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Design a Retrofitting Device As a Earthquake Resistant

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Abstract:-
Seismic retrofitting is essential for strengthening structures against earthquake impacts. This review examines recent advancements in seismic retrofitting techniques, highlighting innovative approaches to enhance the seismic performance of various structures [15]. One notable strategy involves using Polyethylene Terephthalate Fiber-reinforced Polymer (PET FRP) to reinforce central columns in underground structures [1]. By increasing the lateral deformation capacity of these columns, PET FRP retrofitting significantly improves the overall seismic resilience of underground structures, as demonstrated through experimental and numerical analyses [1]. Another innovative method employs shear-compressive metal dampers (SCMDs) to repair critically damaged masonry piers [5]. SCMDs demonstrate stable performance and significant energy dissipation, enhancing the ductility and seismic capacity of retrofitted walls, supported by quasi-static tests and seismic behavior analyses [5]. Furthermore, the use of isolation systems with weak restoring forces shows promise for retrofitting historic buildings [13]. These systems integrate devices like elastic sliding bearings and viscous dampers to enhance the seismic performance of timber structures while preserving architectural integrity [13]. Additionally, novel retrofitting systems such as the gapped eccentric steel brace (GESB) and varied yielding cross-section dampers effectively modify existing reinforced concrete (RC) frame structures and steel moment-resisting frames (SMRFs), enhancing their strength, stiffness, and ductility [14, 22]. External sub-structure retrofitting methods provide a comprehensive approach to enhancing overall structural seismic performance [22]. By connecting external sub-structures to existing buildings, these methods improve structural-system-level resilience, with ongoing developments focusing on optimization strategies and practical engineering applications [22]. Shaking table tests validate innovative retrofitting approaches, demonstrating significant improvements in structural seismic capacity and damage reduction compared to traditional methods [24]. Overall, this review offers valuable insights into recent advancements in seismic retrofitting techniques, contributing to ongoing efforts to mitigate seismic risks and safeguard communities worldwide.*Keywords:* Retrofitting for seismic resilience, seismic engineering, structural strengthening, PET FRP reinforcement, metallic dampers, heritage structures, GESB retrofitting, cross-sectional dampening, retrofitting of external sub-structures, frictional damping, shake table experiments.

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1. INTRODUCTION

In regions prone to seismic activity, like the Pacific Ring of Fire, safeguarding the structural integrity of buildings is crucial for mitigating the devastating impact of earthquakes. Retrofitting plays a vital role in fortifying existing structures to withstand seismic forces. In this discussion, we explore the fundamental aspects of earthquake retrofitting devices and their pivotal role in averting earthquake-induced damageDampers are pivotal devices capable of absorbing the kinetic energy generated within a building during seismic events. Vibrational energy, in its various forms, exerts tensile and compressive forces that endanger structural integrity, potentially leading to catastrophic collapses. Dampers counteract these forces, with their arrangement contingent upon the materials and principles employed. For example, viscous dampers utilize fluids to convert kinetic energy into heat energy, while friction dampers use steel plates to induce movement in opposing directions, nullifying forces.

Strategic placement of dampers is imperative to maximize their effectiveness in absorbing movement and forces. They are typically positioned diagonally across floors, affixed to sites or floors, or connected to opposing corner sides, depending on the type of damper utilized. Additionally, their configuration can vary, adopting shapes such as W or inverted V, based on prevailing loading conditions.

Seismic retrofitting is essential to modify existing structures, making them more resilient against seismic activity, ground motion, or soil failure induced by earthquakes. Recent years have seen moderate to severe earthquakes ravage regions across India, resulting in considerable loss of life, property, and structural failures. In this context, augmenting building systems to bolster resistance to seismic activity is of paramount importance.

Retrofitting goes beyond economic considerations, providing immediate solutions to mitigate problems and offering essential shelter. As we delve into the design of earthquake retrofitting devices, it becomes evident that the seismic threat posed by earthquakes, originating from the sudden release of energy in the Earth's crust, necessitates proactive measures. The magnitude, depth, and proximity of earthquakes to populated areas underscore the urgency of retrofitting structures in vulnerable regions.

The overarching purpose of earthquake retrofitting is to modify existing buildings and structures, enhancing their resilience to seismic forces. By safeguarding human lives, averting injuries, and minimizing economic losses through the reduction of damage to buildings and infrastructure, retrofitting embodies a proactive stance in the face of seismic threats.

2. OBJECTIVE

1.Reviewing Existing Literature and Case Studies on Retrofitting Systems: -This phase involves an extensive investigation into the advantages of retrofitting systems in bolstering a structure's earthquake resistance. Through a comprehensive review of literature and analysis of relevant case studies, this research aims to identify key benefits such as increased structural integrity, enhanced seismic performance, and reduced vulnerability to earthquake-induced damage.

2. Comparative Analysis of Seismic Performance:- This step entails a comparative assessment of buildings with and without retrofitting systems. By analyzing factors including maximum frequency resistance, duration of seismic resistance, and failure mechanisms, this research aims to quantify the effectiveness of retrofitting interventions in improving a structure's ability to withstand seismic forces. Case studies and empirical data will be utilized to provide insights into the tangible differences in seismic performance between retrofitted and non-retrofitted structures.

3. Exploration of Materials and Structural Configurations:-Through a thorough exploration of various materials and structural configurations, this phase aims to identify optimal options for designing an earthquake-resisting retrofitting device. Considerations such as material strength, stiffness, and ductility will guide the selection process, ensuring that the chosen materials and configurations offer maximum resilience against seismic loading.

4.Development of Retrofitting Device Prototype:- Building upon the identified materials and structural configurations, this step involves the development of a prototype retrofitting device. The prototype will be designed to be both feasible and effective in enhancing seismic resilience, with a focus on practicality and scalability for real-world implementation.

5. Experimental Evaluation on Shake Table:- Extensive experimentation will be conducted on a shake table to evaluate the performance of the retrofitting device under simulated seismic loading conditions. This experimental phase aims to validate the efficacy of the retrofitting device in improving the structure's seismic resistance, providing empirical evidence of its effectiveness in mitigating earthquake-induced damage.

6. Interpretation of Experimental Results:- The final step involves the interpretation of experimental results to assess the effectiveness of the retrofitting device. By analyzing data obtained from shake table tests, this research aims to draw conclusions regarding the device's impact on the structure's seismic performance, informing future retrofitting strategies and contributing to the advancement of earthquake-resistant design practices.

3. MATERIAL USAGE

3.1 PLYWOOD:-

Figure no 1 represents plywood is a versatile building material commonly used in construction and woodworking projects. Measuring 100 cm by 100 cm, it offers a convenient and manageable size for various applications. Plywood consists of thin layers of wood veneer glued together with adjacent layers having their wood grain rotated up to 90 degrees to improve strength and stability. This construction method provides plywood with excellent structural integrity, making it suitable for a wide range of projects, including furniture making, cabinet construction, flooring, roofing, and wall sheathing. Additionally, plywood's uniform thickness and smooth surface allow for easy cutting, shaping, and finishing. Its inherent resistance to warping, cracking, and shrinking makes plywood a reliable choice for both interior and exterior applications. Moreover, plywood can be further enhanced through treatments such as painting, staining, or laminating to improve its durability and aesthetic appeal. Overall, plywood measuring 100 cm by 100 cm offers versatility, durability, and ease of use, making it a popular choice among builders, carpenters, and DIY enthusiasts alike.

Plywood
Figure no :- 1

3.2.BAMBO STICK :-

Figure no 2 represents Bamboo sticks have gained popularity as a sustainable and versatile building material, offering numerous advantages for constructing models and prototypes. Due to its lightweight, strength, and flexibility, bamboo is increasingly used in architectural modeling, design prototypes, and educational projects.One significant advantage of bamboo sticks is their eco-friendliness. Bamboo is a renewable resource that grows rapidly, making it a sustainable alternative to traditional building materials like wood or plastic. Its cultivation requires minimal water, pesticides, and fertilizers, further reducing its environmental impact.

In building models, bamboo sticks provide structural integrity while being lightweight, allowing for easy handling and transportation. Their inherent strength-to-weight ratio makes them ideal for creating intricate architectural designs and scaled-down structures. Additionally, bamboo's flexibility enables it to be bent, curved, or shaped to suit various design requirements, offering versatility in model construction.

Moreover, bamboo sticks are relatively affordable compared to other modeling materials, making them accessible to students, hobbyists, and professionals alike. Their availability in various lengths and diameters allows for customization and creativity in model building.Beyond their practical benefits, bamboo sticks also add aesthetic appeal to models. Their natural color and texture create visually pleasing designs, enhancing the overall presentation of architectural concepts and design ideas. Furthermore, bamboo's organic appearance can evoke a sense of sustainability and environmental consciousness in model representations.

In educational settings, using bamboo sticks for model building can promote awareness of sustainable design practices and green building materials. Students can explore concepts of structural engineering, geometry, and design principles while working with bamboo, fostering creativity and problem-solving skills.In conclusion, bamboo sticks offer a sustainable, versatile, and aesthetically pleasing option for building models. Whether used in architectural prototypes, design projects, or educational activities, bamboo's attributes make it an attractive choice for model construction, contributing to sustainable practices and innovative design solutions.

Bamboo Stick
Figure no :- 2

3.3 GLUE STICKS :-

Glue sticks are commonly used to adhere bamboo sticks together in model building projects due to their convenience, ease of use, and strong bonding capabilities. When applying glue sticks to bamboo, it's essential to ensure that the surfaces are clean and dry to maximize adhesion. By simply applying a thin layer of glue to the connecting ends of the bamboo sticks and pressing them firmly together, users can create secure and durable bonds. Glue sticks provide a mess-free application and quick drying time, allowing for efficient assembly of bamboo structures in model making, crafting, and various DIY projects.

4. Testing Equipment

4.1 Shake Table

Earthquake shake tables are essential tools used in earthquake engineering research to simulate the seismic forces experienced by structures during earthquakes. These tables consist of large platforms mounted on hydraulic actuators capable of replicating various types of ground motions, including those generated by natural seismic events. They play a crucial role in testing the resilience and performance of buildings, bridges, and other infrastructure under earthquake conditions.

Shake Table

Figure no :- 3

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The primary purpose of shake tables is to subject physical models or full-scale structures to controlled seismic vibrations, allowing researchers to study their behavior and response. By replicating different magnitudes, frequencies, and directions of ground motion, scientists can assess the structural integrity, identify weaknesses, and develop strategies to improve earthquake resistance.Shake tables are equipped with sophisticated instrumentation to measure parameters such as acceleration, displacement, and velocity, providing detailed data on how structures react to seismic loading. This data is crucial for validating computer simulations and mathematical models used in earthquake engineering.

Various types of shake tables exist, ranging from small-scale models for laboratory experiments to large-scale platforms capable of testing full-size structures. Some shake tables are capable of simulating multi-dimensional motions, allowing researchers to investigate the complex interactions between structures and seismic waves.In addition to structural testing, shake tables are also used for research in other fields, such as geotechnical engineering and seismology. They can simulate soil-structure interaction effects, evaluate the performance of foundation systems, and study the propagation of seismic waves through different geological conditions.

The findings from shake table experiments contribute to advancements in earthquake-resistant design and construction practices, ultimately helping to mitigate the impact of earthquakes on communities and infrastructure. By understanding how structures behave under seismic loading, engineers can develop more resilient buildings and infrastructure, reducing the risk of casualties and economic losses associated with earthquakes.

Configration of Shake table Usage for Testing
Table no 1

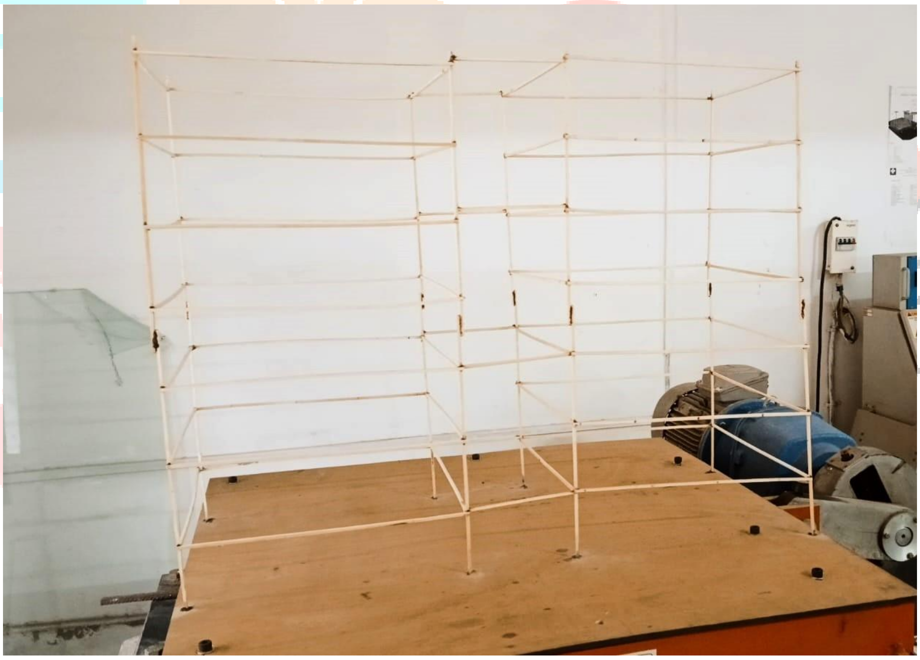
MECHNICAL SHAKE TABLE		
1	Make	Rodyne Make
2	Type	Mechnical –Cam Type
3	Motion	Uni Direction
4	Number Of Axis	Single Axis
5	Direction Of Motion	Horizontal
6	Payload	1000kg
7	Top Table Size	1000mmX1000mm
8	Amplitude	1-50mm (Total 100mm)
9	Maximum Frequency	1-10 Hertz
10	Prime Mover	AC Motor -10 HP
11	Input Power	3 Phase-440 Volts
12	Operated By	Control Panel

5. METHODOLOGY:-

1. Building Selection: Identify old construction buildings susceptible to seismic hazards, representing typical structures with known structural weaknesses.
2. Seismic Assessment: Conduct a thorough evaluation of selected buildings to assess current condition and vulnerabilities. This includes structural analysis, site assessment, and review of historical data to gauge earthquake risk.
3. Retrofitting Device Selection: Choose suitable retrofitting devices considering building characteristics. Evaluate girders as a reinforcement option alongside traditional methods like base isolators and dampers.
4. Device Installation: Install selected retrofitting devices as per manufacturer guidelines, strategically reinforcing critical elements and dissipating seismic energy.
5. Untreated Building Modeling: Create models of two untreated buildings to accurately depict existing vulnerabilities.

G+7 building Without retrofitting Solution before testing
Figure no :- 4

6. Retrofitting Modeling: Figure no 5 represents develop models of two additional buildings, incorporating girders at mid-span with proper alignment and anchorage.



G+7 building With retrofitting Solution before testing
Figure no :- 5

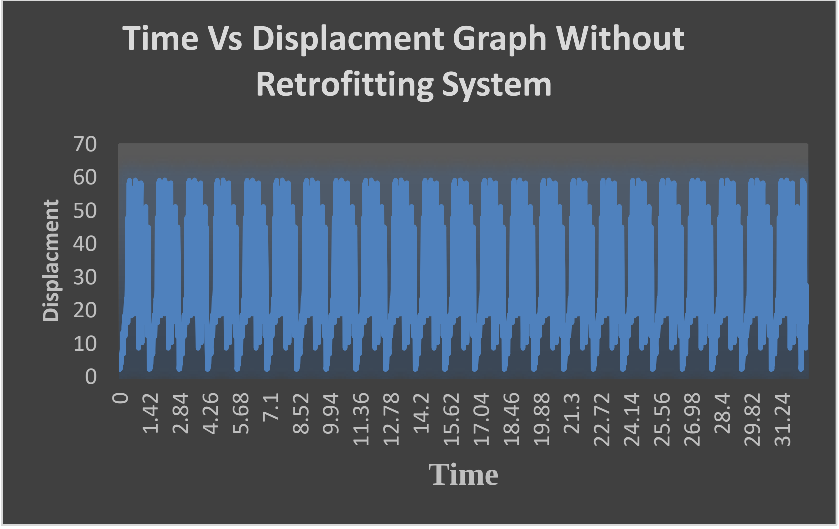
7. Channel Section Plate Integration: Enhance retrofitting by integrating channel section plates to reinforce connections between girders and columns.
8. Ice Stick Model Representation: Construct ice stick models portraying building components, including columns, girders, and channel section plates, to illustrate retrofitting configurations.
9. Experimental Testing: Perform experimental testing on ice stick models to simulate seismic conditions, comparing structural responses of untreated and retrofitted buildings.

CONTROL PANAL
Figure no :- 6

6. RESLUT AND DISCUSSION

6.1 WITHOUT RETROFITTIING SOLUTION

G+7 Building Without Retrofitting Solution After Testing
Figure No:-07



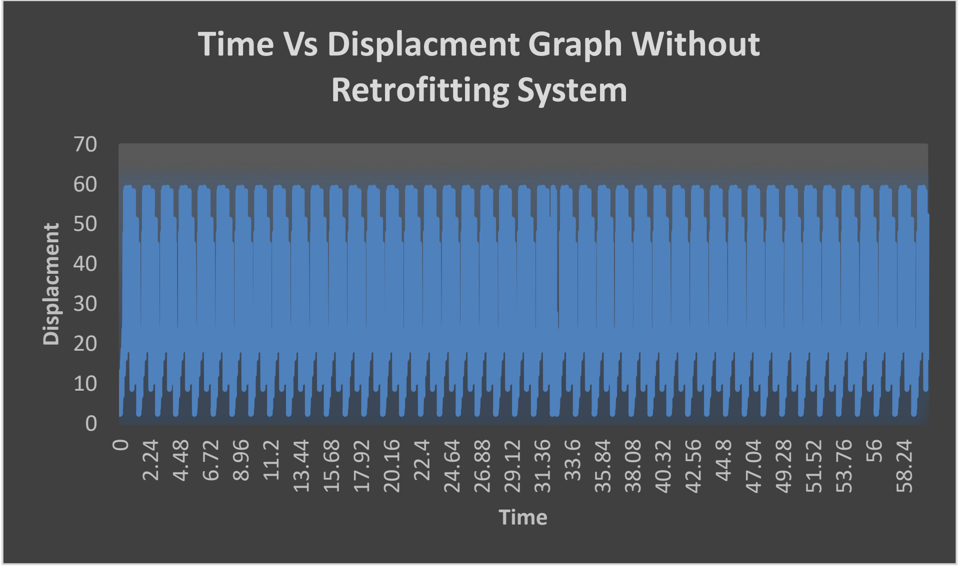
Time Vs Displacement Graph
Figure no:-8

Figure no 7 represents The experiments on two G+7 bamboo stick models without retrofitting solutions revealed critical structural failure under seismic loading on a shake table. Both models collapsed within 32.44 seconds, highlighting their vulnerability to seismic events due to insufficient reinforcement. The failure likely resulted from progressive deformation leading to collapse, underscoring the need for effective seismic energy dissipation.

These findings emphasize the necessity of retrofitting or reinforcement measures to improve the seismic resilience of vulnerable buildings. Further analysis of failure mechanisms and the development of cost-effective retrofitting solutions are essential to mitigate seismic risks and ensure the safety of urban infrastructure in earthquake-prone regions. This research provides valuable insights into the seismic performance of existing structures, guiding strategies to enhance their resilience against future seismic events.

5.2.With Retrofittiing Solution

G+7 Building With Retrofitting Solution Model After Testing
Figure no:-9



Time Vs Displacement Graph
Figure no:- 10

The retrofitting strategy aimed to bolster the buildings' figure no 9 represents seismic resistance by placing girders at alternate floors and mid-span in two G+7 floor buildings. Experimental tests on the retrofitted buildings on a shake table yielded promising results. The retrofitting intervention enabled the buildings to withstand higher levels of seismic loading compared to their original configuration

Specifically, the retrofitting resulted in an increase in the duration of seismic resistance to 60 seconds. This significant enhancement in seismic performance indicates the effectiveness of the retrofitting strategy. Moreover, the retrofitting ensured that the buildings did not collapse under the applied seismic forces.

The observed increase in seismic resistance can be attributed to the addition of girders at alternate floors, which contributed to the overall stiffness of the buildings. This reinforcement effectively redistributed and dissipated seismic energy, thereby increasing the buildings' capacity to withstand seismic loading without failure.

These results underscore the efficacy of incorporating girders at mid-span and alternate floors as a retrofitting solution for enhancing the seismic resistance of existing structures. Such retrofitting interventions have the potential to mitigate the risks associated with seismic events and ensure the safety and resilience of urban infrastructure in earthquake-prone regions. Further analysis and validation of these findings could inform future retrofitting strategies aimed at improving the seismic performance of buildings worldwide.

5.3 COMPARISM OF WITH OR WITHOUT RETROFITTING SOLUTION MODELS

5.3.1 Retrofitted Models:

Retrofitting Strategy:Installing girders at alternate floors and mid-span in two G+7 structures.

Experimental Findings: Seismic resistance duration extended to 60 seconds. The retrofitted buildings demonstrated resilience to higher seismic loads without collapse, attributed to increased stiffness and efficient energy dissipation.

Implications: Evidences the efficacy of girder incorporation, enhancing safety and resilience in earthquake-prone areas, and provides insights for global retrofitting strategies.

5.3.2 Non-Retrofitted Models:

Experimental Findings:Collapse occurred within 32.44 seconds due to structural failure from insufficient reinforcement. Progressive deformation leading to collapse highlights the need for effective energy dissipation.

Implications: Exposes vulnerability and emphasizes the urgent need for retrofitting or reinforcement to mitigate safety risks in seismic regions.

Comparism of With and Without Retrofitting Solution Model After Testing
Figure No:- 11

6. CONCLUSION:

The research underscores the significant enhancement in seismic resistance achieved by incorporating girders at alternate floors in seven-story buildings. Comparative analysis between structures with and without girders revealed a clear advantage in seismic performance, particularly evident at the mid-span. Despite using bamboo sticks as substitutes for girders, the consistent trend in improved resilience highlights the effectiveness of this structural configuration. These findings stress the potential benefits of strategically integrating girders into building designs to enhance seismic resistance and overall structural robustness. Further research is crucial to validate and refine these findings, offering promising avenues for advancing earthquake-resistant construction practices.

7. FUCTURE SCOPE

The observed failure of the model without girders under seismic load on the shake table suggests several avenues for future research. Firstly, investigating the specific failure mechanisms at the joints could provide insights into the vulnerabilities of structures lacking girders in seismic events. Additionally, exploring alternative reinforcement methods or structural configurations to mitigate joint failure in the absence of girders could lead to innovative design solutions. Furthermore, conducting comparative studies with different building heights, materials, and seismic intensities would offer a comprehensive understanding of the role of girders in seismic resistance across various contexts. Lastly, assessing the economic and practical feasibility of retrofitting existing structures with girders to enhance seismic performance could have significant implications for seismic risk mitigation strategies. These future research directions hold promise for advancing our knowledge of seismic-resistant construction practices and improving the resilience of built environments to seismic hazards.

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