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INVESTIGATION OF THE STRENGTH OF CONCRETE TILES BY THE ADDITION OF CHOPPED GLASS FIBRES

Prince Kumar

*** M.Tech. Scholar, School of Civil Engineering, Faculty of Engineering and Technology*
*Madhyanchal Professional University, Bhopal, M.P***

Mrs. Kamni Laheriya

*** Assistant Professor, School of Civil Engineering, Faculty of Engineering and Technology*
*Madhyanchal Professional University, Bhopal, M.P***

ABSTRACT

They are utilised for flooring, pavements, footpaths, roofing and also different kinds of building works. Contemporary concrete tiles, on the other hand, are often susceptible to continuous loading and environmental effects resulting in cracking, poor tensile strength and abrasion. GFRC is a possible solution to overcome such limitations. Glass fibres embed and work to mitigate any cracking effect on strengthening of edges; improve concrete durability & therefore its performance significantly through better bonding within the matrix.

Studying the performance and durability test of concrete tiles by adding chopped AR glass fibres to find out the optimum fibre content that provides better mechanical and Durability properties is the aim of this research. For this experiment, M25 grade concrete was taken as the base material and glass fibres were added in percentages of 0%, 0.5%.1.0%.1.5% and 2.0% by weight of cement. During the entire experimental programme, a water-cement ratio of 0.45 was used at all times. The control mix against which other mixes will be compared was the one without fibres.

In total, 225 specimens (concrete cube, beam, cylinder and tile) were prepared, and the curing period was carried out for three ages (7 days, 14 days, and 28 days). Laboratory tests were conducted to assess the concrete properties, including compressive strength, flexural strength, split tensile strength, abrasion resistance and impact resistance tests. During specimen preparation, curing and testing procedures, the standard Indian Standard (IS) codes were followed to obtain reliable and accurate results.

The experimental results showed that the addition of glass fibres enhanced various properties of concrete. The concrete containing 1.0% AR glass fibre—with respect to all analysed properties—was found to provide the best overall behaviour amongst all mixes. At this fibre content, the compressive strength was 18.7% higher than conventional concrete, with flexural and split tensile strength being improved by 31.4% and 24.6% compared to conventional concrete at the age of curing of 28 days. The enhancement took place because the glass fibres reached crack-arresting materials where micro-cracks are unable to propagate, and their advancement in concrete benefits from more load-carrying capability.

Higher fibre content than 1.0% was likewise witnessed to lessen the strength of mortar. The decrease was primarily attributed to fibre clustering, poor workability, uneven distribution of fibres, and increased air voids in concrete due to the use of fibres. So adding a large amount of fibre will not help in the performance of concrete.

In durability tests, GFRC tiles showed more detraction value (abrasion resistance) and impact resistance compared to ordinary concrete tiles. These fibres aided in the resistance of surface wear and more impact energy absorption of tiles — ideal for heavy traffic areas like industrial floors, parking lots, pavements, walkways and commercial buildings. Enhanced resilience is a testament to GFRC tiles that can potentially ensure a longer life and lower costs of having them maintained.

Microstructural investigations were conducted with the help of a scanning electron microscope (SEM) and x-ray diffraction (XRD) to understand the behaviour of glass fibre reinforced concrete. All these investigations later demonstrated good bonding of the glass fibres to the cement matrix and proved that they could bridge microcracks, thereby allowing the formation of a denser, stronger concrete mass.

Also, an economic analysis was done to assess the practicability of using glass fibres in concrete tiles. The results showed that the better mix with 1.0% glass fibre only increased the cost of producing the material by around 9.2% over standard concrete tiles. This additional cost is therefore economically justified by virtue of the greatly improved strength, durability and service life.

From the experimental results, it can be concluded that 1.0% chopped AR glass fibre is the optimum addition for high-performance and attractive concrete tiles production. This was the initial step toward producing more sustainable construction materials that were crack-resistant and long-lasting, using Glass Fibre Reinforced Concrete. These findings can serve as a guideline for engineers, researchers and construction practitioners for developing enhanced concrete tile technology over the current and modern usage in construction practices.

Keywords: GFRC (Glass Fibre Reinforced Concrete), AR Glass Fibres, Concrete Tiles, Compressive Strength, Split Tensile Test, Flexural Strength, Durability Property, abrasion Resistance, Impact Resistance, M25 concrete.

Introduction

We know that concrete is one of the most prominent, frequently used materials all around. This is used in most types of structures, like buildings, bridges, roads, pavements, and dams, as well as flooring systems. The widespread use of concrete is due to its compressive strength, durability, availability of raw materials and low price. Though conventional concrete does have a few limitations. Along with being brittle in nature, it has low tensile strength, inferior cracking resistance, and impact energy absorption capability.

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In concrete tiles, which are widely used for flooring applications in residential, commercial, and industrial structures, these limitations become even more important. During the service life of concrete tiles, they are subjected to loads of various types. These include bearing loads from foot traffic and vehicles, flexural stresses from non-uniform loading, abrasions due to wear on the surface layer of concrete, and shock forces from falling components. Consequently, traditional cement tiles tend to crack and suffer frontal damage as well as moisture-related decay, reducing their durability and increasing upkeep prices.

These difficulties cause researchers to introduce a kind of concrete called Fibre Reinforced Concrete (FRC). They involve mixing small fibres throughout the concrete matrix. These fibres will help you control cracks and also prevent fine crack into heavy cracks. As a result, this will help concrete in becoming leave it stronger, harder and more durable.

Concrete can be reinforced using various types of fibres, including steel, polypropylene, carbon, basalt and glass fibres. Of these, a substantial amount of attention has been caught by alkali-resistant (AR) glass fibres due to their light weight, high tensile strength, corrosion resistance and low cost. These fibres are manufactured specifically for high alkaline resistance in cement-based materials.

Commercially, Glass Fibre Reinforced Concrete (GFRC) first appeared in the 1970s and has since grown in popularity when it comes to architectural panels and façade systems; precast elements; drainage structures; and decorative concrete articles. Creating alkali-resistant glass fibres that contain a relatively high percentage of zirconia was the first breakthrough, primarily because it addressed durability issues that common glass fibres exhibit when exposed to concrete.

For the past few years, India has also seen a huge demand where consumers are looking for stronger, more durable and sustainable construction materials. Concrete tile provides an attractive and easy-to-install alternative to other materials that are now used for both commercial and residential projects. On the other hand, traditional tile is susceptible to cracking, wear and moisture ingress while in use. They can improve the performance of concrete tiles while remaining economically feasible. Enhanced durability can reduce maintenance costs, increase service life and contribute towards sustainability in construction.

This work has been done to study the influence on strength, durability, and performance of concrete tiles by alkali-resistant glass fibres, as well as to find the optimum fibre dosage.

Literature review

Baybure (2024) reported on the state of the art of Glass Fibre Reinforced Concrete in Construction: recent advances, challenges and prospects. This study reviewed developments in fibre technology, methods for mix design, mechanical properties, durability and sustainability of GFRC are examined; while progress toward smart infrastructure applications for modern construction was also highlighted.

The author emphasised that ongoing advances in alkali-proof glass fibres, chemical admixtures and concrete technology have dramatically expanded the GFRC use palette as well as its requirements for lightweight panels, fortified façades, perpetual formwork systems, bridge parts and prefabricated components. Other suggestions included optimisation of fibre dosage, long-term durability under extreme environmental conditions, use of supplementary cementitious materials and advanced characterisation techniques (for example, SEM using X-ray diffraction [XRD] or computed tomography [CT] scanning to better understand fibre–matrix interactions) for future studies.

It can be concluded that GFRC has a lot of potential to contribute to established principles of sustainable construction because it is highly durable, requires less maintenance and has got more service life.

Hajmoosa et al (2024), the purpose of these tests was to evaluate the retention of reinforcement properties by AR glass fibres under aggressive exposure conditions.

The results showed that after longer exposure time, AR glass fibres still maintained a high amount of the original tensile strength. Very little degradation at the fibre–matrix interface was evident, highlighting high resistance to alkaline attack and environmental destruction. They concluded that based on the findings, glass fibre reinforced composites provide a satisfactory degree of durability for marine structures, coastal infrastructure and precast systems with long service lives.

Zhang (2023) conducted a study on the macro- and micro-mechanical behaviour of Alkali-Resistant Glass Fibre Reinforced Concrete (AR-GFRC) in alkaline exposure conditions. The work integrated standard mechanical characterisation with SEM to elucidate how the interaction occurred at the interface between glass fibres and the cement matrix.

The authors also found that AR glass fibres bonded well to the hydrated cement paste, which allowed stress transfer across microcracks. The fibres remained firmly anchored in the matrix and interacted with the cement paste within the cracks, as confirmed by SEM observations, which resulted in an improvement of compressive tensile strength, flexural behaviour and toughness. Moreover, the fibres did not lose their reinforcement ability even in an extremely alkaline environment, making them ideal candidates for extended use as structural counterparts. The research highlighted that the improvement in GFRC performance has to be explained by microstructural investigations.

Bandaru Venkata, Shiva Kumar, and Premsudha (2023) experimentally studied the mechanical properties and crack-control behaviour of Alkali-Resistant Glass Fibre Reinforced Concrete. In this study, normal thickness concrete specimens with various proportions of AR glass fibres were cast and tested for compressive strength, split tensile strength, flexural strength and crack development.

Experimental results revealed that the incorporation of AR glass fibres enhanced tensile and flexural properties significantly because the fibres can effectively transfer stresses across forming cracks. Compared with ordinary concrete, the crack width of fibre-reinforced specimens increased in a more moderate way, and toughness and impact resistance were better. The researchers also noted that an optimum fibre dosage resulted in the overall best performance, but excessive addition decreased workability and led to fibre agglomeration. The authors found that AR glass fibres are an appropriate selection for structural applications, precast products and concrete components needing enhanced resistance to cracking and durability.

Blazy, Blazy and Drobiec (2022) focus on the application of glass or aramid fibres in contemporary architectural and structural construction. The purpose of the study was to evaluate the effect of adding glass fibres on the mechanical, durability and sustainability properties of concrete and determine its suitability as a material for smart-city infrastructure. To do so, the authors accumulated and analysed research outcomes from several experimental investigations on crack mitigation, mechanical features, even hearthness, freeze–thaw overall performance resistance, abrasion resistance and permeability.

The review found that glass fibres provide a major mechanism for bridging and restraining cracks, leading to increased resistance to crack propagation, therefore increasing the final tensile strength and flexural capacity of concrete as well as improved impact resistance and toughness. The authors also reported that GFRC has improved durability, as the fibres decrease permeability, restrict moisture penetration and increase freeze–thaw damage resistance and abrasive wear surface. GFRC is considerably cheaper in the long run due to its longer life span and less maintenance cost, but the first production put up a higher price tag than most forms of concrete. The findings of the study proved GFRC to be a good match for the design and construction of building façade panels, bridge elements, precast components and other applications that require durability with low maintenance.

Ahmad (2022). The authors reviewed recent studies reported on compressive strength, split tensile strength, flexural strength, modulus of elasticity, workability, chloride permeability and water absorption together with the ultrasonic pulse velocity (UPV), acid resistance and fibre–matrix interaction through scanning electron microscopy (SEM).

The review revealed that the addition of glass fibres always increases the tensile and flexural performance of concrete, by controlling crack initiation and slowing down crack propagation (Hong et al.). You also reported a moderate increase in compressive strength and lower permeability, leading to better durability due to increased resistance towards an aggressive environment. Nevertheless, the study stated that excessive fibre contents have negative impacts on workability due to increased internal friction of the fresh concrete mixture. From the reviewed literature, the optimum fibre dosage (based on volume) was between 2% and recommended the use of superplasticisers to be employed when a higher quantity of fibres is desired. Moreover, this review has advocated for more research on GFRC, especially concerning long-term durability aspects, in-field performance analysis and comprehensive microstructural characterisation.

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Vijayan et al (2022) summarised the effects of glass fibres on engineering properties and their applications in a review of work on the use of GFC (glass fibre concrete) [17]. The authors described fibre behaviour in both fresh and hardened concrete, including its effect on workability, compressive strength, tensile strength, flexural strength, shrinking control behaviour and durability.

It was observed that glass fibres are most successful at improving tensile and flexural properties by minimising the probability of crack development (which also increases the energy absorption capacity), in addition to engaging in bridging action. GFRC also exhibited improvements in impact resistance and surface wear properties appropriate for use in industrial floors, pavements, precast elements, and architectural products. Nevertheless, the study noted that too much fibre can lead to low workability and also pointed out that a good mix design in conjunction with chemical admixtures is vital in ensuring even fibre distribution throughout the fresh concrete and uniformity of performance.

Chandramouli (2010). The study investigated alkali-resistant glass fibres reinforced concrete grades of M20, M30, M40 and M50 at different percentages. Curing for 7 days and 28 days, Compressive strength, split tensile strength and Flexural Strength were obtained.

The results revealed that the mechanical behaviour of concrete was significantly improved with the addition of glass fibres to concrete. These improvements were greatest in split tensile and flexural strengths due to the ability of fibres to bridge cracks and inhibit their propagation. The enhancement was lower than the improvement observed in compressive strength, though that too improved. Researchers found that around 1% fibre content was the most beneficial dosage, though raising percentages reduced workability and forced fibres to clump together.

Glass fibres were found to enhance the concrete strength, toughness, crack resistance and durability. Due to its extensive findings, this has now been among the most cited works for GFRC in India.

Chandramouli (2010) evaluated the durability characteristic of Glass Fibre Reinforced Concrete using the Rapid Chloride Permeability Test (RCPT). Chloride environments were applied to concrete specimens incorporated with specific percentages of AR glass fibres over a year.

The results showed that the proportion of chloride ion penetration in fibre-reinforced concrete was significantly less than that in ordinary concrete. This enhancement was linked to the fibres' capacity to regulate break formation and decrease the connectivity of pore tunnels in the concrete. Thus, the concrete exhibited higher resistance to reinforcement corrosion and degradation due to aggressive atmospheres.

The researchers inferred that the use of AR glass fibres not only improves mechanical performance but also significantly increases durability, which makes GFRC suitable for marine structures, bridge decks, pavements and other infrastructures exposed to a chloride-rich environment.

Yilmaz and Agopyan (2010) studied the wear resistance and surface properties of glass fibre reinforced concrete for flooring/pavement use. The aim was to establish if fibre reinforcement provides additional resistance against the wear effects of repeated traffic and mechanical grinding actions.

Laboratory tests showed that concrete bars reinforced with glass fibres were much more wear-resistant on the surface than standard concrete. The fibres completely limited the cutting of surface fractures and did not permit mortar particles to be removed throughout attrition. As a result, the concrete surface remained relatively smooth and exhibited improved resistance against physical wear.

The authors say the incorporation of glass fibres significantly improves service life as their addition increases abrasion resistance and reduces surface damage in industrial floors, pavements, and concrete tiles. This study also emphasised the appropriateness of GFRC for applications that are under heavy pedestrian and vehicular traffic.

Pannirselvam (2008) investigated the mechanical properties of glass fibre reinforced concrete with varying volume fractions of the fibres. The tests for compressive strength, split tensile strength, and flexural strength were studied by normal curing.

The experimental results showed that glass fibres significantly increased the tensile and flexural strength, because of cracking bridging and improved crack propagation resistance under load. This increase in compressive strength was low and only one-third of the total growth in flexural strength; however, ductility and energy absorption were greatly improved.

According to the researchers, a homogeneous distribution of fibres in the concrete matrix is essential for achieving consistent mechanical performance. The study established that an optimal fibre content provides a good balance between increased strength and reasonable workability, whereas larger fibre contents can result in the formation of clusters of fibres and poor compactness.

Banthia and Gupta (2006) studied the effect of fibre reinforcement on the fresh and hardened properties of concrete with special emphasis on workability. Concrete mixtures containing different fibre contents were evaluated for their slump, distribution of fibre and placement ease.

The fibres tend to increase the internal friction, with the effect of disorderly mass assembled in dense frames leading to decreased movement of aggregates within each phase, which causes the addition of glass fibres to result in decreased workability of fresh concrete. The slump reduced as the fibre content increased to make compaction more difficult. Nonetheless, researchers showed that the use of high-range water-reducing admixtures (more commonly referred to as superplasticisers) could eliminate workability loss without an increase in water-cement ratio.

Selection of an appropriate fibre dosage is key to meet the right compromise between mechanical/performances and workability -the authors concluded. A high volume of fibres may result in fibre balling, inadequate filling and poor distribution of materiel throughout the concrete, leading to negative effects on the properties and performance of hardened concrete.

Ramakrishna and Sundararajan (2005). The parameters, such as water absorption and permeability, along with resistance to environmental degradation. The evaluation of the concrete specimens with varying fibre dosages was done after standard curing periods.

The results indicated that the addition of glass fibres markedly decreased water absorption and permeability by inhibiting the propagation and formation of microcracks. Thus limiting routes for moisture ingress and providing enhanced resistance to liquid water and aggressive environmental conditions. The study also stated that it improved dimensional stability while reducing cracking due to shrinkage.

The researchers demonstrate that AR glass fibres significantly contribute to the long-term durability of concrete, and this contributes positively in structures that are repeatedly under wetting-drying cycles or exposed to weathering and/or chemical attack. The results showed that GFRC has potential applications for other types of infrastructure projects and precast products, as well as flooring systems with long service lives.

Bouzianopoulos (2003) investigated the influence of alkali-resistant (AR) glass fibres on the compressive performance of concrete. The investigation was primarily focused on whether controlling gel formation improves the mechanical behaviour of conventional concrete with an added benefit from glass fibres to reduce microcrack initiation and growth. The AR glass fibres were incorporated in concrete specimens with 0.0%, 1% and 2% by volume, then the tests were performed on these samples after standard curing periods. Date of submission: 18 February,2019 GP:147 Date of acceptance:26 September,2019

The results showed that the use of glass fibres resulted in a moderate improvement (15–20%) in compressive strength compared to unadmixed concrete. The enhancement was a result of the fibre's ability to prevent microcrack growth and improve stress transfer in the concrete matrix. The study, however, shows glass fibres have a greater influence on post-cracking behaviour than compressive strength because compressive failure is largely controlled by the cement matrix.

The author's conclusion states that glass fibres do not increase compressive strength significantly, but rather that they improve crack resistance and overall integrity of concrete structures, which increases performance and makes GFRC a better candidate for structural applications as well as precast applications.

Beddows and Mott (2000) studied the long-term performance of Alkali-Resistant Glass Fibre Reinforced Concrete in natural environments. The researchers wanted to assess whether moisture, weathering and temperature cycling could degrade the performance of AR glass fibres over extended timescales.

It was found that the fibres retained a significant amount of their original tensile strength and were still able to limit crack formation capacity even after long exposure. Results led the researchers to conclude that AR glass fibres perform exceptionally well, both against alkaline environments as well as environmental factors, indicating GFRC is an excellent material for long-lasting structural and architectural elements on bridges, façades and roofing products through cladding panels.

Naaman and Najm (1991) studied the fracture properties and flexural behaviour of glass fibre reinforced cementitious composites containing varying proportions of fibres. Glass fibres increased the flexural strength of the composite and arrested cracks from propagating over time, as was shown in experiments.

Through post-cracking bridging of the crack surfaces and tensile stress transfer, the fibres increased toughness as well as post-cracking behaviour. Results demonstrated that the positive impact of fibre addition was only found up to an optimum level, with workability being adversely affected beyond this and fibres dispersing less effectively. Consequently, an appropriate dosage of fibre was found cogent for obtaining the optimum mechanical behaviour.

Bentur and Mindess (1986). The present work highlighted the interaction between fibres and their peripheral cement matrix, considering bond strength, fibre pull-out and fibre orientation.

It further demonstrated that the fibre–matrix bond is an important parameter and can limit tensile strength, toughness, and crack resistance. Instead of immediate failure, fibres continue to transfer stresses across cracks and increase the ductility and energy absorption capacity through pull-out mechanisms. The researchers suggested that the optimum performance of the composite can be ensured only if appropriate fibre properties are selected along with the uniform distribution throughout the composite.

Swamy (1975) surveyed the state of the art and practical applications of fibre reinforced concrete, referring to fibre reinforcement as an improvement in mechanical specification. The findings of this research took into account parameters such as fibres, aspect ratio, orientation and bonding characteristics to influence the behaviour of concrete.

Through this incorporation of fibres, the research demonstrated that it has led to notable enhancement in tensile strength, flexural capacity, impact resistance and energy absorption. However, in contrast to their traditional counterpart, after cracking, conventional concrete fails by a sudden drop in load-carrying capacity to failure at the crack tip, while fibre-reinforced concrete shows gradual crack propagation with higher post-cracking performance. On the other hand, too many fibres lead to poor workability and fibre agglomeration, which deteriorate concrete quality. The researcher deduced that fibre reinforcement could be beneficial in nature of structures belonging to dynamic and extreme loadings, making them helpful with industrial floors, pavements, tunnel linings and runways of the airport.

Majumdar (1974). One of the first thorough studies on Glass Fibre Reinforced Cement (GRC), focusing on its mechanical properties and durability characteristics, was conducted. The addition of alkali-resistant glass fibres strongly enhanced the tensile and flexural strengths of cement composites.

The fibres helped to prevent any propagation of cracking by joining microcracks together and transferring stresses across the whole matrix. The study also revealed that the bond between fibres and cement paste, as well as the homogenous distribution of fibres in the composite, plays an essential role in determining GRC performance. The results demonstrated the applicability of GRC as a material for lightweight prefabricated elements, cladding sheets and architectural features.

Pilkington Brothers (1971) produced Alkali-Resistant (AR) glass fibres for use in cementitious composites, resulting in the advent of Glass Fibre Reinforced Concrete. Before this, normal glass fibres degraded too quickly in cement's highly alkaline environment for the material to be used in concrete applications.

In this regard, we addressed this issue by increasing the zirconium dioxide (ZrO_2) content of the glass fibres. This change dramatically improved the resistance of these fibres to alkaline attack, and they maintained their strength and durability even after long periods. GFRC technology saw the advent of highly flexible AR glass fibres, which had a transformative effect and opened up GFRC for widespread applications in architectural cladding, facade panels, roofing products, decorative elements and lightweight structural components.

Romualdi and Batson (1963). One of their studies was to investigate how randomly located short fibres change the fracture behaviour of most brittle cementitious materials. Experiments showed that fibres provide bridging across growing cracks, inhibiting their growth and favouring many small versus a few large cracks.

They proposed the idea of crack arrest, saying that the effectiveness of fibres in terms of controlling cracks depends very much on how they are spaced and distributed within the concrete. While the inclusion of fibre led to only a marginal improvement in compressive strength, significant increases were seen in tensile strength and ductility, as well as toughness and greater resistance to catastrophic brittle failure. This was the first initial work that paved the way for the development of Fibre Reinforced Concrete (FRC) and served as a stimulus for later investigations in this field using other types of fibres, including glass fibres.

Methodology

Abstract: The experimental method was designed to study the effects of Alkali-Resistant (AR) glass fibres on the mechanical and durability properties of concrete tiles made from M25-grade concrete. This study used a structured laboratory programme involving material characterisation, concrete mix design, specimen preparation, curing and performance evaluation.

Selection of Materials. At the first step, all constituent materials such as Ordinary Portland Cement (OPC) 53 Grade, natural river sand, crushed granite coarse aggregates, potable water and Alkali Resistant (AR) glass fibres were selected based on prevailing Indian Standards [3]. Before the materials were used for concrete production, their physical and chemical properties were fixed.

Concrete mixes of M25 grade as per IS 10262:2019 were designed to achieve control. Throughout the experiment, a water-cement ratio of 0.45 and a cement content of 415 kg/m3 were retained. Five mixes with different (0%, 0.5%, 1.0%, 1.5% and 2% by weight of cement) contents of AR glass fibres were prepared to assess the effect of fibre reinforcement on concrete properties All other mix parameters (aggregate proportions and water content) were held constant to allow for the effect of glass fibres to be understood relative to that of the known proportion of fibrous material.

The materials for the concrete batching were weighed to use and create a more accurate and stable system. The cement was added to a previously dry mixed coarse and fine aggregates. Gradual addition of water was followed while mixing in a mechanical drum mixer for continuous mixing. In the case of fibre-reinforced mixes, AR glass fibres were subsequently added to the mix during the last mixing step to ensure a uniform dispersion of fibres and avoid fibre balling.

Workability of fresh concrete was evaluated using the slump test in IS 1199 immediately after mixing. It was then poured into lubricated moulds, layer by layer. A tamping rod, as well as a vibration table, was used to compact each layer and facilitate proper consolidation of the sample by eliminating any entrapped air. Various laboratory tests were carried out through casting of cube specimens (150 × 150 × 150 mm), beam specimens (500 × 100 × 100 mm), cylinder specimens (D×H; 25×50 mm)and concrete tile specimens (300 × 300 ×30 mm).

The specimens were not disturbed for 24 h under laboratory conditions after manufacturing before demoulding. The specimens were then cured by immersion in clean drinking water for 7, 14 and 28 days. Curing was maintained such that cement hydration could occur in full, and once the tensile strength of concrete is established.

The mechanical and durability performance of hardened concrete specimens was evaluated. Cube specimens were tested in a Compression Testing Machine (CTM) as compressive strength tests. Two-point loading beams were used to obtain flexural strength and split tensile strength using cylindrical specimens. Concrete tiles were tested for various durability characteristics, including abrasion resistance, impact resistance and water absorption. The tests were conducted to examine wear and impact loading resistance in addition to water penetration through the concrete.

The microstructural characterisation of the hardened concrete was assessed through Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD). The study did not mention the applications of SEM and XRD, but it can be inferred from this that SEM was used for performing detailed studies into the fibre-matrix interface, to characterise the crack-bridging mechanism at fracture origin sites and internal morphology of the concrete;

while XRD gave identification of hydration products and crystalline phases formed in the cement matrix. The overarching aim of this series of microstructural investigations was to elucidate the mechanisms responsible for the improvements in mechanical and durability properties of glass fibre-reinforced concrete.

The global exploratory system allowed for an extensive evaluation of the influence of varying AR glass fibre contents on the new, mechanical, durability and microstructural characteristics of M25-grade concrete tiles in a controlled laboratory setting.

Results And Discussion

The experimental result of M25 grade concrete incorporating Alkali-Resistant(AR) glass fibres partially by varying percentages has been discussed in this chapter. A systematic laboratory investigation was conducted to assess the impact of fibre addition on the fresh, mechanical, durability and microstructural characteristics of concrete.

Concrete with higher fibre content had a progressively lower workability due to increased surface area of the fibres, thereby increasing the internal friction associated with fresh concrete. However, even with this reduction, all mixes were still suitable for casting with sufficient compaction.

At an optimum fibre dosage (1.0% by weight of cement), the mechanical properties of concrete improved significantly with the incorporation of AR glass fibres. The GF1. The 0 mix showed the best compressive, flexural and split tensile strengths respectively since uniformly distributed fibres bridged micro-cracks initiating around them, delaying crack propagation with a stress transfer mechanism within the cement matrix. At doses higher than this optimum, there was a slight drop in strength caused by the decreased workability of the fresh concrete, fibre agglomeration and additional voids.

The use of glass fibres also enhanced some durability properties of concrete [2, 5]. The GF1. 0 mix yielded the lowest abrasion wear depth together with minimal water absorption, showing a formation of denser and less permeable concrete matrix. Likewise, the impact resistance of fibre-reinforced concrete was also much greater than that of conventional concrete, affirming the capacity for AR glass fibres to absorb impact energy, leading to toughness improvement.

Results of the experiments were justified using Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD) microstructural studies. The supplementary material studied using scanning electron microscopy (SEM) showed dense compact internal structures, strong fibre–matrix bonding and good crack-bridging behaviour, while well-developed hydration products of the matrix at longer ages corroborated with improved performance of fibre-reinforced concrete observed in XRD analysis.

It is concluded that the experimental results show that the structure and durability of M25 grade concrete can be improved if AR glass fibres are incorporated into it in suitable proportions. Of all the contact mixtures listened to above, the GF1. Based on the overall performance parameters, 0 mix was reported with the most optimum balance between strength, toughness and workability. The results validate that the application of 1.0% Alkali-Resistant glass fibre is a rated commercial practice towards the development of high-end durable concrete tiles capable of floorings or other applications incurred during mechanical loading and wear.

CONCLUSION

This study was conducted to assess the effect of different quantities of Alkali-Resistant (AR) glass fibres on the fresh, mechanical, durability and microstructure properties of M25-grade concrete tiles. This study was conducted in a controlled laboratory environment by preparing five concrete mixes with the AR glass fibres incorporated at 0%, 0.5%, 1.0%, 1.5%, and 2.0% of the weight of cement. A range of tests like workability, compressive strength, flexural strength, split tensile strength, abrasion resistance, impact resistance and water absorption, along with microstructural studies using Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD), were conducted on the experimental programme. The experimental results of the investigations are highly indicative that the usage of AR glass fibres has a pronounced effect on the properties of concrete.

The results of workability tests on fresh concrete showed that the consistency (test after 30 minutes; Table 4) deteriorated progressively with an increase in fibre content. The slump value changed from 76 mm for the control mix to 41 mm for the concrete with 2.0% glass fibres. This decrease can be explained by the higher surface of the fibres that necessitated a larger quantity of cement paste for coating, leading to an increase in friction within the concrete constituents. An increase in fibre dosage, however, decreased workability, but all the mixes were still suitable for casting with proper compaction.

Addition of AR glass fibres with an optimal fibre dosage of 1.0% by weight of cement considerably enhanced the mechanical properties of concrete. The compressive strength corresponding to various mix designs is increased gradually from the control mix up to GF1. The 0% mix (the most relevant) had the highest 28-day compressive strength with an approximate improvement of 18.7% compared to conventional concrete (31.8 MPa). A similarly high flexibility is reached due to stronger bridging of micro-cracks and crack propagation under bending loads by the fibbers. The GF1 exhibited the highest recorded flexural strength of 4.91 MPa. 0 mix, which denotes a gain of nearly 31% over the control concrete. A similar trend was observed for the split tensile strength, and GF1. 0 mix receiving the highest value (3.24 MPa), signifying a reduction of roughly 24.6 %. AR glass fibres are found to improve load-carrying capacity, crack resistance, ductility, and post-cracking behaviour of concrete.

Studies showed that cement tiles with AR glass fibres improved their durability performance, too. Abrasion resistance increased significantly, as the wear depth reduced from 1.78 mm for the control mix to 1.32 mm just for GF1 [16]. 0 mix. This enhancement recommends that fibre-reinforced concrete has higher durability against surface wear, therefore ideal for floor and pavement applications under constant traffic. The same effect was also true for fibre-reinforced concrete, where significant increases in impact resistance were achieved due to fibre agents absorbing and redistributing impact energy to arrest catastrophic, instantaneous brittle failure. Fibres also reduce the water absorption, while 6.04% was the lowest value recorded for GF1. 0 mix. The decreased water absorption represents a compact concrete matrix with higher impermeability, which leads to better long-term durability and moisture resistance.

Microstructural investigations also reflected the observed experimental findings. The results of SEM analyses showed that a very dense cement matrix occurred along with the promoting bonding between AR glass fibres and the surrounding cement paste. These fibres successfully connected the micro-cracks and improved the integrity of the interfacial transition zone while enhancing the mechanical behaviour of concrete. XRD analysis of fibre-reinforced specimens confirmed normal cement hydration products and showed a relatively well-developed hydrated matrix. Despite not chemically being involved in cement hydration, AR glass fibres play an important role by influencing crack control and structural integrity in the cured concrete microstructure.

The results also show that it does not yield progressively improved performance in concrete as the glass fibre content is increased beyond 1.0%. Though increased fibre contents improved crack resistance, the increase in workability was accompanied by reductions due to fibre agglomeration, poor dispersion, and additional voids in the concrete. Thus, a little decrease in compressive, flexural and tensile strengths has been attained for the 1.5 % and 2.0% fibre mixes, respectively. These results indicate that high levels of fibre addition could have negative impacts on the properties and homogeneity of the concrete matrix.

Based on overall experimental work, it can be deduced that M25-grade concrete tiles fabricated with 1.0% by weight of cement content of Alkali-Resistant (AR) glass fibres display the best balance among workability/mechanical strength/toughness/ durability at normal and aggressive environments. The concrete at this dosage of fibre demonstrated the highest compressive, flexural and split tensile strength, along with better abrasion resistance, impact resistance and lower water absorption. The improved performance is mainly due to the fibres' crack-bridging mechanism, more uniform stress distribution and a denser and more homogeneous microstructure.

Word count: 250. In summary, this research has shown that AR-glass fibres can be employed to enhance the engineering performance of concrete tiles. They can be further included in an ideal quantity, since it improves the structural and mechanical properties of concrete without major alterations to conventional mixing methods. Hence, AR glass fibre reinforced concrete is proposed as a suitable material for producing high-strength concrete tiles in domestic and commercial flooring/tiling regions, along with industrial and pavement applications, where greater mechanical properties and superior durability against various factors are crucial.

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