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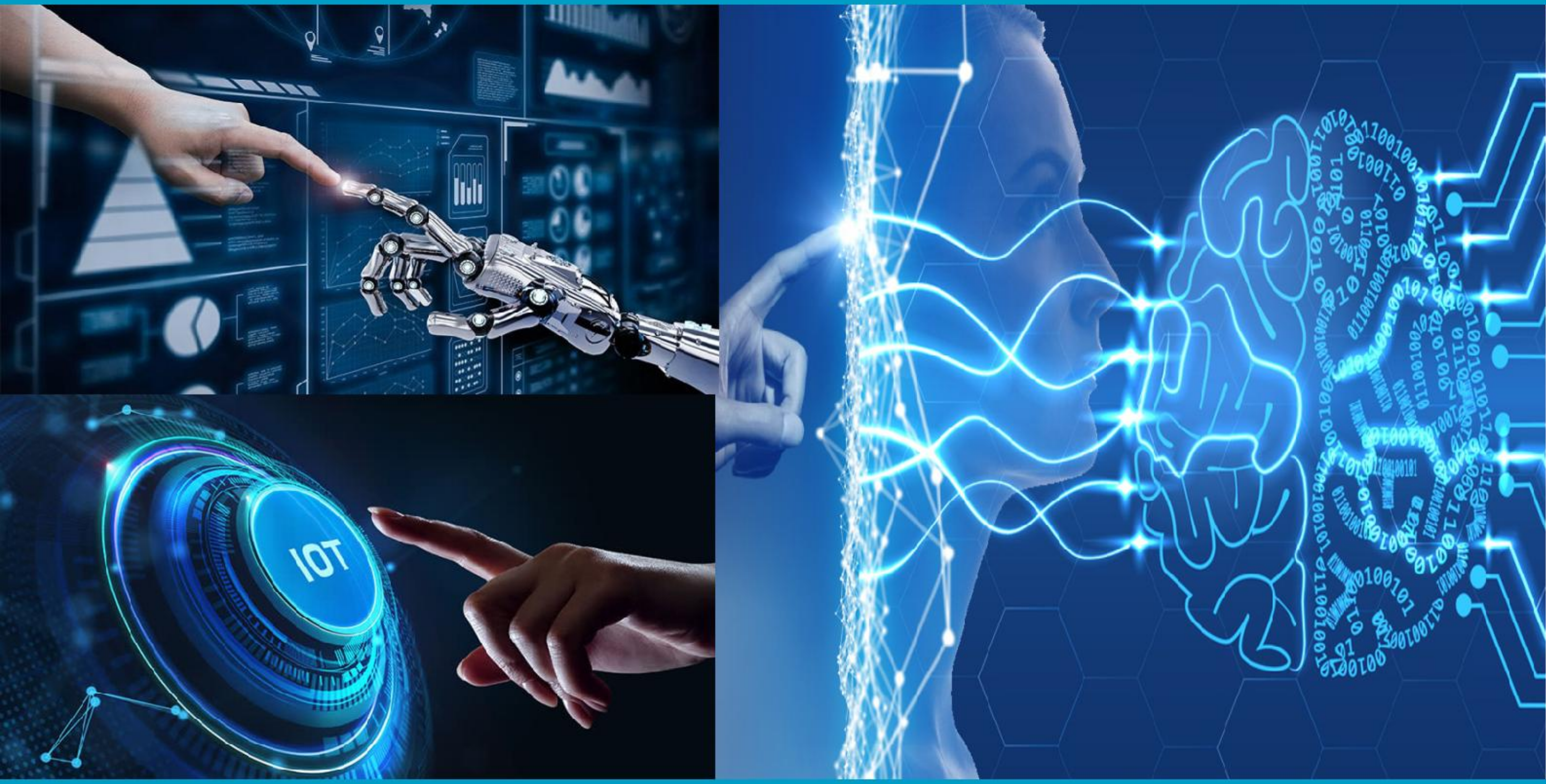


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# Extensive Experimental Study Hybrid Spherical Rollers (HSR) For Design of Earthquake-Resistant Base-Isolated Buildings

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**ABSTRACT:** Extensive experimental research is now being carried out with the goal of establishing which of four possible models is the most useful by assessing the relative utility of each of the potential solutions. Each model is composed of three single-bay frames, and each of those frames has three distinct degrees of capacity. These frames are grouped together to form the model. However, the one with the bare frame has the most spectacular peak displacement reaction of all of the frames, but the one with the braced frame has the most impressive peak acceleration response of all of the frames. This occurs as a result of the increased rigidity of this frame, in addition to its higher excitation frequency, both of which contribute to the occurrence of this phenomena. The peak displacement response of the frames that have infill walls is greater than that of the frames that do not have infill walls. This is the case because the infill walls increase the stiffness of the structure. The existence of an aperture in the wall causes a decrease in the overall stiffness of the wall. The fact that there is a hole in the wall adds to this overall drop in the wall's stiffness. When compared to the frame that had the base isolated frame, the frame that had the single brace demonstrated greater peak acceleration and peak displacement responses. When opposed to the effect that is brought about by the influence of another frame, the damping impact that is produced by the base isolated frame is far less severe in its severity. When contrasted with the in-filled frame, the braced frame is characterized by a greater degree of rigidity owing to the presence of extra bracing. This is the defining characteristic of the braced frame. Because of this, the acceleration response of the bracing system is notably more impressive than that of the in-filled system. The idea that came before this one has a direct bearing on this one, thus this is a direct result of that. When compared with the response of a system that is not braced, the peak displacement response of a system that is braced has a value that is much lower than the value of the response of a system that is not braced. It is not completely out of the question that the fact that in-filled frames lose more energy than braced ones is related to this in some way. It's only a possibility at this point.

**KEYWORDS:** Tectonic Plates, Seismic. HSR, Earthquake-Resistant

## I. INTRODUCTION

It is possible to install seismic isolation devices in buildings in such a way that the base of the structure is separated from its superstructure or in such a manner that individual sections of the structure are placed so that they are isolated from one another. When designing new buildings, energy dissipation technologies are frequently used as the primary method of seismic isolation that the building employs. The devices may be classified in one of two ways: either according to their position in the structure or according to the principles that govern how they work. Both of these approaches have their advantages and disadvantages. Isolators may be separated into two different kinds according to the part of the building in which they are situated. Internal and exterior isolators are the two primary categories of isolators that may be found. It is common practise to place devices that are external to the structure in the foundations of the building, which are therefore situated outside the building. Energy dissipation devices are characterised by the use of internal mechanics into their design. According to Torunbalci, response control systems may be categorised as either active, passive, or hybrid based on the operational principles that direct how they carry out their tasks. He claims that this is the case for all response control systems.

**Control Methods That Are Not Active:**

When properly implemented, passive control systems do not need the application of any extra energy in order to function. Because of this, the cost of creating these systems is lower when compared to the cost of establishing active systems. As a result of this, the cost of establishing these systems is cheaper. These sorts of systems are able to regulate the displacement to a certain degree, but only up to a certain point. The protective mechanisms that are employed in passive control systems are built with the goal of giving the needed degree of protection against earthquakes of a specific size. This protection is intended to be provided against earthquakes of a certain magnitude. These systems are made up of a variety of devices, such as dampers, isolators, and others, all of which are readily available for purchase and installation. There are many different kinds of passive control systems, and many of them have been demonstrated to be more successful in practice. According to Torunbalci, each of these systems is reliant on the existence of components that are capable of absorbing energy at a specific level, either on their own or in conjunction with other components. These components may be capable of absorbing energy on their own or in combination with other components. When it comes to systems that include irreversible displacement, the moving components might be either balls or rollers. (Fig.1.1).

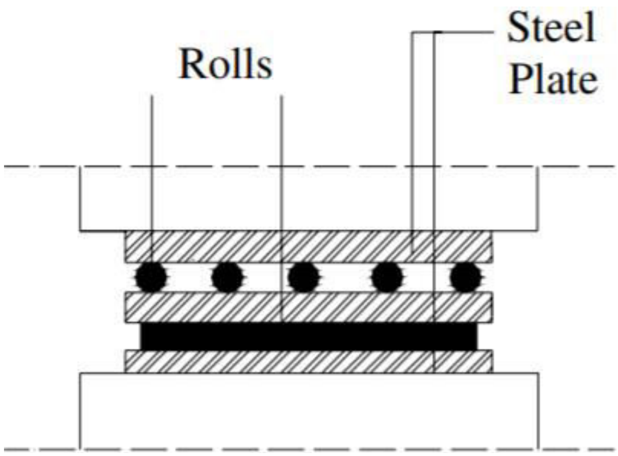


**Fig. 1:** Irreversible displacement system

Because of these rolls, there is a chance that the structure may slide to the side if an earthquake occurs. They are built with the appropriate quantity of rolls or spherical steel balls, both of which are arranged in a direction that is perpendicular to the steel plates, and they are positioned inside the steel plates themselves. Due to the malleability of lead, which is employed in these systems, plastic systems have been developed that allow improved energy absorption for seismic isolation and other vibrations. These systems have been constructed owing to the fact that lead has been used. (Fig. 1.2).

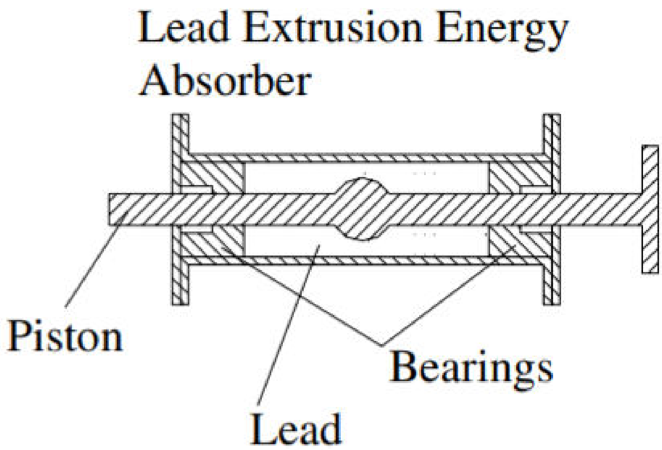


**Fig. 2:** Plastic system

In these types of systems, the cylinders typically contain lead, and the pistons within those cylinders are notoriously difficult to manipulate. Because of the lead that is contained inside the cylinder, the motion of the piston is restricted, which enables the energy to be absorbed. Lead extrusion dampers are often responsible for the regulation of the biggest displacements.

**Earthquakes**

More than 200,000 earthquakes are recorded every year over the whole planet. Monitoring seismic activity on a global, regional, and local scale generates data that may be analysed to get a better understanding of the incidence of earthquakes and, as a consequence, to map regions of high and low seismic risk.In the past half-century, earthquakes have been the natural disaster that have been responsible for the greatest number of fatalities. In addition, earthquakes have wreaked havoc on society's cultural, economic, and political institutions. The unpredictable nature of earthquakes, coupled with people's morbid fixation with dying in them, contributes to the inherent danger that they provide to humans. The majority of the world's most important cities may be found in regions that are prone to earthquakes. The phenomenon known as earthquake generation is a sophisticated process that takes place deep inside the crust of the earth. In addition, the precise level of stress that must be applied in order to burst a flaw is unknown to the specialists.

A low-magnitude earthquake, on the other hand, has the potential to escalate into a large tremor or create one if sufficient stress has accumulated.

## II. RESEARCH METHODOLOGY

If the hybrid spherical roller system is installed in accordance with its guiding principle, which specifies that the structure must be allowed to move freely but in a controlled fashion during an earthquake, then the structure will not experience a large loss of strain energy (elastic energy). Frictional force is the sole force transmitted from the isolator to the structure, and it occurs at the superstructure level. The structures will experience no structural or non-structural damage since the frictional force is low enough for the structure to withstand within its elastic limit. Rather of enhancing a building's capacity to support additional weight, the goal of developing this brand-new hybrid roller bearing isolator was to reduce the pressure imposed on structures. The configuration method, also known as the arrangement of isolating components, is now being utilized to lessen the impact of earthquakes by more than 90 percent. And

The building will float on seismic waves if it has been planned properly. This necessitates that an appropriate size, shape, and location of isolator be included into the design of the building. If this didn't happen, the strong seismic wave would level the building. e.g.,

- Parking a car or bus on open ground during an earthquake protects it from both structural and non-structural damage.Plates made of steel or aluminum don't float on water, but they may be made to do so if their shape and design are modified to resemble a boat.

## III. RESULTS

### COMPARATIVE ANALYSIS OF EXPERIMENTAL RESULTS

Until it reaches its maximum ground acceleration of 0.23g, the experimental investigation will continue. Both the numerical analysis and the experiment yield maximum relative displacements that are in excellent agreement with one another. The highest difference between the two is only 1.8 percent for FF, 2.7 percent for BIF, 0.8 percent for IF, and 1.2 percent for BF. This shows that the numerical analysis and the experiment are both accurate. There is a maximum difference of 3.0 percent between the acceleration of the floor and the acceleration of free fall for FF, 0.9 percent for BIF, 3.0 percent for IF, and 1.0 percent for BF. The damping constant provides us a large difference as a consequence of the numerous components that determine damping constant (friction, structural friction, inter-particle friction, and active damping), which results in the average difference of C (damping) ratio being 35%. This is because these components establish the damping constant, which explains why this is the case. However, due to the fact that the stiffness of the structure has a significant impact on the displacement of the structure, the damping constant only has a very small bearing on the differences in results that can be seen between the theoretical and experimental models. The degree of stiffness that is produced by both the real and theoretical findings is the same. The real value of the seismic force is 10929.4 Newtons, and the theoretical value is 11072.1 Newtons; these two numbers are 98.7 percent equivalent to one another.

In Figure 4.79 through Figure 4.82, you can see the real results of the tests that were performed on each of the four models. These tests were carried out by our research team. The responses of the models for the first level, the second floor, and the third floor are presented in the graphs b, c, and d of the figure that spans from 4.79 to 4.82 respectively. Always keep in mind that the shaking table is only stimulated in one direction; as a result, you should only assess the CH-X response; the CH-Y and CH-Z responses, which reflect the residual reaction, should be disregarded. In this particular scenario, bear in mind that the shaking table is only stimulated in one direction. The greatest values obtained both from theory and experiment are similar, with a difference of 5.9 percent being detected across all four models of the comparison. As a direct result of this, the results that are provided by the theoretical values and the experimental values are congruent with one another. Consequently, this demonstrates that the conclusion can be relied upon.

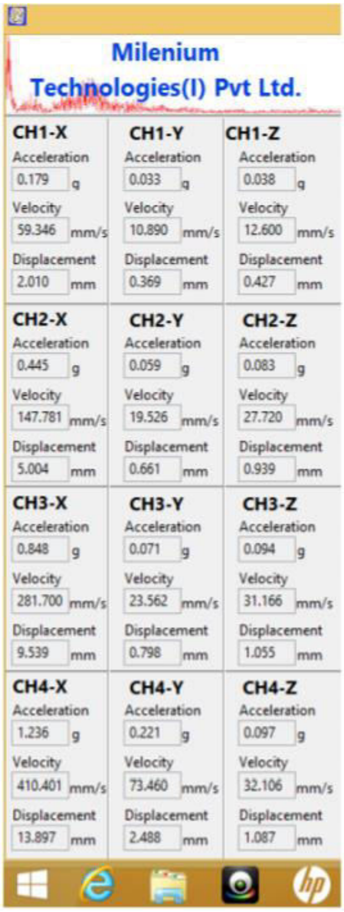


**Fig. 3:** (a) Experimental response of FF. (CH 4, 3, 2 and 1 are the response of III, II, I and ground floor respectively) neglect Y and Z direction.

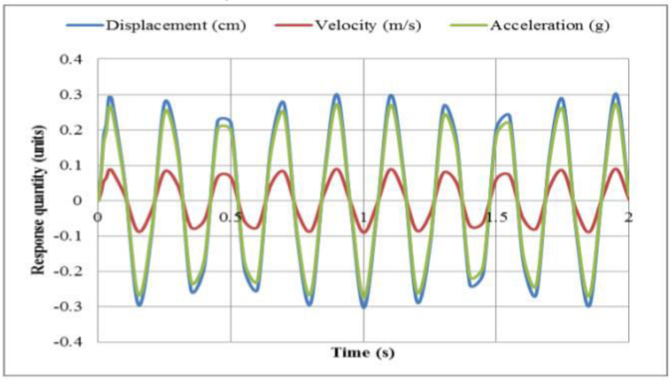


**Fig. 3: (b) Theoretical response of I floor.**

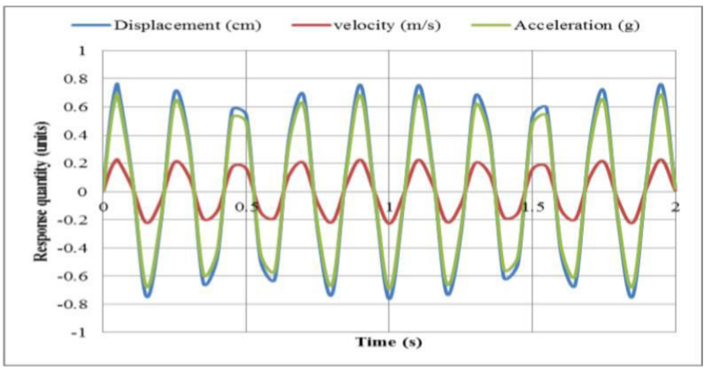


**Fig. 3: (c)Theoretical response of II floor.**

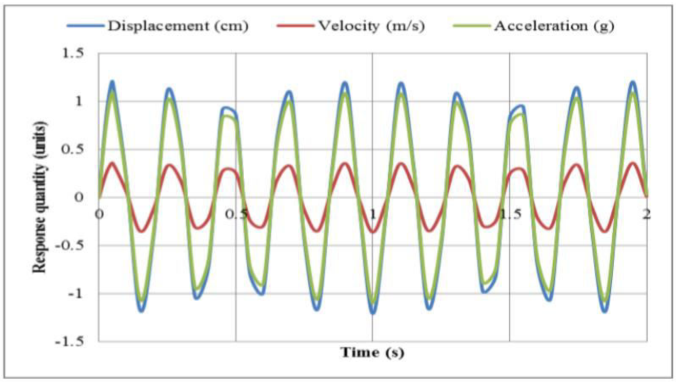


Fig. 3: (d) Theoretical response of III floor.

**Experimental response of FF.**

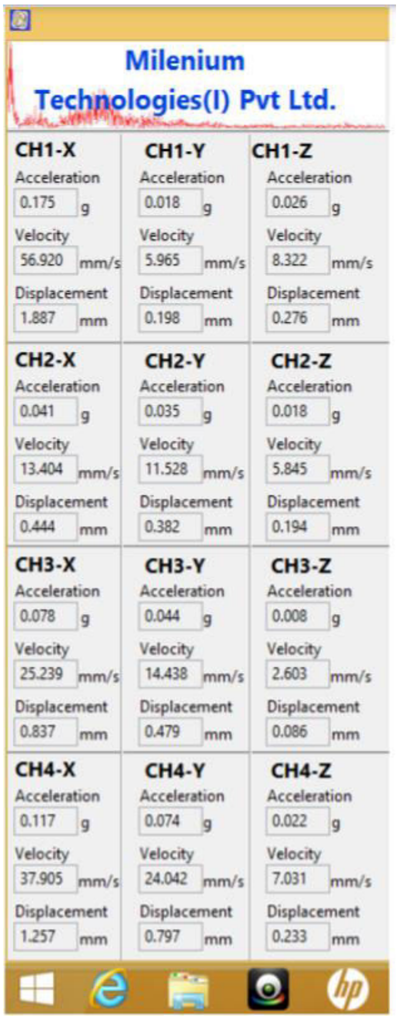


**Fig. 4: (a) Experimental response of BIF. (CH 4, 3, 2 and 1 are the response of III, II, I and ground floor respectively) neglect Y and Z direction.**

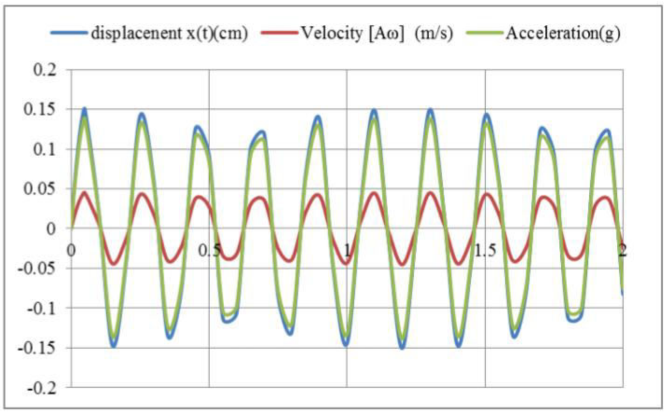


**Fig. 4: (b) Theoretical response of I floor.**

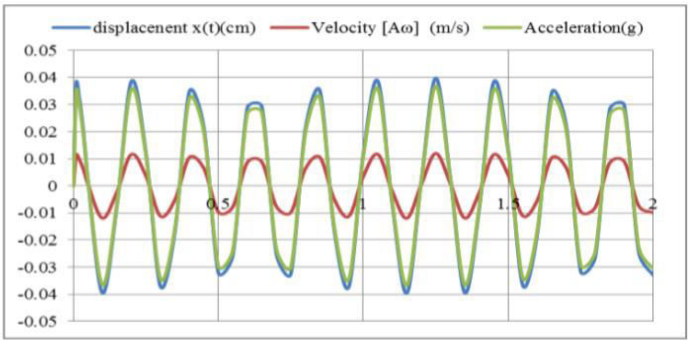


**Fig. 4: (c) Theoretical response of II floor.**

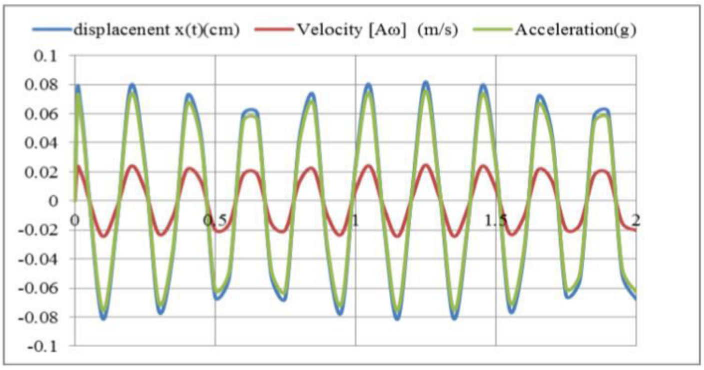


**Fig. 4: (d) Theoretical response of III floor.**

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**Experimental response of BIF.**

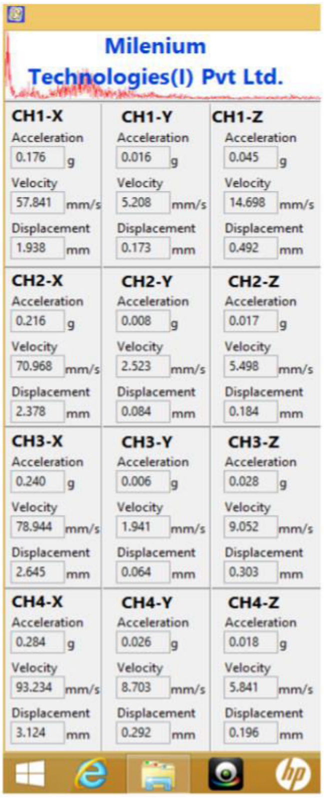


**Fig. 5: (a) Experimental response of IF. (CH 4, 3, 2 and 1 are the response of III, II, I and ground floor respectively) neglect Y and Z direction.**

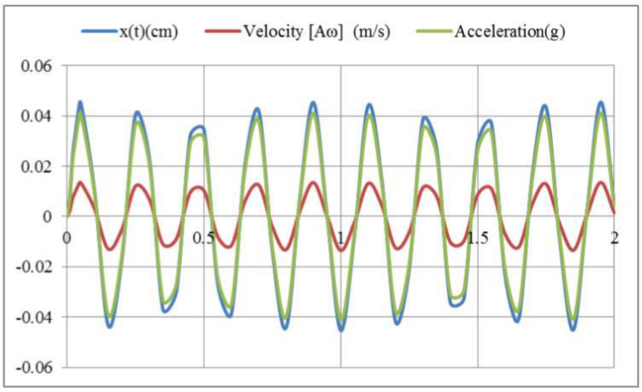


**Fig. 5: (b) Theoretical response of I floor.**

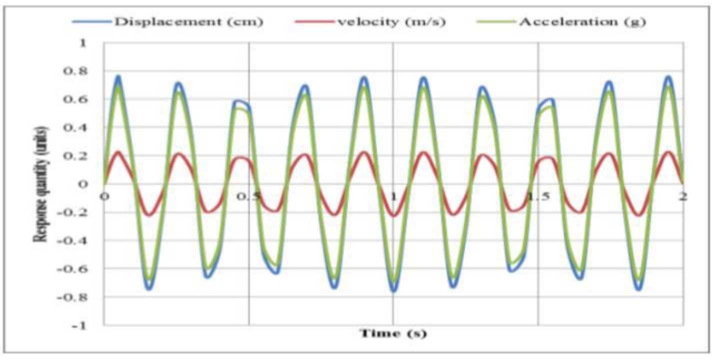


**Fig. 5: (c) Theoretical response of II floor.**

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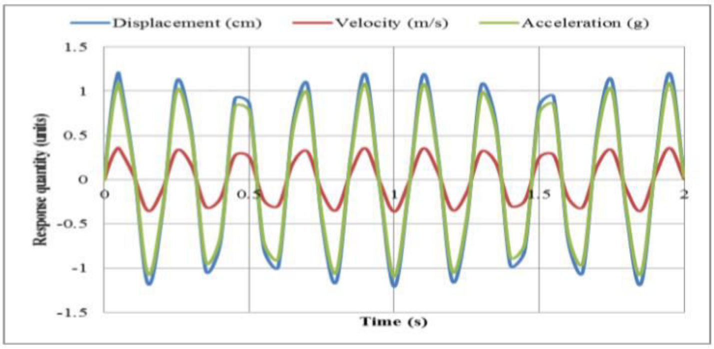


**Fig. 5: (d) Theoretical response of III floor.**

**Experimental response of IF.**

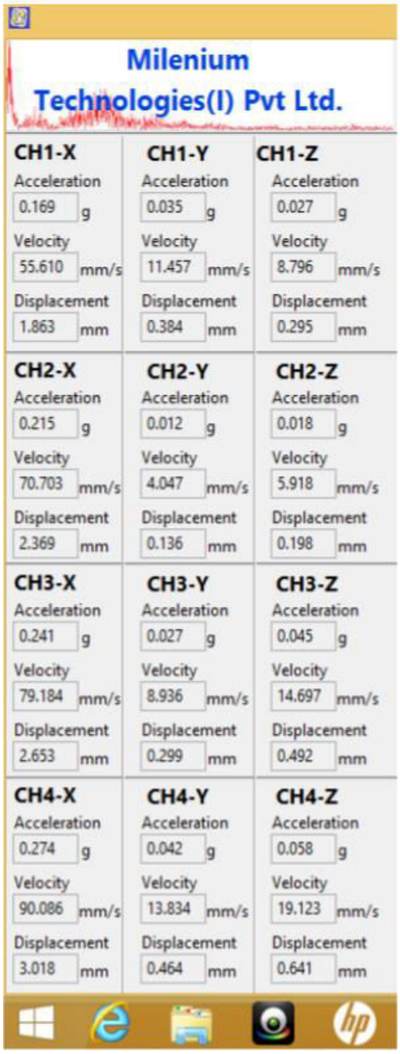


**Fig. 6: (a) Experimental response of BF. (CH 4, 3, 2 and 1 are the response of III, II, I and ground floor respectively) neglect Y and Z direction.**

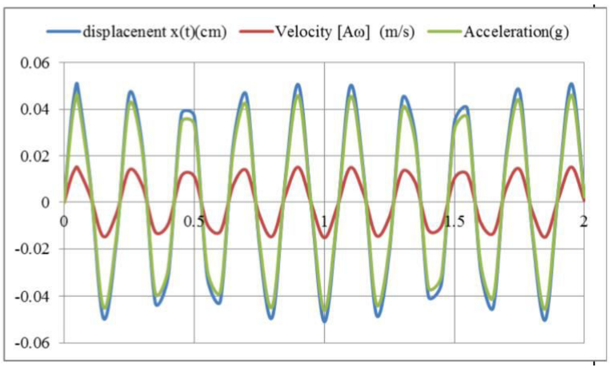


**Fig. 6: (b) Theoretical response of I floor.**

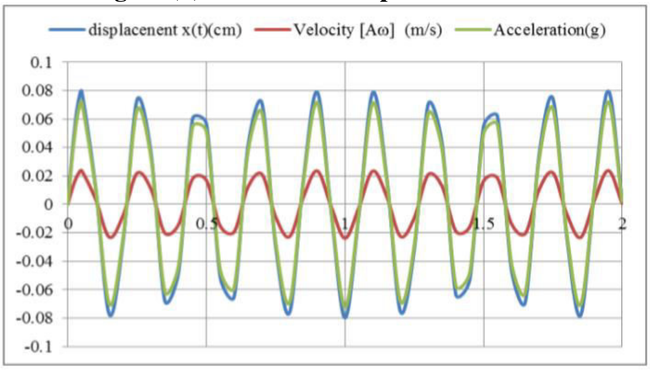


**Fig. 6: (c) Theoretical response of II floor.**

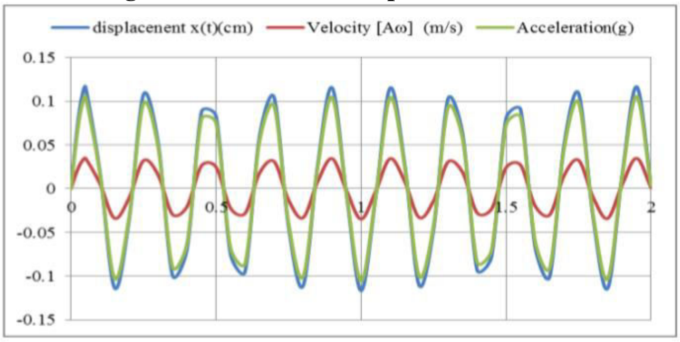


**Fig. 6: (d) Theoretical response of III floor.**

## IV. SUMMARY

In this chapter, an analysis of the findings of the experimental response between time period and acceleration, time period and velocity, time period and displacement, time period and drift ratio, and time period and shear force for each individual model was carried out. Graphs were used to illustrate these findings when they were presented. Following that, each of the four models was evaluated in relation to the others in a single graph for each floor in order to acquire the acceleration spectra, velocity spectra, displacement spectra, drift ratio, and shear force distribution. This was done so that a full grasp of the behaviour of the models could be achieved when they were exposed to harmonic stimulation. The purpose of this was to ensure that the models could be accurately represented. In the third and final portion, the results of peak experimental and analytical response of the FF, BIF, IF, and BF were analyses, and a percentage of variance was produced for the purpose of assessing the quantitative dependability of the data. This section was followed by a discussion of the implications of these findings. By the time we reach the conclusion of this chapter, we will have the ability to understand that the HSR is capable of conforming to the objective of the thesis. In the next chapter, we will come to a conclusion about all of the observations that were made in the chapters that came before it.

## V. CONCLUSION

Experiential study that is very in-depth is now being conducted with the intention of determining which of four potential models is the most helpful to utilize. Every model is constructed up of three single-bay frames, and each of those frames has three different levels of capability. The one with the braced frame has the most impressive peak acceleration response of all of the frames, but the one with the bare frame has the most impressive peak displacement reaction of all of the frames. This happens as a consequence of the greater stiffness of this frame, in addition to its higher excitation frequency, which both contribute to this phenomenon. The peak displacement response of the frames that have infill walls is higher than that of the frames that do not have infill walls. The fact that there is a hole in the wall contributes to the overall reduction in the stiffness of the wall, which is caused by the presence of the aperture. The frame with the single brace displayed stronger peak acceleration and peak displacement responses when contrasted with the frame that had the base isolated frame. The dampening impact that is created by the base isolated frame is far less severe when compared to the effect that is caused by the influence of another frame. When compared with the in-filled frame, the braced frame is distinguished by a higher degree of stiffness due to the presence of additional bracing. The acceleration response of the bracing system is thus noticeably superior than that of the in-filled system because of this. This is a direct consequence of the point that came before this one. On the other hand, the peak displacement response of a system that is braced has a much lower value when contrasted with the response of a system that is not braced. It's not impossible that the fact that in-filled frames lose more energy than braced ones has anything to do with this. It's only a possibility.

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