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Study of High Strength Concrete with Addition of Discrete Fibre

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ABSTRACT : Concrete roads are among the most traditional types of roads, and they may provide a traffic flow that is both secure and unobstructed. The use of concrete in the construction of roads has resulted in a number of advantages, including a longer lifespan and less frequent maintenance. However, concrete roadways are susceptible to cracking, spalling, and the material is also poor in terms of its stress bearing capacity and ductility. In order to reduce the impact of these issues the addition of fiber may provide significant benefits on the pavement made of concrete. The purpose of this research project titled "study the high strength concrete with addition of discrete fiber". For the purpose of this study, polypropylene fiber and polyester fiber were used as the fiber of choice. M25 is the concrete mix that was utilized. The compressive strength, flexural strength, and split tensile strength of the concrete mix are all evaluated using a single specimen of the plain concrete. The second specimen had 1.8% of polypropylene fiber added to the concrete mix, and it was retested using the same three criteria as the first specimen. The third sample has 0.5% polyester fiber included into the concrete mix, and its compressive strength, flexural strength, and split tensile strength are all measured and analyzed. The fourth specimen is a test that involves the addition of 1.8% polypropylene fiber and 0.5% polyester fiber to the concrete mixture before putting it through the three standard tests. Because of the significant increase in strength, it was clear that the use of fiber could significantly enhance the quality of the concrete.

I. INTRODUCTION

The development and expansion of the nation are both significantly aided by the construction of new roads. In addition to this, highways provide access to a variety of diverse areas, including social, health, and educational services. It is anticipated that road pavements will be acceptable in terms of both their strength and their efficiency for the duration of their design life [1]. This will allow for the smooth flow of traffic to be achieved. Cracking, plastic shrinkage, and drying shrinkage are the most typical types of flaws that may occur in the pavement of concrete roads; nevertheless, there are other types of faults that can occur. Nevertheless, these issues may be completely resolved by including fibers into the concrete's mixing process. Polyester and polypropylene fiber are the types of fibers that have been included into the mixture [2]. There is a specific function that fibers provide in raising the quality of concrete. In building, concrete is hardy and adaptable. Aesthetically pleasing, it is also durable, cost-effective, and conforms to the shape into which it is set. However, history shows that without proper precautions taken throughout the design and manufacturing processes, concrete is prone to degradation. The ability to make a concrete mix within tight tolerances and knowledge of how various components affect the material's behavior are essential for this. Because of its mechanical and durability benefits over standard strength concrete (NSC), the usage of high strength concrete (HSC) is steadily rising. HSC is more economical than NSC because it allows for smaller column sizes in lower stories of high-rise structures. To put it simply, high performance concrete is a kind of concrete that is both more long-lasting and stronger than regular concrete. Typically, a super plasticizer is also used in this kind of concrete, in addition to cement elements such fly ash, Silica fume, or crushed granulated blast furnace slag. High performance concrete's fundamental characteristic is that its materials and quantities are selected precisely to have particularly suitable attributes for the planned usage of the construction, such as high strength and low permeability, making the phrase "high performance" rather pompous. Discrete fiber was used to enhance the performance of concrete pavement. Safe travel is made possible by roads. It's crucial that you maintain its long lifespan. The road surface must be strong enough to support vehicle traffic. The durability and resilience of concrete make it an attractive building material. Cement concrete, or a concrete base, is used to create the sturdy pavement. The dependable paving material makes for an effective, cozy, and cheap layout of roads and highways. As a result of its adaptability, durability, and mechanical resistance, the pavement system disperses the weight of passing vehicles evenly throughout its base. Fiber reinforced concrete (FRC) is a kind of concrete that has reinforcement fibers added to it. In recent decades, there has been a rise in interest in the use of FRC for structural

members by researchers and manufacturers alike, particularly in the area of precast components. The benefits of FRC for framed structural members have been shown by a number of experimental and theoretical studies.

II. REVIEW OF LITERATURE

Abdelmonem. et al., (2019) [3] suggested a potential step in the right direction toward protecting the environment is the recycling and use of waste rubber as a substitute for natural aggregate in concrete. The goal of this study is to determine the efficacy of using recycled rubber as a partial replacement for fine aggregate in high-strength concrete. In each of the four different mixes that were made, either zero, ten, twenty, or thirty percent of the fine aggregate was substituted with crumb rubber. Slump, tensile strength, compressive strength, flexural modulus, density, abrasion resistance, saltwater influence on rubberized concrete, impact resistance, and micro structural analysis were some of the characteristics that were analyzed. The rubberized concrete mixes demonstrated excellent workability and had a density that was somewhat lower than that of the control mix. When the rubber component was increased up to 30 percent, there was a discernible drop in compressive, tensile, and flexural strength of approximately up to 50 percent. When the percentage of rubber in the material was increased, the abrasion resistance decreased. The rubberized concrete mixtures performed well in the saltwater environment. When compared to the control mix, the rubberized concrete mixtures demonstrated up to 83% greater impact resistance. The results of this research provide an overall picture of what happens when recycled rubber is mixed in with high-strength concrete.

Al-shamiri. et al., (2019) [4] suggested the compressive strength of concrete is a prominent and significant mechanical characteristic of concrete that is regarded to be one of the main factors in a variety of design codes and standards. It is possible to reduce the amount of time and money spent if an early and precise estimate is performed. The compressive strength of high-strength concrete (also known as HSC) was estimated using the use of extreme learning machine (ELM) in this particular research project. ELM is a relatively recent approach for training artificial neural networks (ANN), and it demonstrates both strong generalization performance and quick learning speed across a wide variety of regression applications. In order to create the ELM model, 324 data records were used from various laboratory investigations. The strength under compression was modeled as a function of five input factors, including water, cement, fine aggregate, coarse aggregate, and super plasticizer. It was determined whether or not the performance of the newly built ELM model was superior to that of an ANN model that had been trained using the back propagation (BP) approach. The findings of the simulation indicate that the ELM model that was suggested has a significant amount of promise for making accurate predictions about the compressive strength of HSC.

Zheng. et al., (2020) [5] evaluated that polyethylene terephthalate (PET) fiber-reinforced polymer (FRP) composites have garnered an increasing amount of interest due to their ecologically favorable origin. These composites are created from recycled PET goods and display significant rupture strain (LRS). One potential use for these fibers is in the construction of concrete walls and other structures. However, there hasn't been a lot of research done on the subject, notably concerning the stress-strain behavior of PET FRP-confined concrete. The goal of this study is to fill this informational void by reporting the findings of a laboratory experiment on the stress and strain behavior of normal, high, and ultra high-strength concrete cylinders contained inside PET FRP. It has been found that the stress-strain behavior of confined high-strength (and ultra high-strength) concrete specimens exhibits strain hardening-softening-hardening, while the stress-strain behavior of confined normal-strength concrete specimens typically exhibits a monotonic rising behavior. This was learned by contrasting the two sample kinds. In addition, an inflection point may be seen in the usual axial strain-hoop strain curve seen in all PET-restricted concrete grades. After that, based on a comprehensive examination of experimental data for PET FRP-confined normal-, high-, and ultra high-strength concrete, a novel design-oriented stress-strain model is offered. The research results informed this model. By comparing model predictions with experimental results, it is shown that the proposed model provides reliable predictions for PET FRP-confined concrete.

Qi et al., (2021) [6] provided the binding behavior of reinforcing bars in UHPC was studied via a series of pullout tests, both experimentally and theoretically. The diameter of the bars, the length of the embeds, and the depth of the concrete all played roles in the tests. The mechanism of failure, fracture pattern, and load-slip response were documented and analyzed over a range of test conditions. The results of the tests showed that the bond strength was reduced because of insufficient concrete cover depth and concrete cone failure due to short embedment length. As the concrete cover depth grew from 0.5d to 2d, the bond strength improved by as much as 229.8 percent and the pullout energy grew by as much as 401. It was suggested that the development times be 6d and 8d, or 2d and 1.5d for concrete cover depth and length, respectively. By comparing the theoretically computed values with the actual test results and 343 test data acquired

from the literature, a theoretical bond strength model was constructed utilizing the fiber-matrix discrete idea and verified. Standard deviations of 0.255 and 0.252 were observed when comparing computed findings to test results and collected data, respectively.

Keke et al., (2022) [7] a rheology pre-control technique, improve the rheological characteristics of UHPC. After the UHPC has been formulated, it is thoroughly tested for its rheological characteristics, mechanical strength, and microstructure. Bentonite's ability to control UHPC's rheological characteristics was shown by the study's findings. Specifically, the flowability of the UHPC slurry decreases by 55.71 percent as the bentonite content rises from 0 to 15.0 weight percent, while the static yield stress, dynamic yield stress, plastic viscosity, and thixotropy all increase by approximately 17.05, 5.57, 1.16, and 0.04 times, respectively. UHPC flexural strength has the potential to grow by as much as 60% if the matrix's rheological characteristics can be optimized to enhance the orientation and distribution of the used steel fibers. The microstructure study also shows that the ideal amount of bentonite was used, which helped the UHPC composite achieve a substantially denser structure.

Bashar et al., (2023) [8] examined that UHPC's flexural/ tensile characteristics are determined by the individual contribution of discrete fibers. This means that under a constant pressure, the creep of UHPC is determined by the creep of individual fibers while being pulled out. The pull-out creep of a single steel fiber has received surprisingly little attention. To fill this knowledge gap, this study examines the effects of fibre embedment length, fibre embedment angle, and sustained load on pull-out creep. Results reveal that hook-end fibers' pull-out creep is not noticeably affected by variations in embedment length. Concrete failure at the loading end often happened under prolonged stress, and the inclination angle played a key influence in this. Consequently, the angle of the fibre inclination for concrete fracture under a sustained load had an effect on the pull-out creep. Finally, the load-induced increase in fibre pull-out creep was anticipated.

You et al., (2023) [9] studied that a potential cementitious composite, ultra-high-performance concrete (UHPC) may be used to make lightweight, high-performance buildings. UHPC relies on steel fibers, a costly constituent material, to avoid brittle failure, but this also limits the material's widespread use. The high cost of UHPCs and the difficulties in disposing of waste GFRP composites are both addressed by the proposal proposed in this research, which is to make UHPCs reinforced with macro fibers produced from waste GFRP composites. The impact of macro fiber addition on UHPC qualities has been studied via a battery of experiments. Incorporating macro fibres resulted in a loss of workability and a drop of up to 21.8% in compressive strength, but a significant improvement of up to 27.9% in flexural strength and 46.9 times in flexural toughness, as shown by the results of the tests. Inverse analyses were used to transform the data from the bending tests into a tensile constitutive relationship. An efficient routine to valorize the waste GFRP is established, and the cost of UHPC with qualities equivalent to UHPC with steel fibres is reduced thanks to the suggested approach of making UHPC with recycled macro fibres.

III. PROBLEM STATEMENT

Fibres are often added in order to stop cracking in the concrete that is brought on by the plastic's shrinking. The incorporation of discrete fibers into concrete applications results in improvements to the material's flexural capacity, tensile strength, toughness, fatigue resistance, ultimate strain, and impact strength, as well as a reduction in the crack width and necessary thickness. In general, high-strength concrete, often known as HSC, will have a high cementitious quantity but a low water binder ratio. Nevertheless, this would result in significant alterations to the volume of the concrete, which in turn would have an effect on the growth of its strength. In addition to this, the brittleness of HSC was found to be exacerbated when silica fume was utilized as a partial substitute for cement in order to obtain high strength.

IV. RESEARCH METHODOLOGY

There are a variety of different ways that the FRC may be mixed. The fibers in the mix should be dispersed in an even manner so as to prevent the fibers from being clumped together or separated in any way when the mix is being created. The majority of balling takes place over the course of the fiber inclusion process. The balling affinities will increase with a higher aspect ratio and capacity percentage of fiber, as well as with a larger size and quantity of coarse aggregate, while the workability will decrease. It has been shown through experience that a water cement ratio of between 0.4 and 0.6 and a minimum cement concentration of 400 kg/m are necessary in order to cover the enormous surface area of the fibers with paste. In comparison to ordinary concrete, fiber-Ferro concrete mixes often have a

greater cement factor, a higher fine aggregate content, and coarse aggregates of a smaller size. The process of uniting a fiber mix often requires more vibration than just the fibers themselves. When trying to avoid fiber segregation, external vibration is preferable. Polishing the surface often involves the use of metallic trowels, tube floats, and spinning power floats. The accumulation of fibers in concrete has an effect on the mechanical characteristics of the concrete, which in major part are determined by the kind and proportion of fiber. It is possible to use the same tools and process that are used when working with regular concrete. The flexural test, the compressive strength test, and the split tensile strength test are the ones that need to be completed. Each of the tests was performed on a group of four specimens representing the respective combination. The tests will be conducted using polyester and polypropylene as the fibers of choice. The grade of concrete that was used was M25 grade. One of the specimens will be regular plain concrete, another will have 0.5% polyester added to it, another will have 1.8% polypropylene added, and the last specimen will have a combination of both types of fibers. The mechanical qualities of each of these specimens are being evaluated side by side. The common Portland cement that was used in each and every composition. Figure 1 depict the flow chart of the process as shown below.

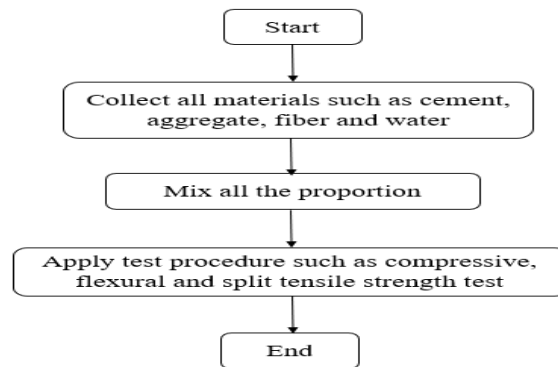


Figure 1. Flow chart

1.1 MATERIALS

The following ingredients are required for a successful batch of Fiber Reinforced Concrete:

1. Cement: In this test Khyber cement Grade M53 OPC is used. A paste is generated when water is added to it, and this paste eventually becomes hard. This grade of cement is used for specialized construction projects, including runways, concrete highways, bridges, and other RCC works where the grade of concrete is M25 or higher. Other applications include pre-stressed concrete components, precast items such as paving blocks, building blocks, and so on, and other RCC works.

2. Aggregates: One of the essential components of concrete, aggregates are which give the substance its body and also help to prevent it from expanding. The aggregate in a good concrete mix has to be pristine, inflexible, and powerful. Fine Aggregate and Coarse Aggregate are the two most common forms of aggregates that are used.

- **Fine Aggregate:** These are particles with a diameter of less than 9.55 mm, such as sand or crushed stone. The fine aggregate was sand. To increase uniformity and workability, fine aggregate is used. The fineness modulus is a measure of the average grain size of sand. Sand has a fineness modulus that may be ranging from 2.0 to 4.0.

- **Coarse aggregate:** These are particles that are larger than 9.55 millimeters in size. This study makes use of a coarse aggregate that is 20 millimeters in size.

3. Fiber: Polyester and polypropylene were the types of fibers that were used for the test. These fibers feature a surface that is resistant to water. When used as reinforcement, these fibers reduce the permeability of concrete, improve its resistance to shrinkage, and restore both its compressional and tensile strengths.

4. Water: It is important that the water that is utilized be devoid of any contaminants so that it does not have an effect on the mixture. If the water includes a significant number of chlorides, there is a possibility that efflorescence and dampness may be produced. Therefore, the water that was used had a pH value of 7.0 and was completely devoid of salts.

4.2 Test procedure

- **Compressive strength test**

In the present study, cubes were cast, and the dimensions of those cubes were determined to be 150 millimeters on all sides. Only a typical concrete mix designed with an M25 mix ratio was created for the first mold. The second cube was made with the addition of 1.8% polypropylene fiber, and it had the same dimensions as the first cube. The third cube

was manufactured using the mix design with the addition of polyester fiber at a percentage of 0.5%, and the final cube was constructed using the same mix proportions but with the addition of polypropylene fiber and polyester fiber at the same percentages of 1.8% and 0.5%, respectively. After that, these testing specimens were positioned into the gap between the bearing surfaces. The loading is delivered to the specimen in an axial direction without producing any shock, and the rate of increase is set at 140 kilograms per square centimeter per minute. until the specimen reached its lowest point. After a certain point, the specimen begins cracking as a result of the continuous application of stress, and this is followed by the eventual failure of the specimen.

● **Flexural strength test**

Beam samples with dimensions of 100 x 100 x 500 millimeters were produced in order to assess flexural strength. The flexural strength of these specimens was evaluated using a universal testing machine and was subjected to four-point loading in accordance with I.S. 516-1959. In order to carry out this test, the necessary pieces of equipment are a mold in which the specimen will be cast, a tampered rod for the purpose of tamping, and a flexural testing machine. In order to prepare the test specimen, the mold was filled with concrete in three roughly equal levels. This created a consistent layer thickness across the specimen. Only a typical concrete mix designed with an M25 mix ratio was created for the first mold. The first cube's proportions were carried over to the second cube, which was manufactured with the addition of 1.8% more polypropylene fiber based on its total weight. The mix design was used to produce the third cube, which included the addition of polypropylene fiber at the same proportion (1.8%) and the addition of polyester fiber at the same percentage (0.5%). The finished cube was made by applying the mix design to the preparation process, with the inclusion of both kinds of fiber at the same amount (1.8% and 0.5%). The sample to be tested was properly centered inside the machine, and its longitudinal axis was aligned to be perpendicular to the rollers. In the case of specimens produced via molding, the direction of mold filling must be perpendicular to the loading direction. The load was applied at a rate of 180 kilograms per minute for the specimens measuring 10.0 centimeters.

● **Split tensile strength**

The sample for this test is a cylinder that is 15 centimeters in diameter and 30 centimeters in height. The mold that was utilized is made of metal, and its height is 30 +/- 0.1 cm while the mean interior diameter of the mold is 15 cm 0.2 mm. Before they were used, the molds were given a coating of mold oil in the form of a thin layer to prevent the concrete from sticking to them. Each of the four different concrete mixes was layered into the molds to a depth of roughly five centimeters. Each layer was then crushed using either the hand or a machine. After the last layer was packed down, the concrete was smoothed out with a trowel until it was flush with the top of the mold. A metal plate was placed over the mold thereafter to contain any leaking water. The test samples were kept in a refrigerator at 27 degrees Celsius (give or take two degrees) for 24 hours. After a while, samples were taken out of the molds and immersed for 28 days in sterile water. The water was changed out once a week for a new supply. After curing, the surface water was removed, and diametrical lines were drawn with a marker to ensure that both ends of the specimen were at the same axial position. This was done to ensure that the specimen was in the correct orientation. Following that, the dimensions of the specimen were determined.

V. RESEARCH OBJECTIVE

- To compare the changes in strength in concrete with and without fiber.
- To study the variation in compressive strength in concrete pavement with the incorporation the mixture of different amounts of polypropylene and polyester fiber.
- To study the changes in tensile strength in concrete pavement with the addition of mixture of different amounts of polypropylene and polyester fibers.

VI. SCOPE OF THE STUDY

Concrete pavements can be enhanced stronger by including steel fiber, polypropylene fiber, or synthetic fiber. The unique qualities of each fiber may improve the material's performance in concrete. The performance of ductility, tensile strength, fatigue strength, impact strength, and eradication of temperature and shrinkage fissures are all improved by the addition of fibers. The benefits that fiber brings to concrete include a rise in ductility, the suppression of cracking, and the absorption of impact energy.

VII. EXPECTED OUTCOME

The compressive strength, flexural strength, and split tensile strength of conventional concrete mix will be lower, and increasing the proportion of polypropylene and polyester in the mix will result in an increase in the concrete's overall strength. The incorporation of polyester fiber into concrete has the potential to result in a substantial increase in the material's strength.

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