A Survey Studied on Hybrid Spherical Rollers and Earthquake Resistant Structures

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***Abstract*: In a very comprehensive experimental investigation, the effectiveness of four different models is examined. Each model is composed of three single bay frames with three stores each. The naked frame has the highest peak displacement reaction of all of the frames, while the braced frame has the highest peak acceleration response. Because the braced frame has a higher stiffness and is subjected to a higher excitation frequency, it has the greatest acceleration response. The frame with designed hybrid spherical roller base isolated frame has the lowest peak displacement response among the frames with infill walls due to greater energy dissipation. Despite this, the peak acceleration response of this frame is the highest among frames with infill wall due to greater stiffness and higher excitation frequency; nevertheless, due to damping effect, its peak acceleration is lower than a naked frame. The frames with infill walls exhibit the greatest peak displacement response because the presence of an opening in the wall reduces its rigidity. The peak acceleration and peak displacement responses of the single braced frame are higher when compared to the frame with the base isolated frame. The damping impact of the base isolated frame is decreased when compared to another frame. Braced frames are stiffer than in-filled frames. As a consequence, the acceleration response of the brace system is much higher than that of the in-filled systems. However, this paper presented the peak displacement response is smaller when compared to a braced system. This may be because in-filled frames dissipate more energy than braced frames.**

***Keywords*: Earthquake Resistant, Rollers, Hybrid Spherical Rollers, Damping Impact**

I. INTRODUCTION

The natural phenomenon known as an earthquake is caused by the movement of tectonic plates, which includes shocks and impulses of catastrophic size conveyed through the earth's surface. Isolating load bearing buildings from the transmission medium is the most rational and effective means of protecting against the excessive degree of acceleration caused by an earthquake. When a proper base isolation system is used instead of a permanent base structure, the fundamental period of the structure is raised, and the isolation effectiveness rises as the earthquake strength rises. The building is protected from seismic effects by the base isolation. It separates a superstructure from a substructure that is supported by the earth. The main difference between an isolator and a damper is that an isolator reduces the system's natural frequency to below the excitation frequency, while a damper removes mechanical energy from the system. Most earthquakes have a range of times during which the structure's acceleration is enhanced beyond the maximal ground acceleration. The relative displacement will not usually surpass the peak ground displacement, i.e. finite period displacement, although there are occasional exceptions, particularly for soft soil locations near the fault. The implementation of base isolation in codes is based on the premise that the energy input is constant during the mid-frequency range of around 0.5 sec to 4 sec, i.e., the velocity is constant. After reaching a peak, damping decreases in comparison to tiny displacement, and regrettably, the greater the earthquake, the less damping there is. Damping works by lowering the yield level (as a percentage of the building's weight), however the greater the yielding level, the less effective the isolation system will be in minor to moderate earthquakes. This is because the isolation system does not start working until the yield threshold is surpassed, and if a high threshold is set, the system will not work if earthquakes occur more often. The features of the isolation devices and superstructure, as well as the characteristics of the input excitations, determine the efficacy of base isolation systems. As a result, a complete preliminary research is required to determine the effectiveness of a given base isolation system for a building in relation to the seismic map for the region and the characteristics of the likely earthquakes. The expense of isolation will always be a major factor to consider, and one of the primary concerns of innovators in any project. A newly separated structure, on average, costs more than a non-isolated structure. In addition, more technical effort is required to study and design the structure and its isolation system in detail. The flexibility of the superstructure in a base isolated building, on the other hand, is often less than in a non-isolated building, which may result in lower construction costs. There is another concern when choosing a heavily damped system for a possible construction: heavier dampers may cause greater floor acceleration. It is critical to pick the proper isolation type for the particular location and mass of the building. The most major benefit of employing the base isolation system, however, is that the structure will function better during an earthquake, perhaps saving many lives. This might be classified as a long-term cost-cutting investment. This thesis demonstrates the feasibility of constructing an effective hybrid base isolation technique based on the newest technology and state-of-the-art isolation methods.

SEISMIC ISOLATION

The base isolation method was developed in response to the pressing need for earthquake-resistant constructions. The notion has matured since its inception in 1909 B. C. by a doctor called Culinarians, who advised using the talc layer between the foundation and superstructure. Numerous other types of isolators have since been developed and effectively utilized in many nations. The basic principle of an isolator is to isolate the superstructure from the foundation in order to mitigate the damaging impacts of an earthquake. The fundamental idea behind base isolation devices is to create a layer between the foundation and the superstructure that is rigid vertically but highly flexible horizontally. Because the isolators are more flexible in the horizontal direction than the superstructure, they will introduce a new mode of vibration into the superstructure, which will lengthen the superstructure's fundamental period, which will not match the input period. The basic goal of base isolation is to alter the fundamental frequency of the superstructure away from the dominating frequencies of the input, and (ii) limit displacement by increasing the quantity of damping material in isolators like lead.

II. REVIEW OF LITERATURE

Reviewing the literature entails halting the flow of already completed research. Review of relevant previous work, including inconsistencies, traps, and other flaws, in order to demonstrate the necessity for a new examination study. Past research considerations are extracted, and the essentiality composition of specialists in the subject area is examined. Such a review lays the groundwork for the present investigation's progression and encourages the reader to think forward. A brief overview should be included, highlighting areas of confusion or disagreement in findings, as well as gaps in current knowledge.

A good literature review is essential since it displays the current state of knowledge in the subject and also aids in the discovery of the most important as well as overlooked topics and their relevance to current research. Each of these elements is critical in defining a topic of study and its place within the setting. Reviewing relevant literature aids in the formation of a hypothetical structure and methodological center, which leads to the formulation of credible hypotheses. Regardless, this evaluating aids in the discovery and abridgement of additional identical queries regarding. This will shed light on any caveats or gaps that previous probes have failed to address. It reduces the need for current research and also aids in persuading the reader that what is going on is important. Last but not least, after reviewing the literature, scientists are in a better position to choose appropriate research strategies to address a specific issue and recognize areas of previous grant to avoid duplication of effort.

Any investigation or research project requires a thorough review of the literature. It arouses awareness and increases the depth of knowledge about the problem. A review of relevant literature is a key step forward in educational research. It gives the agent the ability to look for gaps and trends in a certain area. Future experts may use information on the structures, tests, and research gadgets used by various agents to better design their strategy. Specialists must be aware of previous research projects, and at that point, they will be in a position to add something unique. The following sections have been used to sift down the literature that is available:

BG Kavyashree, Shantharam Patil and Vidya S. Rao (2020) From the Palaeolithic era through today's skyscrapers, permanent building has progressed. Because of the uncertainties in nature, constructing a building that ensures the safety of its people has become a worry. As a result, in recent years, focus has shifted to the creation of structural protection systems that can withstand external stresses. In this work, structural control against wind and earthquake loads has been thoroughly investigated, with the structure behaving differently for wind and seismic loads. The article begins with a discussion of the construction's history, followed by a short discussion of the passive control system, which was employed in structural control. In addition, the introduction of active control, which was adopted later in the structural control for more effective control, has been explored. However, due to the limitations of passive and active control systems, semi-active control and hybrid control strategies have been developed. The two techniques are combined in a semi-active and hybrid system to acquire all of the algorithm's benefits while also overcoming its limitations. The review also discusses stochastic vibrational control of structures, in which unpredictability is taken into account in external loads, system parameters, and external devices used in structural control. Because the construction industry is such a complicated system, big data analysis, a new topic in structural control systems, is examined, as well as its future potential.

Agus Bambang Siswanto and M. Afif Salim (2018) The size, direction, and time of occurrence of earthquake loads are all very unpredictable. The effects of earthquakes of various magnitudes on building constructions are dependent on a variety of factors. The weight and stiffness of the structural material, the configuration and structural system, the period or time of vibration of the structure, ground conditions, earthquake zones, and earthquake behavior are all factors that influence the horizontal force, vertical force, and torque moment that occur as a result of earthquakes in the structure. The provisions that need to be considered in the structural design of buildings in earthquake prone areas are: the layout of the structure, capacity planning with the concept of strong column - weak beam, as well as the distribution of earthquake loads can be done in a simple way, in order for earthquake loads on structures that counts is not too large and the direction is quite predictable, as well as the distribution of earthquake loads can be done in a simple way. By meeting the following criteria, it is possible to design buildings in earthquake-prone locations in a simple, safe, and cost-effective manner.

Bo Wang, Tao Wu, Huijuan Dai, and Guoliang Bai (2018) The seismic performance of a steel–concrete hybrid structure consisting of reinforced concrete (RC) tubular columns and steel braced truss with A-shaped steel frames, which is a novel supporting structural system to house air-cooled condensers (ACC) in large-capacity thermal power plants, is investigated numerically in this paper (TPPs). First, a series of pseudo-dynamic tests (PDTs) on a 1/8-scaled sub-structure verified the finite element (FE) modeling methodology for this hybrid structure using the program ABAQUS. With increasing peak ground acceleration (PGA), the failure process, lateral displacement responses, changing rules of dynamic characteristic parameters, and lateral stiffness were all shown. The prototype structure was then subjected to a nonlinear time-history analysis. The dynamics, base shear force, lateral deformation capacity, stiffness degradation, and damage characteristics were studied. Despite the intricacy and irregularity of the structure, both experimental and computational findings show that the overall seismic performance of this steel–concrete hybrid supporting structure fulfills the seismic design criteria for high-intensity earthquakes.

Snehansu Nath, Dr. Nirmalendu Debnath, Prof. Satyabrata Choudhury (2018) In the topic of structural seismic performance, there has been a tremendous amount of study. For academics and engineers, improving performance continues to be a difficult issue. In order to accomplish the desired effect, a variety of tactics have been examined. The most common way of safeguarding buildings from earthquakes is base isolation. The employment of various dampers, on the other hand, has been a big revolution in enhancing building seismic activity. This review article will show how to improve the seismic performance of buildings and bridges using various strategies. The research focuses on the role of various isolators and dampers in preventing damage to buildings and other civil infrastructure. A key research in the review looks at how the devices may be used to improve the efficiency of buildings, bridge piers, and other structures. For academics and experts, improving the seismic performance of buildings has always been a difficult problem. The mitigation of civil infrastructure damage caused by strong seismic vibrations is a key challenge that must be addressed. The current study focuses on several techniques for increasing infrastructure seismic performance. The project focuses primarily on base isolation and the use of dampers to improve seismic performance. Due to its simple design, low space requirements, mobility, and ease of installation, tuned mass dampers and liquid dampers have sparked a lot of interest. Magneto-rheological dampers, on the other hand, have a maximum damping force of 200KN, which is more than enough to dampen significant seismic movements. After seismic tremors, some shape memory alloy dampers have the ability to recover from distorted structural forms. Furthermore, the seismic performance of structures may be considerably improved by using a base isolation system. In construction, an elastomeric bearing made of fiber reinforced polymers acts as the primary foundation isolator. Rubber plates are used for base isolation in high damping bearings and lead rubber bearings. High damping bearings, on the other hand, are now made of CFRP plates for greater seismic performance. Flat slider bearings may be stiff or elastic, depending on the application, and they reduce bridge seismic vibrations regardless of temperature. Pendulum bearings are formed consisting of sliding surfaces with a spherical form, which increases the time period and hence reduces seismic vibrations in buildings. The evaluation will look at how base isolators and dampers may help improve the seismic performance of buildings, bridge piers, equipment, and other civil infrastructure and design elements.

Nicos Makris (2018) Seismic isolation, also known as aseismic base isolation, is an earthquake-prevention approach that tries to decouple a structure's motion from ground shaking, reducing structural pressures. Seismic isolation, a highly effective and successful seismic protection method, is now a mature and viable alternative to conventional capacity design, and has been used in a variety of bridges, buildings, and other specific structures across the globe. The beginnings and early advances of seismic isolation (up to the early 1990s) are documented in this work. Major buildings and bridges were supported by leadrubber bearings, natural rubber bearings, or singleconcave sliding bearings by the early 1990s, making seismic isolation a practical and stable seismic protection approach. Following the earthquakes in Northridge, California, in 1994, and Kobe, Japan, in 1995, seismic isolation became more widely accepted for the seismic protection of civil structures across the globe.

Aravinthan. et al (2016) A new seismic isolation bearing is designed and modernized for improving the performance of structures during seismic forces. This new bearing uses hybrid spherical rollers (HSR) on the concave sloping surface to achieve isolation with additional shock absorbing sandwich plates surrounded by them to increase the damping of the structure. The bearing is characterized by a self-centered capability. Each roller is free to displace under 3-translational and 3-rotational directions hence, it is capable of reducing the seismic response and prevents the structure from transmitting the destructive surface wave. The objective of this research is to understand the seismic behavior through analytical and experimental investigation on a model using a linear harmonic shake table to verify its dynamic characteristics. The results are discussed to show that there is a possibility of improving the efficiency of base isolation using the HSR isolator during strong earthquakes where the majority of base isolation techniques do not perform well. Other observations that were derived from this experiment are, the structure is rocked due to the cushioning effect of rubber layers and the frictional force due to the rubber is induced to the structure which caused the relative displacement. From the results, this new pattern of the Hybrid spherical rolling isolator was found to perform well to reduce the dynamic characteristics of a structure in the one-dimensional test. Further, the three-dimensional test should be conducted and the time history analysis should be done to establish the exact performance during the earthquake.

The principle of base isolation is to modify the response of the building, so that the ground can move the building without transmitting the motions into the building **Nikita Gupta (2014).** In an ideal system, this separation would be total. For most earthquakes, there is a range of periods at which the acceleration in the structure will be amplified beyond the maximum ground acceleration. The relative displacement will generally not exceed the peak ground displacement, i.e., finite period displacement, but these are some exceptions to this, especially for soft soil sites which are situated close to the fault implementation of base isolation in codes is based on the assumption that over the mid frequency range from periods of about 0.5 sec to 4 sec, the energy input is constant, i.e., the velocity is constant.

According to **Moti Perets (2014),** the friction pendulum bearing suffers due to the highly concentrated stress produced by the rolling ball or cylindrical rod due to the small contact surface area between rolling ball and the concave surface which results in scratches and damages to concave surface caused by the motion of ball or cylindrical rod during earthquakes.

Chong-Shien Tsai (2012) and Abbas Moustafa (2012) explained the common techniques that are used to resist the seismic force by designing to use the strength and ductility of the structural member to resist the seismic forces or dissipate earthquake-induced energy. Many past earthquakes have proven that structures collapse or lose their functionality when the ductility capacity of the structure is consumed during the earthquake. Even if survives earthquake through the excellent pattern to offer more strength or ductility to structures, the vibration sensitive equipment in the structure may still lose its functionality due to floor acceleration.

George c. Lee (2010) carried out a shake table study on a certain version of such bearing which does not have hybrid spherical rollers. It consists of a cylindrical roller for zero post stiffness and self-certain capability. However, the vertical loading, loading history and loading rate were not considered. But, in this research, these effects are considered and the costly shear wall and costly base isolator are eliminated. The hybrid spherical roller allows the structure to displace vertically in near-field earthquake to reduce the vertical stress, whereas the elastomeric bearing fails to do so.

To increase damping for a rolling bearing and to prolong the service life of the bearing, an isolation system SDI-BSP (static, dynamic interchangeable – ball pendulum system) was proposed by **Tsai et.al (2008)** which prevents damage and scratches to the concave surfaces during the earthquake and several small steel balls to support static weight with variable radius curvature. This can be applied for only light weight or heavy equipment structures. For heavy structures, the roller should be adequate enough to take care of the heavy static and dynamic loads. An attempt has been made to design a new isolator which will be capable of handling the above requirements.

Fathali and Filiatrault (2007) presented a spring isolation system with resistant, which is a rubber snubbed to restrain displacement.

Necdet Torunbalci (2004) Seismic isolation and energy dissipation systems are an efficient technique to improve the seismic performance of buildings using standard seismic design. Traditional seismic design requires more strength and ductility to withstand seismic forces, while these approaches lower seismic forces by modifying the stiffness and/or damping in the structures. Passive, active, and hybrid technologies are all undergoing extensive study and development. This study gives a short history of isolation methods and introduces these systems, which range from simple passive devices to complex and fully active systems. The growth and growth of passive systems, particularly base isolation systems, are examined by concentrating on them. A comment concerning applications is included, as well as a discussion of the suggested requirements from codes for new buildings and other structures. This research, on the other hand, examines the state of earthquake protection measures in Turkey. Although this methodology is not widely used, it is the subject of a number of studies to better understand how solitary structures behave. Civil engineers, architects, builders, and owners all have significant responsibilities when it comes to the usage of these systems, but consumers, in particular, have responsibility, therefore widespread adoption of earthquake protective systems will be facilitated by user understanding.

Durgesh C. Rai (2000) Structures designed to withstand earthquakes have evolved into a truly multidisciplinary subject of engineering, with many new advances conceivable in the near future. The following are the most notable: (a) a comprehensive probabilistic analysis and design approach; (b) performance-based design codes; (c) multiple annual probability hazard maps for response spectral accelerations and peak ground accelerations with improved characterization of site soils, topography, and near-field effects; and (d) new structural systems and devices utilizing non-traditional civil engineering materials. This article discusses several key events that will occur in the following years. Earthquakes will continue to occur and inflict tragedies if we are not prepared, it is widely believed. The only alternatives we have are to assess earthquake risk and improve engineering solutions to limit damage. Improved zoning maps, trustworthy databases of earthquake processes and their impacts, a greater knowledge of site features, and the construction of EQRDs are all priorities for geologists, seismologists, and engineers. The ultimate aim for the engineer will remain the same: to create the optimal, cost-effective building that acts in a predictable and acceptable way. In the future years, continuing research and development initiatives in the domain of EQRD of structures hold a lot of potential for achieving that aim.

III. CONCLUSION

A comprehensive experimental research examines the efficacy of four different approaches. Each model consists of three single frames with three stores each. The bare frame reacts most effectively to the peak of all the frames, while the frame with the braced frame reacts most quickly. The fact that the braced frame is more rigid and exposed to higher frequency of stimulation results in the greatest reaction. The framework with designed hybrid spherical roller base frame provides the lowest peak displacement between frames with infill walls due to better energy dissipation. With this increase in rigidity and high excitation frequency, the peak acceleration response of the frame is the largest among frames with infill wall; nevertheless, its peak acceleration is lower than a bare framework because of the damping effect. As the presence of an opening in the wall reduces its rigidity, the frames with infill walls have the greatest reaction to peak displacement. Compared to the frame with the isolated base frame, the peak acceleration and peak displacement of the single brace frame are higher. The damping effect of the insulated base frame is decreased in comparison to another frame. The braced frame is stiffer than the filled frame. As a consequence, the acceleration response of the brace system is considerably higher than the filled systems. However, the peak displacement response is smaller compared to a braced system. This may be because in-filled frames dissipate more energy than braced frames.

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