziegler(1973) modified prager's hardening rule to develop a plasticity theory to apply to kinematic hardening.

The modified Ziegler(1959) plasticity is also adapted from this dissertation, which modified the stress-strain formulation to apply it to the more convenient force- displacement relationship.

The treatment of nonlinearities in the bearing response is nit restricted to the plasticity theory. It had been used in New Zealand, as well as in India, Japan, Italy and the USA.

Hamid Reza Tabatabaiefar, Ali Massumi (2010) As the Iranian seismic code does not address the soil–structure interaction (SSI) explicitly; the effects of SSI on RC-MRFs are studied using the direct method in this paper. Four types of structures on three types of soils, with and without the soil interaction, are modeled and subjected to different earthquake records. The results led to a criterion indicating that considering SSI in seismic design, for buildings higher than three and seven stories on soil with (shear wave velocity) Vs<175m/s and175<Vs<375 m/s, respectively, is essential. A simplified procedure has been presented, on the basis that lateral displacement increments could be applied to the fixed base models using simple factors.

Eduardo Kausel (2010) Soil–structure interaction is an interdisciplinary field of endeavor which lies at the intersection of soil and structural mechanics, soil and structural dynamics, earthquake engineering, geophysics and geo-mechanics, material science, computational and numerical methods, and diverse other technical disciplines. Its origins trace back to the late 19th century, evolved and matured gradually in the ensuing decades and during the first half of the 20th century, and progressed rapidly in the second half stimulated mainly by the needs of the nuclear power and offshore industries, by the debut of powerful computers and simulation tools such as finite elements, and by the needs for improvements in seismic safety.

## IV. FUTURE SCOPE –

More than twenty buildings with passive response control system, including "base-isolation", have been constructed up to the present, while, active response control system is now entering the stage of practical use. But their technology have not perfectly been completed yet. Base-isolated device is now widely used, which employs laminated rubbers some types of dampers, do not work well for certain types of input earthquake wave,especially predominate in longer period, and for vertical direction. Active vibration control system have weak points in the costs and reliability of devices and power supply, but it might be used for partial control of very important things like computers, nuclear power generators and so on, or for control of weak vibrations excited by winds. The existing problems to be solved are development of devices and precise estimation of input motions, but the former point may be expected to mechanical engineers. Architectural engineers will do duty as system designers, and use the developed devices for the suitable purpose. Various types of response control system will be used widely in future, not only for earthquake resistant design of structures but also for comfortable and ease feeling of the inhabitants.

In future base isolation system will be widely used in multi-storey RC frame buildings. Due to several significant features of base isolation, it will be used in many structures such as hospitals, schools. In future, base-isolation may also be used in soft soil and also consider the unsymmetrical structures and their heights. Base isolation may be used in high rise building in future. In current time it is used only for hard soil and not for soft soil. In short the base isolation technique is mostly used in all types of structures as compared to other retrofitting seismic technique.

Base isolation gives the best architectural impact and has a better seismic performance among the other global retrofitting techniques. It saves a major amount of destruction and its maintenance cost is also less. The success of the method largely depends upon development of isolation devices. Planning and Displacements in isolated structures are often large and attempts are made to add energy scattered or damping in the isolation method to reduce movements. The addition of damping to the isolation systems serves to reduce displacements in the seismic isolators. The entire superstructure is to be supported on discrete isolators whose dynamic properties are chosen to separate the ground motion.

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## V. CONLUSION –

Tectonic plate movements give rise to seismic events. In any such event huge amount of energy is released. For instance energy released in 2001 Bhuj earthquake was 400 times greater than that released by atomic bomb dropped at Hiroshima in 1945. Needless to say, any such major event causes great casualties, sometime claiming lives even over number of lakhs and causing innumerable amount of property destruction. High unpredictability of its occurrence makes an earthquake even more perilous. Possibility of any such happenings cannot be ruled out in a life span of a structure located in severe seismic zones. So its a moral responsibility of any structural engineer to be comprehensive with his work. With the appreciation to research in the field of structural dynamics many innovative techniques & devices has been suggested to build an earthquake resistant structure. Base isolation is one of such techniques widely accepted as seismic protection system. Base isolation is one of the most powerful tools of earthquake engineering pertaining to the passive structural vibration control technologies. It is meant to enable a building or non building structure to survive a potentially devastating seismic impact through a proper initial design or subsequent modifications.

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