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Evaluation of Crack Resistance in Glass Reinforced Fibre Concrete under Tensile Loading

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ABSTRACT: The use of glass reinforced fibre concrete (GFRC) has gained prominence due to its enhanced mechanical properties and durability compared to traditional concrete. This research paper evaluates the crack resistance of GFRC under tensile loading. It investigates the impact of varying glass fibre content on crack development, tensile strength, and overall performance. The study utilizes experimental methods to assess the effectiveness of glass fibres in mitigating crack formation and compares GFRC with standard concrete mixtures. The findings suggest that GFRC significantly improves crack resistance, offering a promising solution for applications requiring enhanced structural integrity.

I. INTRODUCTION

Concrete is a widely used construction material due to its strength and durability. However, traditional concrete often suffers from cracking under tensile stresses, which can compromise structural integrity and durability. To address these issues, various reinforcement methods have been employed, including the use of fibres. Glass fibre reinforced concrete (GFRC) has emerged as an innovative approach to enhance concrete's performance.

GFRC incorporates glass fibres into the concrete mix to improve its mechanical properties, including crack resistance. Glass fibres offer several advantages, including high tensile strength, low weight, and resistance to environmental degradation. This paper explores the effectiveness of glass fibres in enhancing crack resistance under tensile loading, providing insights into the potential benefits of using GFRC in construction applications.

II. LITERATURE REVIEW

Conventional Concrete and Cracking

Traditional concrete is prone to cracking due to its brittleness and low tensile strength. Cracks can form due to various factors, including shrinkage, thermal expansion, and applied loads. Cracking compromises the durability and longevity of concrete structures, making it essential to develop methods to enhance crack resistance.

Fibre Reinforced Concrete

Fibre reinforced concrete (FRC) is a composite material that incorporates fibres to improve concrete's mechanical properties. The addition of fibres enhances tensile strength, ductility, and crack resistance. Various types of fibres have been used in FRC, including steel, synthetic, and glass fibres.

Glass Fibre Reinforced Concrete (GFRC)

Glass fibre reinforced concrete (GFRC) is a type of FRC that uses glass fibres as reinforcement. Glass fibres are known for their high tensile strength and resistance to chemical attack. GFRC has been found to improve crack resistance, impact resistance, and durability compared to traditional concrete.

Previous Studies on GFRC

Several studies have investigated the performance of GFRC in various applications:

1. **Mechanical Properties:** Research has shown that GFRC exhibits improved tensile strength and ductility compared to conventional concrete. Glass fibres contribute to these improvements by providing reinforcement that enhances the material's ability to withstand applied stresses.

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2. **Crack Resistance:** Studies have demonstrated that GFRC exhibits superior crack resistance under various loading conditions. The addition of glass fibres helps to control crack propagation and reduce the formation of new cracks.
3. **Durability:** GFRC has been shown to have enhanced durability, including resistance to environmental factors such as moisture and chemicals. This makes it suitable for use in challenging environments.

III. METHODOLOGY

Materials

Concrete Mixes

Two types of concrete mixes were prepared for the study:

1. **Standard Concrete Mix (SCM):** A control mix with no fibres added.
2. **Glass Fibre Reinforced Concrete (GFRC):** Concrete mix with varying glass fibre content.

The concrete mixes were designed with a constant water-cement ratio and aggregate proportions, with only the fibre content varying.

Glass Fibres

Glass fibres used in the study were of uniform length and diameter. The fibre content was varied in the GFRC mixes to evaluate its effect on crack resistance.

Experimental Procedure

Sample Preparation

1. **Mixing:** Concrete mixes were prepared using standard procedures. For GFRC, glass fibres were added at different volume fractions (0.5%, 1%, and 1.5%) to evaluate their impact on crack resistance.
2. **Casting:** Concrete samples were cast into standard moulds and cured under controlled conditions.
3. **Testing:** Samples were subjected to tensile loading tests to evaluate crack formation and resistance. The tests were performed according to established standards.

Testing Methods

Tensile Testing

1. **Apparatus:** A universal testing machine was used to apply tensile loads to the concrete samples.
2. **Procedure:** The samples were subjected to increasing tensile loads until failure occurred. Crack development and resistance were recorded.
3. **Data Collection:** The tensile strength, crack pattern, and crack width were measured and analyzed.

IV. RESULTS AND DISCUSSION

Tensile Strength

The addition of glass fibres to the concrete mix resulted in increased tensile strength compared to the standard concrete mix. The tensile strength of GFRC samples improved with higher glass fibre content, indicating that fibres effectively enhance the concrete's ability to withstand tensile stresses.

Crack Resistance

Crack Formation

1. **Standard Concrete Mix (SCM):** The SCM samples exhibited significant crack formation under tensile loading. Cracks initiated from localized stress points and propagated throughout the sample.
2. **GFRC:** GFRC samples demonstrated improved crack resistance. The presence of glass fibres helped to control crack formation and reduce the overall number and width of cracks.
3. **Effect of Fibre Content:** Higher glass fibre content in GFRC samples led to a reduction in crack width and propagation. The 1.5% glass fibre content showed the most significant improvement in crack resistance.

Crack Patterns

1. **SCM:** Cracks in the SCM samples were typically wide and irregular, with significant branching and propagation.

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2. **GFRC:** Cracks in GFRC samples were narrower and more localized. Glass fibres helped to reinforce the concrete matrix, reducing the extent of crack propagation.

Comparison of GFRC and SCM

1. **Crack Width:** GFRC exhibited reduced crack widths compared to SCM. The reduction in crack width was more pronounced with higher glass fibre content.
2. **Crack Density:** GFRC samples showed a lower density of cracks compared to SCM. The glass fibres effectively distributed stresses within the concrete, minimizing crack formation.
3. **Tensile Strength Improvement:** GFRC samples had higher tensile strength compared to SCM, with the improvement correlating with the fibre content.

Environmental and Economic Considerations

Environmental Impact

GFRC offers several environmental benefits:

1. **Reduced Material Usage:** The use of GFRC can reduce the amount of cement required in concrete mixtures, lowering the overall environmental impact.
2. **Longevity:** GFRC's improved durability and crack resistance contribute to longer-lasting structures, reducing the need for repairs and maintenance.

Economic Impact

1. **Cost of Glass Fibres:** While glass fibres may increase the initial cost of concrete, the benefits of improved performance and reduced maintenance can offset these costs over the lifespan of the structure.
2. **Construction Efficiency:** GFRC's enhanced properties can lead to more efficient construction processes and longer-lasting structures, providing economic advantages in the long term.

V. CONCLUSION

The evaluation of glass reinforced fibre concrete (GFRC) under tensile loading has demonstrated its effectiveness in improving crack resistance compared to traditional concrete. The study found that GFRC with higher glass fibre content exhibited increased tensile strength and reduced crack formation, offering a promising alternative for applications requiring enhanced structural integrity.

The results indicate that glass fibres play a significant role in controlling crack propagation and improving the overall performance of concrete. GFRC provides environmental and economic benefits, making it a viable option for sustainable construction practices.

Further research could explore additional factors influencing the performance of GFRC, including different types and lengths of glass fibres, as well as their interaction with other additives and reinforcement methods. The continued development and application of GFRC have the potential to revolutionize concrete technology and improve the durability and longevity of structures.

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