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Study of Earthquake-Resisting Buildings Using Shake Table and Magnetic Levitation

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Abstract: Earthquakes are one of the most dangerous natural disasters. They can cause buildings to collapse, leading to loss of life and property. Every year, thousands of earthquakes occur worldwide, and some of them are extremely destructive. Constructions intended to withstand earthquakes are known as earthquakeresistant structures.This project is based on the study of earthquake resisting buildings using the shake table concept and magnetic levitation. The main aim of this model is to show how buildings react during an earthquake and how proper techniques can reduce damage. Two different setups are made. In the first setup, two building models are mounted on a shake table. One building is fixed, and the other is supported on steel springs to absorb vibrations. A DC motor, connected through an ice-cream stick mechanism and a battery, is used to create vibrations similar to an earthquake. LED lights are installed inside the building for visualization. The second setup is based on magnetic levitation, where repelling magnets are used to create a gap and reduce the transmission of vibrations. This project helps in understanding how damping and isolation systems can protect buildings from earthquakes.

I. INTRODUCTION

Earthquakes cause sudden ground shaking that can damage or destroy buildings. It is the cause of a unexpected discharge of energy in the earth's crust that generates seismic waves. Earthquakes are dignified by with seismometers. The only alternative is to construct and build the building structures which by earthquake resistant. There are so many techniques to withstand earthquake, but they are costly are not used by ordinary people. Here a variety of beneficial small cost techniques to resist earthquake effects. To study and reduce the impact of these vibrations, engineers use shake tables to test building models. In this project, we created a small working model to demonstrate how spring and magnetic levitation systems can resist earthquake effects. The purpose is to show how flexible foundations like springs and magnetic levitation help in absorbing vibrations and protecting the structure.

A. Shake table using Springs

A shake table is a tool used to test how buildings and structures react during an earthquake. It creates shaking motions like real earthquakes to study the performance and strength of different building models. There are big shake tables in countries like Japan and the USA that can test full-scale buildings.

1) Uses of Shake Table:

- To check the stability of building models.
- To check the stability of bridge models.
- To test beams, columns, and foundations.

2) Advantages of Shake Table:

- It helps to test the earthquake resistance of structures. 2. It helps in studying how structures behave when dynamic loads (like vibrations) act on them.
- It helps engineers understand the types of ground vibrations and their effects on structures.

3) Base Isolation

Base isolation is a method used to make buildings more resistant to earthquakes. In this method (Fig 1), the building is separated from its foundation using flexible materials like rubber pads, springs, or rollers. This reduces the transfer of vibrations from the ground to the building. When an earthquake happens, the base isolators move or shake, but the building above stays almost steady.

This happens because the isolators act like shock absorbers and reduce the shaking. If the isolators are chosen properly, the earthquake forces on the building can become much smaller than on a normal fixed-base building. So, base isolation helps protect the structure and minimize damage during an earthquake.

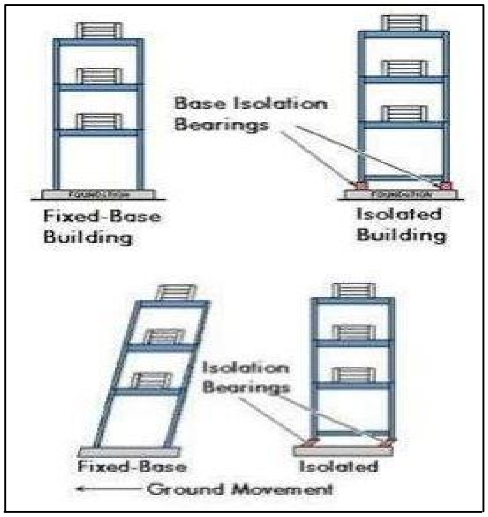

Fig 1. Shake Table Concept

B. Magnetic levitation

The idea is to separate the building from the ground by using repelling magnets(Fig 2), so the vibrations from the ground do not reach the structure directly. When two magnets are placed with the same poles facing each other, they push away (repel). This repulsive force helps lift or "float" the platform slightly, reducing contact between the base and the building foundation. Because of this, when shaking happens, the vibrations are absorbed or reduced by the magnetic field.

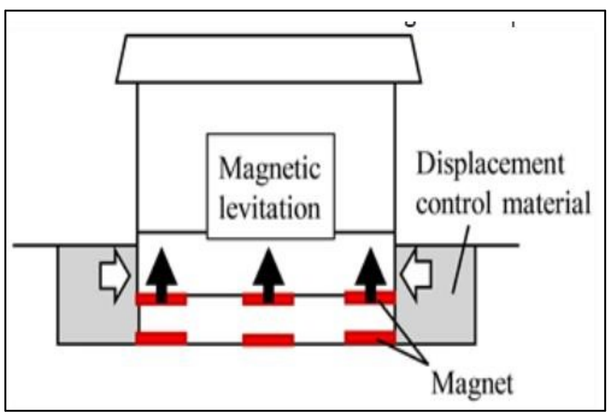

Fig 2. Magnetic levitations Concept

II. METHODOLOGY

The purpose of this chapter is to describe the experimental procedure and setup used in the project "Study of Earthquake Resisting Building Using Shake Table Concept with Spring and Magnetic Levitation."

This explains how the experiment on earthquake resisting building models was carried out. The main aim is to study how different base systems fixed base, spring base, and magnetic levitation base affect the stability of a structure during vibrations

This project aims to understand these techniques through a small-scale experimental model. This experimental approach helps students visualize how simple engineering techniques like springs and magnetic levitation can make buildings more resistant to earthquakes. It also provides a practical understanding of the dynamic behavior of structures under vibrating conditions.

III. EXPERIMENTAL SETUP

The experimental setup of this project consists of two different working models one based on the shake table using springs, and the other based on the concept of magnetic levitation. Both models were developed to study how different base supports can reduce vibration effects during an earthquake.

A. Shake Table Model

In the first setup (Shake Table Model)(Fig 3),two small house made from PVC sheets were prepared. Each house for decoration is fitted with LED lights. One house was kept fixed directly on the base,while the other was placed on steel springs to act as a baseisolated structure. Both houses were mounted on a large flat sheet that acts as the shake table platform. The platform was supported on eight small wheels to allow horizontal movement. For generating motion, a DC motor was attached and connected through an ice cream stick linkage mechanism, which converted the motor’s rotation into a shaking or pulling motion. When powered by a battery, the motor caused the platform to vibrate side-to-side, imitating an earthquake.

Fig 3.Shake Table Model (one Fixed house & another on spring)

B. Magnetic Levitation Model

In the second setup (Magnetic Levitation Model)(Fig 4.), the base was prepared using two strong magnets placed with like poles facing each other to create a repulsive force. Above these magnets, a small PVC sheet house with LED lights was carefully placed, floating slightly or remaining semi-suspended due to magnetic repulsion. This created a non-contact base isolation system. The same vibration motion was applied to this model using the motor and shake table arrangement similar to the first setup. This allowed direct comparison between the fixed, spring, and magnetic systems under identical shaking conditions. This experimental arrangement helped in observing the performance of each base type and understanding how spring isolation and magnetic levitation reduce the effect of vibrations on structures during an earthquake.

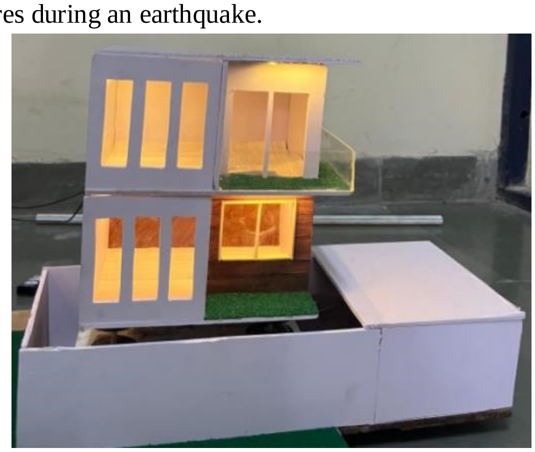

Fig 4. Magnetic levitations Model using Magnets

IV. WORKING PRINCIPLE

The working of this project is based on the concept of base isolation and vibration reduction, which are important techniques used in earthquake-resistant design.

When an earthquake occurs, ground vibrations travel through the building foundation, causing movement and sometimes structural failure. By modifying the base with materials like springs or using magnetic levitation, we can reduce the vibration energy transmitted to the building.

This project demonstrates this principle using two different setups -the Shake Table and the Magnetic Levitation Model.

A. Shake Table Model

In this setup, two house models made from PVC sheets are placed on a moving platform (shake table).One house is fixed directly to the platform to act as a normal building without isolation.The second house is placed on 6 steel springs, which act as flexible supports or isolators. The shake table is operated by a DC motor connected through an ice cream stick linkage mechanism, powered by a battery. When the motor rotates, it moves the platform back and forth,

simulating earthquake vibrations During shaking:

The fixed house experiences high vibration because the ground motion is directly transferred to the structure. The spring-based house experiences less vibration, as the springs absorb and dissipate part of the energy, acting as shock absorbers. Thus, the spring system helps in reducing vibration transmission and improves building stability.

B. Magnetic Levitation Model:

The second setup works on the principle of magnetic repulsion. Two strong magnets are placed with like poles facing each other, producing a repulsive force. A small PVC house is then placed above this base so that it slightly floats or stays balanced due to magnetic repulsion.

When the base is shaken using the same shake table mechanism, the magnetic force acts as a cushion, reducing direct contact and minimizing vibration transfer. This setup shows how magnetic levitation can act as a non-contact base isolation system.

Overall Principle:

Both models prove that if a structure is provided with a flexible or non-contact base, the amount of vibration reaching the building is significantly reduced. This simple demonstration helps understand the real-world engineering technique of base isolation, used in earthquake-resistant structures to improve safety and stability.

V. OBSERVATION

During the experimental testing, the behavior of all three models — Fixed Base, Spring Base, and Magnetic Levitation Base was carefully observed under similar vibration conditions.The comparison was made based on the amount of vibration, stability, and movement of each house model when the shake table was in motion.

The following table shows the observations recorded during the experiment:

Sr. No	Type of Model	Base Type	Observation During Shaking
1.	Model 1	Fixed Base	The structure experienced strong vibrations and moved significantly with the platform. High shaking, less stable.
2.	Model 2	Spring Base	Springs absorbed part of the vibration; motion was smoother compared to the fixed base. Moderate vibration, stable structure.
3.	Model 3	Magnetic Levitation Base	Magnetic repulsion reduced direct contact; the house showed very less vibration. Least vibration, most stable.

Table 1. Base Observation

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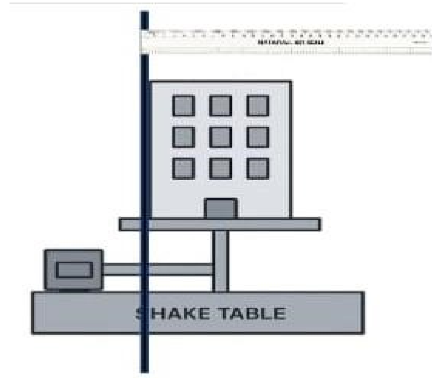
VI. RESULT

The results obtained from the shake table experiment show the relationship between the applied vibration speed and the horizontal displacement of the building model. The observations indicate that as the speed of vibration increases, the displacement of the structure also increases.These results clearly demonstrate that vibration speed has a direct effect on structural displacement. Higher vibration levels produce greater displacement, which may increase the risk of structural damage. This experiment highlights the importance of vibration control and base isolation techniques, as reducing displacement during earthquakes can significantly improve the stability and safety of buildings.



SPEED	DISPLACEMENT
1 UNIT	3 CM
2 UNIT	4 CM
3 UNIT	4.3 CM
4 UNIT	4.5 CM
5 UNIT	5 CM

VII. FUTURE SCOPE

The present study demonstrates the working of earthquake-resisting building models using spring base isolation and magnetic levitation concepts on a small scale. However, this experiment can be further improved and expanded in the future for better accuracy and real-life applications.

The possible future scopes of this project are listed below:

1) Use of Sensors and Measuring Devices: Vibration sensors or accelerometers can be added to measure the exact amount of vibration and displacement in each model. This would make the results more precise and scientific.
2) Computer-Based Simulation: The experiment can be compared with computer simulations using software like ANSYS, ETABS, or MATLAB to analyze stress, vibration, and damping performance.
3) Use of Different Materials: Future models can use different types of springs, rubbers, or damping materials to find the most effective base isolation material.
4) Scaling to Real Buildings: The concept can be applied to larger structural models or small building prototypes to study practical earthquake performance.
5) Improvement in Magnetic Levitation: By using stronger electromagnets and controlled magnetic fields, the levitation effect can be made more stable and efficient.
6) Energy Storage Concept: The vibration energy absorbed by springs or magnetic fields could be utilized for energy harvesting in future smart structures.
7) Automation and Control: The shake table and vibration control can be automated using Arduino or microcontroller circuits for continuous testing and controlled vibration input.

8) Educational Demonstration Model: The project can be improved as a working educational model for schools and colleges to help students understand earthquake-resistant design concepts easily.

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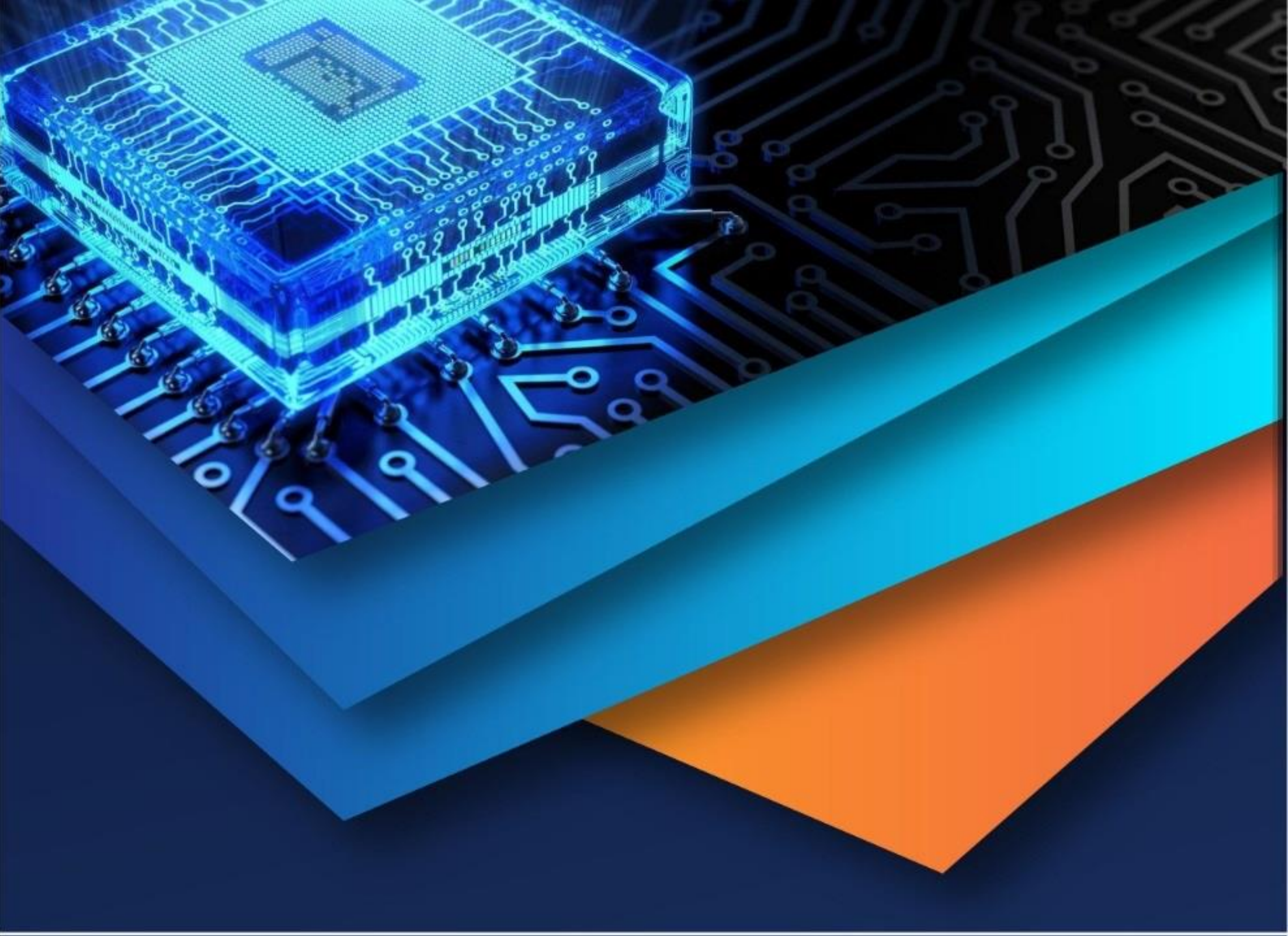

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