Earthquake-Resistant Joint Buildings: Using Fiber-Reinforced Concrete Material for Earthquake-Resistant Foundations

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***Abstract*—Earthquake-resistant building structures are designed to withstand seismic forces, minimizing structural damage, human casualties, and economic loss. Achieving earthquake resistance requires not only advanced structural designs but also proper construction techniques, including site selection, foundation reinforcement, and secure structural joints. Flexibility is a key factor in mitigating seismic stress, allowing structures to deform without collapsing. Fiber-reinforced concrete (FRC) has emerged as a promising material for enhancing earthquake resilience, offering improved crack resistance, durability, and tensile strength. This study evaluates the effectiveness of FRC in earthquake-resistant structures using shake table simulations, aiming to develop cost-effective solutions for safer construction in seismic-prone regions. This study evaluated the performance of Controlled Concrete and Fiber-Reinforced Concrete (FRC) with 0.5% and 1% fiber content through Compression and Split Tensile Tests using a Universal Testing Machine (UTM). The Compression Test assessed load-bearing capacity and structural integrity, while the Split Tensile Test analyzed tensile behavior and resistance. Results indicated that Controlled Concrete exhibited superior strength, resilience, and structural integrity compared to fiber-reinforced variations. Although FRC enhanced specific properties such as crack resistance, it did not surpass Controlled Concrete in overall performance. These findings contribute to engineering knowledge for earthquake-resistant foundations, emphasizing the need for further research on fiber reinforcement optimization for structural applications.**

Keywords—Earthquake-resistant structures, Fiber-reinforced concrete, Controlled Concrete, Compression Test

I. INTRODUCTION

An earthquake-resistant structure is designed to withstand sudden ground shaking, minimizing structural damage, injuries, and fatalities. Achieving earthquake resistance requires appropriate construction techniques, including careful site selection, strong foundations, and well-reinforced structural joints. Flexibility is a crucial design feature that allows buildings to bend and absorb seismic forces without collapsing. Properly reinforced joints ensure structural stability, while deep foundations and driven piles help buildings withstand extreme seismic forces by maintaining structural cohesion. Despite the infrequency of earthquakes, earthquake-resistant designs provide protection against various natural disasters. Safety professionals prioritize human welfare by developing preventive measures for structural integrity. Fiber-reinforced concrete (FRC) enhances durability and crack resistance by incorporating materials such as steel, glass, or synthetic fibers. Properly engineered FRC improves a structure's long-term serviceability and integrity by mitigating shrinkage and reinforcing overall strength. An earthquake-resistant structure is built to endure sudden ground shaking, reducing structural damage, injuries, and fatalities. This requires a combination of advanced design principles and proper construction techniques, including careful site selection, strong foundations, and reinforced structural components. A key characteristic of earthquake-resistant buildings is flexibility, which allows structures to absorb seismic forces without collapsing. Properly designed joints play a crucial role in distributing stress evenly, preventing catastrophic failure. Concrete joints must be compacted and reinforced to enhance durability, while unreinforced masonry connections, such as mortar joints in brick buildings, require secure anchoring to maintain stability. Deep foundations and driven piles further strengthen a building's ability to withstand seismic activity by ensuring that all structural components move together as a cohesive unit. Although earthquakes are less frequent than other natural disasters, designing earthquake-resistant structures enhances overall resilience against various calamities. Safety experts prioritize human well-being by researching structural integrity and collaborating with professionals from multiple disciplines. The primary goal of earthquake-resistant construction is to prevent collapse, minimize casualties, and reduce economic losses. This involves assessing seismic excitation and structural response at a given site to optimize performance. Fiber-reinforced concrete (FRC) plays a significant role in enhancing structural integrity, using materials such as steel, glass, synthetic fibers, or natural fibers like sisal and jute to improve strength and durability. FRC is particularly effective in preventing cracks caused by drying and plastic shrinkage, making it a valuable material for increasing a structure's long-term serviceability. By integrating these engineering advancements, earthquake-resistant buildings can better

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withstand seismic forces and ensure greater safety and sustainability.

II. Materials and Methods

The purpose of this study is to ascertain the seismic resistance of Fiber-Reinforced Concrete as a building material. This chapter includes the Research Design, Research instrument, Conceptual Framework, Theoretical Framework, and Analytical Framework. The researchers will adopt a qualitative research approach, utilizing unstructured questionnaires as a survey tool to gather essential data. Surveys provide an effective method for collecting information, allowing respondents to closely observe and share insights on the subject. The primary objective of the questionnaire is to obtain specific, relevant information from participants.

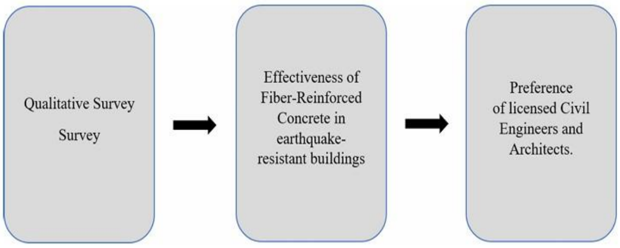

Fig. 1. Conceptual Framework

The framework demonstrates the relationship between the variables included in the study. The first column indicated how the researchers planned to use a Qualitative approach survey in terms of the respondents' perspectives on the effectiveness of Fiber-Reinforced Concrete in earthquake resistant buildings. The researchers construct a relationship between the Effectiveness of Fiber Reinforced Concrete and the preference of licensed Civil Engineers and Architects. The analysis and synthesis of the findings from investigations into the deformation and fracture of fiber-reinforced concrete are the focus of the proposed survey. The researchers present an overview of the following aspects of this issue: the development and use of fiber-concrete technologies, the fundamental structural characteristics of fiber concrete, the distinctive characteristics of their deformation and fracture, and the approaches used to assess their tensile strength and durability. These are the topics that will be included in the survey that will be answered by the respondents. Fiber reinforced concrete confinement is one of the effective approaches to improve the seismic response of key places, such as beam-column joints, structural walls, and shear walls, according to research on the subject. Numerous civil engineering applications now accept fiber reinforced concrete. Because steel fiber reinforced concrete has certain specific functional and structural advantages over traditional reinforced concrete, a new generation of engineers is more likely to adopt it.

III. Results and Discussion

The first test conducted was the Compression Test, which involved applying pressure or force to the material until it deformed, allowing the researchers to assess its load-bearing capacity and structural integrity in relation to building an earthquake-resistant building foundation.

Table 1. Laboratory Results Summary

Name	Diameter (mm)	Height (mm)	Test	Max Force (kN)	Max Stress (MPa)	Break Force (kN)	Break Stress (MPa)
Controlled 1	152.4	270.0	Compression	74.781	6.0276	11.844	2.5773
Controlled 2	152.4	270.0	Compression	96.875	7.7568	18.156	1.9594
Controlled 3	152.4	270.0	Compression	101.781	6.5437	76.094	5.1355
Controlled 4	152.4	270.0	Split Tensile	63.656	3.97166	21.781	1.67607
FRC (0.5%) 1	152.4	274.0	Split Tensile	27.375	1.98272	0.7188	0.78041
FRC (0.5%) 2	152.4	279.0	Split Tensile	24.156	1.80627	0.2188	0.75300
FRC (0.5%) 3	152.4	278.5	Compression	71.469	4.8820	39.656	3.1380
FRC (0.5%) 4	152.4	274.0	Compression	131.156	8.1540	20.250	2.0741
FRC (1%) 1	152.4	274.0	Split Tensile	19.906	0.57328	0.3750	0.76157
FRC (1%) 2	152.4	270.0	Split Tensile	28.563	0.04782	0.0928	0.74615
FRC (1%) 3	152.4	270.0	Compression	112.531	1.6510	0.850	0.960
FRC (1%) 4	152.4	277.0	Compression	173.031	4.9676	1.250	0.980

A. Controlled Concrete Sample

1. Controlled 1

The first controlled concrete sample exhibited the highest performance among all tested samples, achieving a breakage force of 411.844 kN with a maximum applied force of 474.781 kN. It also recorded a breakage stress of 22.5773 MPa and a peak stress of 26.0276 MPa. This sample produced the most favorable results, aligning with the researchers' expectations. In assessing its compressive strength to determine structural integrity and material durability, the sample demonstrated exceptional resistance to compression forces, surpassing all other tested samples. These results were achieved using the standard M20 mixture ratio and adhering to proper procedures to ensure the correct consistency.

2. Controlled 2

The second controlled concrete sample achieved a breakage force of 218.156 kN, with a maximum applied force of 396.875 kN, and recorded a breakage stress of 11.9594 MPa, with a peak stress of 21.7568 MPa. Among all tested samples, including the Fiber-Reinforced ones, it ranked second in overall performance. While it demonstrated a clear difference in strength compared to the first controlled sample, which consistently exhibited superior durability, it still outperformed the Fiber-Reinforced samples. Although it did not reach the highest strength within the controlled samples, Controlled Sample 2 displayed remarkable resistance to breakage, further emphasizing the structural integrity of well-proportioned controlled concrete mixtures. These findings highlight the inherent strength of properly designed controlled concrete, reinforcing its advantage over fiber-reinforced alternatives.

3. Controlled 3

The third controlled concrete sample recorded a breakage force of 276.094 kN, with a maximum applied force of 301.781 kN, and a breakage stress of 15.1355 MPa, reaching a peak stress of 16.5437 MPa. Ranking third among all tested samples, including the FiberReinforced ones, it demonstrated a slight difference in compressive strength compared to the second-best performer, Controlled Sample 2. While it did not exhibit the same high strength as Controlled Samples 1 and 2, it still outperformed the Fiber-Reinforced samples. Despite not achieving the highest strength within the controlled concrete group, this sample showcased a strong resistance to breakage, reinforcing the idea that well-proportioned controlled concrete mixtures inherently possess superior strength and durability compared to fiber-reinforced alternatives.

B. Fiber-Reinforced Concrete

1. Fiber-Reinforced Concrete Sample 3 (0.5%)

The FRC (0.5%) Sample 3, measuring 152.4 x 278.5 mm, recorded a breakage force of 239.656 kN, with a maximum applied force of 271.469 kN, and a breakage stress of 13.1380 MPa, peaking at 14.8820 MPa. This result shows that Fiber-Reinforced Concrete is significantly weaker than the controlled samples, likely due to factors such as mixture ratio, consistency, curing time, and environmental conditions. However, since all samples were developed under the same conditions, this suggests that the Fiber-Reinforced Concrete mixture is inherently more brittle. The lower breakage point may be due to uneven fiber distribution, likely influenced by the lack of a standardized mixture ratio in FRC development.

2. Fiber-Reinforced Concrete Sample 4 (0.5%)

The FRC (0.5%) Sample 4, with dimensions of 152.4 x 274.0 mm, recorded a breakage force of 220.250 kN, a maximum applied force of 331.156 kN, and a breakage stress of 12.0741 MPa, peaking at 18.1540 MPa. Among all the Fiber-Reinforced Concrete (FRC) samples, this one exhibited the highest breakage point, suggesting relatively lower brittleness. However, compared to the Controlled Concrete Samples, it still displayed significantly lower strength. All FRC mixtures used the standard M20 mix with added Carbon Fiber, but the absence of a standardized procedure for creating the FRC mix may have hindered its full potential.

3. Fiber-Reinforced Concrete Sample 3 (1%)

The compressive strength test for the Fiber-Reinforced Concrete (1%) Sample 3, with dimensions of 152.4 x 270.0 mm, recorded a maximum applied force of 212.531 kN and a peak stress of 11.6510 MPa. Among the FRC samples, this one exhibited the highest brittleness, despite containing a greater amount of fiber. This suggests that higher fiber content may not necessarily enhance compressive strength. As with other FRC samples, its performance was likely influenced by factors such as the mixture composition and environmental conditions during curing.

4. Fiber-Reinforced Concrete Sample 4 (1%)

The compressive strength test on Fiber-Reinforced Concrete (1%) Sample 2, with dimensions of 152.4 x 277.0 mm, recorded a maximum applied force of 273.031 kN and a peak stress of 14.9676 MPa. Compressive strength represents a material's ability to withstand loads before failure, and in this case, the sample endured a significant force before breaking. However, several factors influence concrete's ultimate strength, including the water-to-cement ratio, aggregate properties, curing conditions, and fiber distribution. While fiber reinforcement can enhance certain properties, uneven fiber distribution may lead to weaker areas within the mix, making the concrete more susceptible to cracking. The precise mix design, including aggregate selection and curing methods, plays a crucial role in determining mechanical performance. Proper curing techniques, such as moisture and temperature control, are essential for achieving maximum strength and durability.

Split Tensile Test

C. Controlled Concrete Sample

1. Controlled 4

The fourth controlled concrete sample experienced a breakage force of 121.781 kN, with a maximum applied force of 163.656 kN. It also recorded a breakage stress of 6.67607 MPa and a peak stress of 8.97166 MPa. The fact that the sample failed at a lower capacity suggests reduced resistance to external loads. Potential factors contributing to this outcome include insufficient fiber content, an imbalanced concrete mix design, or inadequate curing conditions. Poor fiber distribution can weaken structural integrity, while inconsistencies in material proportions may lower overall strength. Additionally, improper curing could prevent the concrete from reaching its full strength, increasing its vulnerability to breakage.

D. Fiber-Reinforced Concrete

1. Fiber-Reinforced Concrete Sample 1 (0.5%)

The split tensile strength test on Fiber-Reinforced Concrete (FRC) 0.5% sample 1, with dimensions of 152.4 x 274.0 mm, recorded a breakage force of 50.7188 kN and a maximum applied force of 127.375 kN. It also reached a breakage stress of 2.78041 MPa, with a peak stress of 6.98272 MPa. This sample exhibited greater breakability than the controlled sample but ranked third among all split tensile strength tests. Its reduced resistance to tensile forces may be attributed to factors such as insufficient or uneven fiber distribution, suboptimal fiber properties, an imbalanced mix design, or the sample's dimensions. Further analysis is necessary to refine fiber content, optimize mix proportions, and improve testing conditions to enhance the tensile strength of FRC.

2. Fiber-Reinforced Concrete Sample 2 (0.5%)

The split tensile strength test on Fiber-Reinforced Concrete (FRC) 0.5% sample 2, with dimensions of 152.4 x 279.0 mm, recorded a breakage force of 50.2188 kN and a maximum applied force of 124.156 kN. It reached a breakage stress of 2.7530 MPa, with a peak stress of 6.80627 MPa. This sample ranked as the second most breakable among the split tensile strength tests, indicating high susceptibility to tensile failure. Factors such as insufficient or uneven fiber distribution, suboptimal fiber properties, an imbalanced mix design, and sample dimensions may have contributed to its reduced strength. Further testing and optimization of fiber content, mix proportions, and curing conditions are necessary to enhance its tensile resistance.

3. Fiber-Reinforced Concrete Sample 1 (1%)

The split tensile strength test on Fiber-Reinforced Concrete (FRC) 1% sample 1, with dimensions of 152.4 x 274.0 mm, recorded a breakage force of 50.3750 kN and a maximum applied force of 119.906 kN. It reached a breakage stress of 2.76157 MPa, with a peak stress of 6.57328 MPa. The sample exhibited notable breakability, indicating a reduced capacity to withstand tensile forces. Factors such as fiber content, distribution, type, and properties, along with the concrete mix design and sample dimensions, likely influenced its performance. A detailed analysis is needed to identify the specific causes of breakability and optimize these elements to enhance the overall tensile strength of the FRC sample.

4. Fiber-Reinforced Concrete Sample 2 (1%)

The split tensile strength test on Fiber-Reinforced Concrete (FRC) 1% sample 2, with dimensions of 152.4 x 270.0 mm, recorded a breakage force of 50.0938 kN and a maximum applied force of 128.563 kN. It reached a breakage stress of 2.74615 MPa, with a peak stress of 7.04782 MPa. The sample exhibited significant breakability, indicating a reduced capacity to withstand tensile forces. Factors such as fiber content, distribution, type, and properties, along with the concrete mix design and sample dimensions, likely influenced its performance. To improve tensile strength and minimize breakability, further analysis, experimentation, and optimization of these variables are essential.

E. Survey Assessment on Fiber Reinforced Concrete

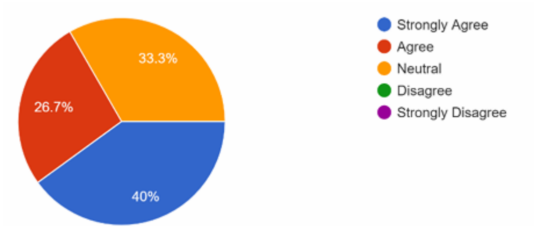

Fig. 2. Licensed Civil Engineers' Professional Perspectives on Incorporating Fiber-Reinforced Concrete in Building Foundations: Perspectives on Incorporating Fiber Reinforced Concrete in Building Foundations

The graph reveals that 40% (six respondents) strongly agree with the concept of incorporating Fiber-Reinforced Concrete in Building Foundations. 33.3% (five respondents) were neutral. Conversely, 26.7% (four respondents) demonstrated agree with the topic.

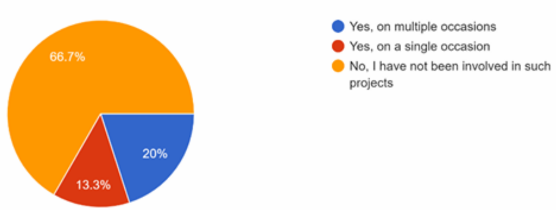

Fig. 3. Professional Experience with Fiber-Reinforced Concrete in Earthquake-Resistant Foundation Design and Construction

The graph reveals that 66.7% (ten respondents) have not been involved in such projects with the concept of Fiber-Reinforced Concrete in Earthquake-Resistant Foundation Design and Construction. 20% (three respondents) have been involved on multiple occasions. Conversely, 13.3% (two respondents) demonstrated have been involved on a single occasion.

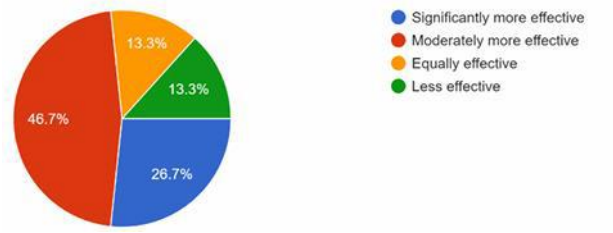

Fig. 4. Assessing the Effectiveness of Fiber-Reinforced Concrete in Enhancing Seismic Resistance: A Comparative Evaluation with Traditional Concrete Materials

The graph reveals that 46.7% (seven respondents) indicated that it is moderately more effective with the concept of comparative evaluation with traditional concrete materials and Fiber-Reinforced Concrete in enhancing seismic resistance. 26.7% (four respondents) stated that it is significantly more effective and 13.3% (two respondents) demonstrated that it is equally effective. Conversely, 13.3% (two respondents) demonstrated that it is less effective.

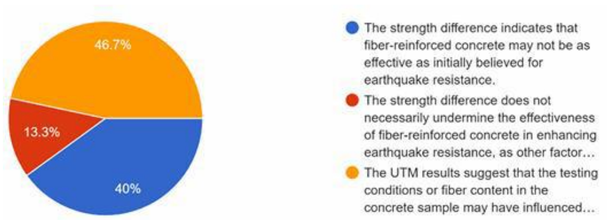

Fig. 5. Interpreting UTM Results: Assessing the Effectiveness of Fiber-Reinforced Concrete Material for Earthquake-Resistant Foundations

The graph results show that 46.7% of respondents (seven individuals) stated that the UTM results suggest that the testing conditions or fiber content in the concrete sample may have influenced the strength outcomes, warranting further investigation. Meanwhile, 40% of respondents (six individuals) indicated that the strength difference indicates that fiber reinforced concrete may not be as effective as initially believed for earthquake resistance. However, 13.3% of respondents (two individuals) stated that the strength difference does not necessarily undermine the effectiveness of fiber-reinforced concrete in enhancing earthquake resistance, as other factors such as ductility and crack control may come into play.

IV. CONCLUSION

Constructing earthquake-resistant buildings requires suitable construction methods that go beyond design considerations. Critical elements for ensuring building integrity during seismic events include flexible structures capable of withstanding shear forces, reinforced solid structural joints, and well-prepared foundations. Collaboration among safety professionals and experts is crucial for developing earthquake-resistant features that prioritize human safety and minimize economic losses. Incorporating these techniques and materials enables structures to withstand earthquakes, reduce damage and financial loss, and prevent human casualties. Fiberreinforced concrete also helps prevent cracks caused by drying and plastic shrinkage, enhancing durability. Evaluating earthquake excitation and structure response at specific sites is vital for designing earthquake-resistant buildings. Fiber Reinforced Concrete (FRC) enhances concrete's hardness, toughness, and tensile strength, reducing shrinkage cracking and providing impact, abrasion, and shatter resistance. While fibers do not replace structural steel reinforcement, they offer benefits for crack control and impact resistance. Microfibers outperform longer fibers in impact resistance and decrease concrete permeability. FRC improves strain capacity and durability, making it significant for high tensile strength and minimal cracking requirements.

This study explores the feasibility of using Fiber-Reinforced Concrete for earthquake- resistant building foundations, gathering insights through analysis, expert opinions, and surveys. The research aims to contribute to understanding the benefits and considerations of FRC in construction and provide valuable insights for evaluation and implementation. The study evaluated three types of concrete samples: Controlled Concrete, Fiber-Reinforced Concrete (0.5%), and Fiber-Reinforced Concrete (1%). Testing included Compression Tests and Split Tensile Tests using the Universal Testing Machine (UTM). The Compression Test assessed load-bearing capacity and structural integrity, providing insights for earthquake-resistant building foundations. The Split Tensile Test evaluated tensile behavior and resistance by applying compressive strength, resulting in tension and fracture perpendicular to the load. The researchers analyzed the results of the UTM procedure and survey questionnaire to achieve the study's objectives. The findings provided insights into the performance of Controlled Concrete, Fiber-Reinforced Concrete (0.5%), and Fiber-Reinforced Concrete (1%) in terms of loadbearing capacity, structural integrity, tensile behavior, and resistance. The conclusions drawn from this analysis contribute to understanding the suitability of Fiber- Reinforced Concrete for earthquake-resistant building foundations and support the development of more resilient structures. Design considerations, such as water-cement ratio, fiber percentage, and adherence to guidelines, are crucial for successful implementation. Further research is needed to explore different fiber types, availability, and reinforcement behavior. Careful adjustment of concrete mixtures and consideration of various factors are necessary for desired strength and performance. The study found that Controlled Concrete exhibited superior strength and resilience compared to the tested variations of Fiber-Reinforced Concrete.

In conclusion, based on the compression test results, the first controlled concrete sample exhibited the most favorable outcomes among all the tested samples. It achieved a breakage forceof 411.844 kN, with a maximum force of 474.781 kN applied, and a breakage stress of 9

22.5773 MPa, with a maximum stress of 26.0276 MPa applied. This indicates that the controlled concrete sample surpassed the performance of the other samples analyzed by the researchers. Comparatively, in the case of sample 2, which was reinforced with 0.5% fibers, it reacheda breakage force of 220.250 kN, with a maximum force of 331.156 kN applied, and a breakage stress of 12.0741 MPa, with a maximum stress of 18.1540 MPa applied. On the other hand, sample. 2 with 1% fiber reinforcement reached a maximum force of 273.031 kN, with a maximum stress of 14.9676 MPa applied. The controlled concrete sample demonstrated superior performance in the compression test compared to the fiber-reinforced concrete samples. This indicates that controlled concrete is more suitable for applications that require high compressive strength.

In summary, the split test results indicate that the fourth controlled concrete sample demonstrated the most favorable outcomes among all the tested samples. It achieved a breakage force of 121.781 kN, with a maximum force of 163.656 kN applied, and a breakage stress of 6.67607 MPa, with a maximum stress of 8.97166 MPa applied. This controlled concrete sample exhibited the highest performance as expected by the researchers. In terms of fiber-reinforced concrete samples, the best results were observed in Fiber-Reinforced Concrete Sample 1 (0.5%). It reached a breakage force of 50.7188 kN, with a maximum force of 127.375 kN applied, and a breakage stress of 2.78041 MPa, with a maximum stress of 6.98272 MPa applied. While this sample demonstrated higher breakability compared to the controlled sample, it ranked as the third best result among the split tensile strength tests. For Fiber-Reinforced Concrete Sample 2 (1%), the best results were obtained. It achieved a breakage force of 50.0938 kN, with a maximum force of 128.563 kN applied, and a breakage stress of 2.74615 MPa, with a maximum stress of 7.04782 MPa applied. Overall, the fourth controlled concrete sample displayed superior performance in the split test, while Fiber-Reinforced concrete sample 2 (1%) demonstrated the best outcomes among the Fiber-Reinforced concrete samples. The laboratory tests consistently showed that Controlled Concrete had better load-bearing capacity, structural integrity, and tensile strength than Fiber- Reinforced Concrete. This highlights the reliability and stability of Controlled Concrete in constructing structures that can withstand external forces, including seismic events. While Fiber- Reinforced Concrete enhances specific properties, Controlled Concrete outperformed in overall strength. The findings contribute to substantial engineering knowledge and assist professionals in material selection for earthquakeresistant foundations. Further research is needed to explore Fiber- Reinforced Concrete's potential in specific scenarios. Controlled Concrete's superior strength and resilience make it suitable for robust and durable structures, especially in seismic-prone areas. Ongoing research is essential to optimize the potential of Fiber-Reinforced concrete in specific applications requiring enhanced properties.

V. Recommendation

Researchers recommended that future civil engineering structures start by understanding Fiber Reinforced Concrete and its properties. Learn about the fibers commonly used in FRC, suchas steel, glass, or synthetic fibers. Understand how these fibers enhance the mechanical propertiesof concrete and provide added resistance to cracking and deformation. Furthermore, they should gain knowledge of earthquake engineering principles and seismic design to conduct effective andreliable research. Understand the behavior of structures during earthquakes,

including the dynamicforces acting on them. Learn about various design philosophies, building 10 codes, and standards related to seismic-resistant design. This knowledge will help them develop a holistic approach to foundation design. Moreover, always explore case studies, research papers, and real-life projects utilizing FRC in earthquake-resistant foundations. Analyze their design methodologies, construction techniques, and performance during seismic events.

Researchers recommended that civil engineering professionals do more experiments on using fiber reinforcement concrete, such as the pull-out test. All construction methodologies should be further reviewed and analyzed before their implementation in construction. Further testing and studies must be conducted first. Consider conducting experimental investigations to evaluate the mechanical properties of FRC. Design and execute laboratory tests to assess the behavior of FRC under static and dynamic loading conditions resembling earthquakes. Focus on crucial parameters such as fiber type, dosage, length, and aspect ratio to understand their influenceon the performance of FRC foundations. Lastly, engage with academic and industry experts in FRC and earthquake engineering. To share ideas, work on research projects with others, and get feedback on your work, go to conferences, workshops, and seminars. By forming professional connections, you may expand your knowledge and create new possibilities for future study.

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