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Effect of polyester fiber on compressive strength and split tensile strength properties of high strength concrete

Mohsin Ali [a], Aneel Kumar [b, *], Samar Hussain Rizvi [b], Naraindas Bheel [c]

[a] *Graduate School of Urban Innovation, Department of Civil Engineering, Yokohama National University, Kanagawa, 240-8501, Japan*

[b] *Department of Civil Engineering, Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan*

[c] *Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, Tronoh, 32610, Bandar, Seri Iskandar, Perak, Malaysia*

[*] Corresponding author: Aneel Kumar, Email: aneel.kumar@faculty.muet.edu.pk

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ABSTRACT

High strength concrete (HSC) is essential for large-scale projects, such as bridges, dams, and high-rise buildings, as it allows for reduced dimensions of beams and columns. This experimental study investigates the effect of polyester fiber on the compressive and split tensile strength properties of HSC grade C60. A total of 90 concrete mixes were prepared, incorporating polyester fiber at varying volumes of 0%, 0.2%, 0.3%, 0.4%, and 0.5%, with curing periods ranging from 3 to 28 days. The results demonstrate that the inclusion of polyester fiber significantly enhances the mechanical properties of HSC, with optimal compressive strength achieved at 0.3% fiber content, leading to a 14.17% increase compared to the control mix. Additionally, split tensile strength improved by 40.63% at 0.2% fiber content and by 65.68% at 0.3% fiber content. Although the slump decreased by 14% to 57% with increased fiber content, no bleeding or segregation was observed in any of the mixes. These findings underscore the potential of polyester fiber to improve the performance of high strength concrete in structural applications.

1. Introduction

The construction industry extensively uses high strength concrete (HSC) due to its superior engineering properties and economic advantages over standard concrete. It is used for longer span bridges and wider underpass clearance widths, preventing the unacceptably massive columns on the lower floors of high rise buildings. Furthermore, it allows for lower, lighter bridge piers by reducing the dead weight on bridge girders. Without reducing the number of lower floors, it also increases the number of possible stories[1]. The implementation of HSC has resulted in significant cost reductions in bridge maintenance and an extension of the usable lifespan of the bridges[2]. Moreover, HSC has a consistently high density and remarkable impermeability, enhancing its ability to withstand harsh environmental conditions and deteriorating agents. This characteristic contributes to the long lasting nature of concrete constructions and structures[3].

High strength concrete was mainly developed to focus on the issue of low compressive strength in conventional concrete. Over time, the technology behind HSC has advanced, resulting in concrete development with increasingly higher strength levels. A lowered w/c ratio, typically in the limit of 0.22-0.35, is necessary to build high strength concrete [4]. By using a particular additive that enhances workability and controls the heat of hydration, which leads to cracks in concrete, achieving high strength in HSC by reducing the amount of water is frequently possible. However, the lower water/cement ratio results in less porosity, making HSC more brittle and decreasing its tensile and flexural strengths compared to NSC[5]. Due to its low tensile strength and constrained ductility, high strength concrete is, by its very nature, a brittle material. High strength concrete increases overall strength while reducing permeability. High strength concrete is typically used to improve the flexural strength, elastic modulus, tensile strength, and durability of concrete. Concrete is a building material that is inherently weak in tension and often experiences the formation of cracks for several reasons, such as plastic and hardened states, drying shrinkage, and other related causes. The waterproofing properties of concrete are sometimes damaged due to the formation of fractures over time and under stress, which subsequently expose the interior to corrosive elements such as moisture, bromine, acid sulphate, and others. The concrete deteriorates because of exposure, and the reinforcing steel corrodes. A mitigation mechanism has been implemented to incorporate discrete fibers into the concrete mixture to prevent the possibility of cracks. The homogeneous distribution of fibers throughout the concrete in all directions is attributed to the mixing action. The evenly dispersed fibers in the fresh concrete reinforce the development of plastic shrinkage fractures. When the concrete has hardened, evenly distributed fibers slow the spread of microcracks, reducing the chance that they will grow into macrocracks and cause other problems[6, 7]. Furthermore, these fibers connect and subsequently strengthen the pre-existing macrocracks, enhancing the structural integrity of the concrete and preventing its deterioration. The most famous textile fibers used in the concrete industry are natural fibers like hemp, jute, bagasse, sisal, and coconut, as well as synthetic fibers like steel, glass, carbon, polyethylene, polypropylene, polyvinyl alcohol, rubber, and nylon[8-10].

Polyester fiber is one of the most widely used synthetic fibers and is highly resistant to environmental degradation due to its high modulus and melting point [11]. It is commonly used to manufacture textile products for the house and clothes, and numerous other applications. Polyester fiber benefits include low cost, simple processing, simple mixing, and natural fibers like cotton, which have excellent heat and light resistance, breaking solid strength, and elastic modulus. In 2021, the production of this synthetic fiber exceeded a significant quantity of eighty eight million tons, indicating an increasing rate above that of all other synthetic fibers [12-14]. To conserve resources and maintain environmental sustainability, various types of fibers present in the environment must be used in concrete matrices, especially to improve mechanical qualities and thermal resilience. However, polyester fiber, derived from cotton, demonstrates superior performance compared to polyethylene, establishing it as an excellent option for reinforcement applications. Most studies focus on using these fibers for reinforcement in concrete, asphalt, and polymer fabrics, among other applications[15, 16]. This study investigates the incorporation of polyester fibers and calcium lignosulfonate as additives that enhance the fracture resistance of asphalt concrete tested under a freeze thaw environment[17].Based on the experimental results, the asphalt concrete's fracture toughness and energy absorption were enhanced by adding calcium lignosulfonate and polyester fibers compared to the normal specimen. An additional investigation analyzed the mechanical properties and resistance to cracking of steel slag/polyester fiber permeable bitumen at low temperatures environments. The purpose of this study was to clarify the mechanisms that improve the composite's resistance to thermally induced cracking and, consequently, its performance in cold environments. The study aimed to optimize the material's overall stability and performance under extreme environmental conditions by analyzing the interactions between the steel slag and polyester fibers within the bitumen matrix[18]. Also, this study investigated the mechanical characteristics of a hybrid fabric made from cotton and reinforced with waste polyester fibers [19]. In order to improve its mechanical properties, Thermoset epoxy resin was reinforced with cotton and polyester filaments derived from pre-consumer textile waste. The study evaluated the influence of these fibers on thermal stability, impact resistance, and tensile strength. Further, it conducted an analysis of the interactions between fibers and matrixes to promote the management of sustainable materials[20]. This study examines the influence of an elevated fiber volume fraction on the mechanical properties of polyester/epoxy and cotton/epoxy composites. The abrasive wear properties of a composite made of polytetrafluoroethylene (PTFE) particles and multilayer interlaced polyester fibers have been thoroughly investigated. The objective of the research is to clarify the interactions between these components and their impact on the composite's wear resistance and durability[21]. The investigation focused on analyzing the mechanical properties of a cement concrete road overlay material modified with polyester fiber and SBR latex compound. The objective was to address the issues of brittleness and subpar dynamic performance often observed in cement concrete overlays used in pavement applications[22]. The ultrahigh molecular weight polyethylene reinforcement was achieved by creating innovative multilayer directional composites that utilize various polyester fiber orientations[23]. The results suggest that the friction coefficient is reduced, and the ultimate flexural strength of the composites is substantially improved by incorporating polyester fibers. The improvement in flexural strength indicates that the composites are more suitable for demanding applications due to their increased load-bearing capacity and structural integrity. The durability and durability of the composite materials can be improved by changing operating settings due to the decreased friction coefficient, which suggests reduced wear and improved wear resistance. Overall, these results emphasize the advantageous role of polyester fibers in enhancing the mechanical properties of composite materials. Therefore, it can be inferred that waste polyester fiber has favorable properties as a reinforcing agent, warranting further investigation into its potential application in enhancing the strength of waste plastic materials. In contrast, the study explored the influence of high-volume fly ash (HVFA) and polyester fibers on concrete's properties while also thoroughly investigating the relevant engineering factors. To provide insights into optimizing the composite material properties for better structural applications, this study sought to evaluate the influence of polyester fibers on the mechanical performance, durability, and workability of HVFA concrete mixes M25, M30, and M35[24]. Another study investigated the compressive strength of M25 concrete manufactured using a combination of polypropylene fiber at 1.8% and polyester fiber at 0.5%[25]. Furthermore, the study examined the strength characteristics of M30 concrete using various proportions of fly ash (10%) and polyester fiber (0%, 0.025%, 0.05%, 0.075%, and 0.1%)[26].Overall, while previous research has investigated the inclusion of polyester fibers in conventional concrete and these influences on the compressive and tensile strength properties of HSC, this study aims to address a significant gap by developing a mix design for HSC using locally sourced materials and high range water reducers.

This research aims to evaluate the potential of HSC to enhance strength by incorporating polyester fibers at varying weight percentages of 0.2%, 0.3%, 0.4%, and 0.5%. The C60 concrete grade serves as a reference to ensure that the research objectives are effectively achieved.

2. Experimental Setup And Methodologies

2.1 Experimental Programs

In this study, local materials were utilized to develop HSC. For casting concrete specimens is a local ordinary Portland Type I power-53 grade cement, locally available sand fineness modulus of 3.15 (Bholari/Jamshoro area), aggregates with a maximum size of 20 mm were used for the development of target high strength concrete C60. The source of the water was the tap water system. During mixing operations, a high range water-reducing ingredient (superplasticizer) was added to make concrete more workable[27, 28]. Cotton is used to make polyester fiber, commonly available in Pakistan. Compared to other fibers, using these fibers will be low-cost and available in the market. The polyester fibers used in this study were obtained from Bhanero Textile Mill Limited, a company located in Kotri, Sindh Province, Pakistan. The fiber size of 32mm, 1.29g/cm —-3 density and water absorption of 3.27% are used because of its local availability and other physical properties [29] as shown in Fig. 1.

Table 1 shows the cost analysis of different fibers polyester fiber, steel fiber, glass fiber, poly vinal alcohol fiber and polypropylene used in the construction industry for different projects.

Table 1

Cost analysis of fibers

Materials	Cost ($/Kg)	References
Polyester fiber	0.089	This study
Steel fiber	0.95-3	[13][34][35]
Glass fiber	0.5=2	[13][34][36]
Polypropylene fiber	07-3	[13][34][36]
Polyvinyl alcohol fiber	20-25	[36]

Fig. 1. Local Raw Materials For High Strength Concrete

According to the mix design, concrete cubes with dimensions of $100mm \times 100mm \times 100mm$ and dimensions of cylinders 100mm in diameter and 200mm in height were cast and stored in water tanks for curing. A total of 45 cubes and 45 cylinders were subjected to testing. The cubes achieved the desired strength specified by the mix design within a curing period of 28 days. A high-strength concrete (HSC) mix was developed to achieve a compressive strength of 60 MPa at 28 days, with a slump range of 75 to 180 mm. The water-to-cement (w/c) ratio was set at 0.33, and the final mix proportions were established at a ratio of 1:1.48:2.0 (cement: fine aggregate: coarse aggregate). A superplasticizer was added at a fixed dosage of 1.2% (by weight of cement) to enhance workability. The concrete was mixed using a mechanical mixer, utilizing the specific materials detailed in Table 1. To effectively satisfy the project's requirements, this detailed design assures that the desired strength and workability are achieved[29]. Four mixtures were prepared with different percentages of polyester fiber by cement weight in HSC, ranging from 0.2%, 0.3%, 0.4%, and 0.5%) to investigate its effect on the compressive strength and split tensile strength.

Table 2

Detail of mix proportions of high strength concrete (HSC+Polyester fiber)

Polyester Fiber Content (%)	Cement $(\frac{kg}{m^3})$	Fine Aggregate $(\frac{kg}{m^3})$	Coarse Aggregate $(\frac{kg}{m^3})$		Admixture	w/c ratio
			20mm	13mm		
0(HSC)	480	710	392	588	1.2%	0.33
0.2	480	710	392	588	1.2%	0.33
0.3	480	710	392	588	1.2%	0.33
0.4	480	710	392	588	1.2%	0.33
0.5	480	710	392	588	1.2%	0.33

2.2 Manufacture Of The Concrete Specimens And Curing

Fig. 2 shows the flow chart of the entire raw material and HSC concrete mixing process. HSC was developed using local constituent materials without adding polyester fibers. To incorporate the polyester fiber into a control mix of HSC, the following procedures were carried out. First, the sand and gravel were combined in a concrete mixer and allowed to dry for one minute. Then, the cement was added and mixed dry for an additional minute. The third stage was to add the mixing water gradually continuously mixing for another two minutes. After which, the specified number of fibers was distributed and mixed for 3 min. Fibers were added in small increments to avoid fiber balling, leading to homogeneous material consistency and increased workability. The inside surfaces of the molds used to cast the samples were cleaned completely and covered with a release agent to make demolding simple and preserve the quality of the cast specimens. A tamping rod is used to compact each layer of concrete 25 times after it has been filled into two-layer cubes and three-layer cylinders. Cubes of size $100mm \times 100mm \times 100$ mm and cylinders of length 100mm diameter and 200mm height were cast. After 24 hours, the specimens were removed from molds and put in water for curing until 28 days at 23.8°C. After the curing period, the specimens were removed and stored at ambient temperature until the strength testing tests were performed.

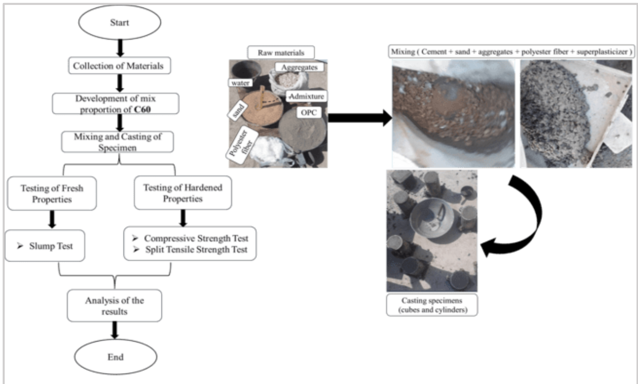

Fig. 2. Experimental procedure for High Strength Concrete

2.3 Test methods

A compressive strength test was performed on 45 standard cubic concrete specimens by ASTM C39-20. At a rate of 0.3 MPa/s, the cubes were subjected to a testing apparatus under stress control until failure occurred[35]. To evaluate the splitting tensile strength, 45 more cylindrical concrete specimens were tested using the ASTM C496 standard [36].

Table 3

Experimental Results of Strength Properties in Control and Fiber-Reinforced Mixes

Fiber content (%)	Compressive strength (MPa)			Splitting tensile Strength (MPa)		
	3 Days	7 Days	28 Days	3 Days	7 Days	28 Days
(HSC)0 %	48.31	51.49	63	3.18	3.45	4.16
0.2 0 %	52.75	53.95	67.13	3.44	3.77	5.85
0.3 %	56.37	57.83	71.93	3.69	3.81	6.89
0.4%	54.62	59.48	70.19	3.84	3.98	6.12
0.5%	53.19	55.69	68.28	3.94	4.86	5.39

However, according to ACI Committee 544.2R, fiber reinforced concrete should be tested[37].In addition, past research has demonstrated the suitability of the ASTM C496 test for the assessment of reinforced concrete samples[38]. In the experiment, the load applications were carried out steadily and gradually, without sudden shock, at a consistent rate of 900 kPa per minute. This was done to measure the splitting tensile stress of the specimens until they reached failure.

3. Results And Discussion

3.1 Slump Test

The workability of concrete was characterized by its slump. It is essential to acknowledge that the composition ratios of the reference and control concrete mixtures, precisely the amounts of cement, aggregates, superplasticizers, and water, were constant throughout the study.

The relationship between polyester fiber and the workability of HSC is illustrated in Fig. 3. The control mix, which did not contain polyester fiber, exhibited the highest recorded slump in value. The slump value decreased from 178, 153, 127, and 102 to 76mm by adding polyester fiber at 0, 0.2%, 0.3%, and 0.4% to 0.5%, respectively. The slump was reduced more as the proportion of polyester fibers in HSC increased. It has been noted that using fiber (0.2 to 0.5%) reduces the workability of HSC between 14% and 57%[29]. With the addition of fibers, conventional concrete also showed a similar trend of decreased slump[12], [39]. Due to the significant increase in frictional resistance created between polyester fibers and the concrete particles by the HSC control mix, the workability of the concrete decreases with an increase in polyester fiber. Depending on the particular needs of the project, a variety of techniques should be used to reduce slump and loss of workability when adding fiber content to concrete. One of the best ways is to change the dosage of superplasticizer, but other important elements include the water-to-cement ratio, the type of fiber, the mix design, and the usage of additives such as VMAs. The practical optimization of fiber-reinforced concrete mixes should be guided by a careful balance between fiber content, workability, and concrete performance (strength, and durability). The workability and homogeneity of fresh concrete mixtures containing steel fibers are greatly influenced by the fiber's geometrical properties, aspect ratio, and concentration. It was also observed that, like industrial steel fibers, the shape of recycled steel fibers has an impact on the uniform fiber dispersion and workability of concrete. In the literature, the word "balling" refers to the tendency of steel fibers to interlock during mixing, which has been recognized as another possible issue for the decline in workability of recycled steel fiber concrete[31-33, 40]. One of the main causes of the balling effect in fresh concrete was found to be the irregular size and form of recycled steel fibers. Workability and balling effect issues in recycled steel fiber concrete can be resolved by increasing the amount of superplasticizer, altering the mixing process, and lowering the component ratio and amount of recycled steel fiber. To prevent the balling effect, some suggestions were offered, such as adding recycled steel fiber gradually while mixing and scattering it after wetting all the ingredients in a forceful action mixer [35, 39, 40].The strength increases and slump reductions shown in fiber-reinforced concrete (FRC) with a low water-to-cement ratio have significant ramifications for practical uses such as infrastructure projects and high-rise building. Using superplasticizers can help to counteract the reduced droop, which is a sign of lower workability and could cause problems during placement. When slump is reduced in high-rise construction, segregation resistance is improved and problems like bleeding and honeycombing are avoided because the concrete stays consistent when pumped to high elevations.

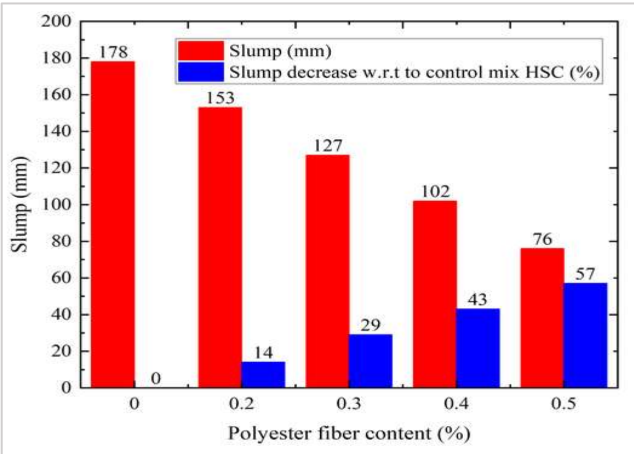

Fig. 3. Effect Of Polyester Fiber On Slump Of HSC [29]

3.2 Hardened Properties

Table 2 compares control mixes with and without the addition of polyester fibers to evaluate high strength concrete's compressive strength and split tensile strength. The results indicate the influence of fiber reinforcement on the mechanical properties of the concrete matrix, emphasizing the differences in tensile performance and overall structural integrity. This analysis facilitates a better understanding of how effectively polyester fibers enhance the strength of high strength concrete mixtures.

3.2.1 Compressive strength

The effects of polyester fiber on cubical compressive strength were investigated by adding the control mix.

The strength of high strength concrete was assessed at curing intervals of 3, 7, and 28 days. Overall, the strength of HSC increased as the amount of polyester fiber increased, starting with dosages of 0.2% to 0.5% for C60 grade concrete. According to the experimental results presented in Table 2, the initial strength effectiveness of 40.63% was seen at 0.2%, and 65.68% was increased at 0.3% of polyester fiber. However, the cohesiveness of the concrete matrix can be compromised as the fiber content increases, resulting in a decrease in strength. This phenomenon occurs due to excessive fibers disrupting the bonding between cement particles and aggregates, forming voids or weak points within the matrix. Consequently, the advantages of fiber reinforcement may be negated, reducing the overall structural integrity[42-46, 44]. So, balancing the fiber content to maximize performance while preserving the concrete's intended strength properties is essential. This investigation showed that adding polyester fiber in varying proportions and under different curing durations enhanced splitting tensile strength compared to the control mix of HSC (C60). It shows that the increase in splitting tensile strength is caused by the improvement of compressive strength carried on by adding filler components. The internal structure of the concrete is improved by the finer particle sizes, which contribute to increased performance and strength by enhancing packing density and microstructure. This improvement in particle size enables improved particle interlock and reduces gaps, resulting in a more durable and homogeneous concrete matrix. Therefore, these enhancements lead to an increase in the concrete's overall durability and mechanical properties. The observed behaviour led to a decrease in the number of voids in the interfacial transition zone between the concrete and the matrix. Improved overall strength and durability result from this gap reduction, which strengthens the bond between the matrix and aggregates[45]. The structural integrity of the concrete is enhanced by a denser interfacial transition zone, which reduces potential points of failure and problems [35-37].

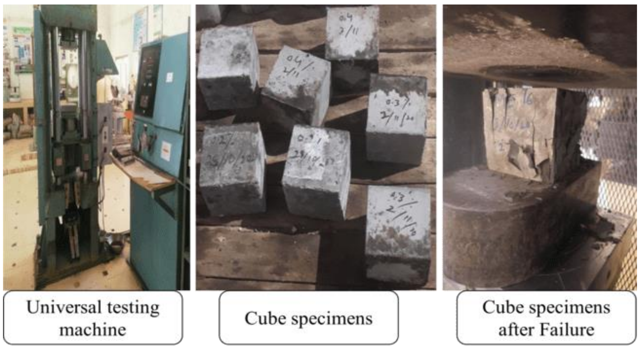

Fig. 4. Setup Compressive Strength Of High Strength Concrete

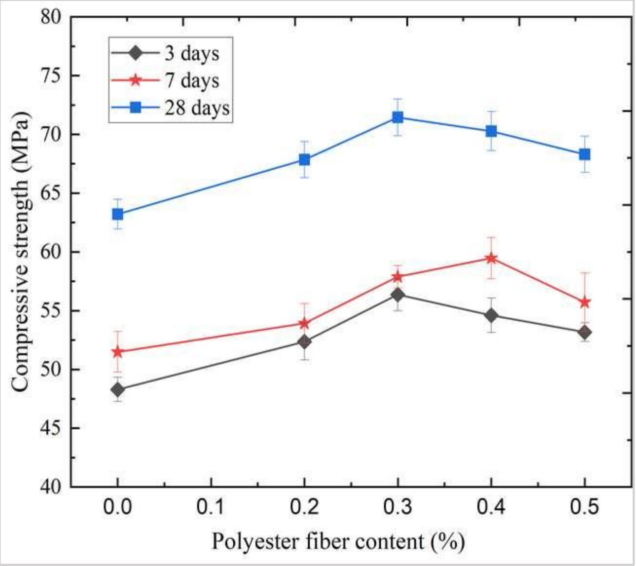

Fig. 5. Results Of Compressive Strength Of High Strength Concrete

Fig. 4 and 5 show the setup of compressive strength and results of the compressive strength of the control mix of HSC was 63 MPa and polyester fiber HSC showed an improvement at each volume fraction, which supplied an improvement. The improvement, as demonstrated by the strength effectiveness in Table 2, was 6.66% at the 0.2% fraction, 14.17% at the 0.3% fraction, 11.41% at the 0.4% fraction, and fell to 8.38% at the 0.5% fraction, a minor reduction compared to the maximum improvement at the 0.4% fraction. The compressive strength gain varied from 14.17% to 11.41% at volume fractions ranging from 0.3% to 0.4%, equivalent to improvements ranging from 4.3 to 10.4% for normal strength [25, 26, 50].

3.2.2 Split tensile strength

The setup and development of splitting tensile strength of HSC with the addition of Polyester fiber, as shown in Fig. 6 and 7, compared to the control mix of HSC. The splitting tensile strength development of HSC versus the addition of polyester fiber in control mix HSC was determined by varying percentages of polyester fiber at the curing times of 3 days, 7 days, and 28 days in C60 grade, then the strength of HSC improved with increasing the percentages of polyester fiber. Based on experimental data summarized in Table 2, the initial effectiveness of strength at 40.63% was seen at 0.2%, and 65.68% was increased at 0.3% percent of polyester fiber. Fiber content significantly impacts the tensile strength of concrete, as it is essential for optimizing structural performance. The incorporation of fibers prevents the propagation of fractures and maintains the structural integrity of the concrete by bridging them as they form, thereby aiding in the control of cracking. Furthermore, by distributing the load more evenly throughout the concrete matrix, fibers lower concentrated areas of stress and increase the material's overall tensile strength. In situations where flexibility and resilience are essential, they also improve ductility, which enables the concrete to deform under tensile stress without failing abruptly. A certain percentage of fiber can increase strength, but too much might cause issues like fiber balling, which damages the concrete matrix and lowers performance. Nevertheless, the effect of fiber content is usually dependent on dosage. The tensile strength is also influenced by the fiber type, steel, polypropylene, nylon or polyester, as each fiber possesses distinct characteristics that interact with the concrete blend differently. To maximize concrete's tensile strength and performance in various structural applications, it is imperative to optimize both the fiber content and type [43, 45, 46].

Fig. 6. Setup Of Split Tensile Strength

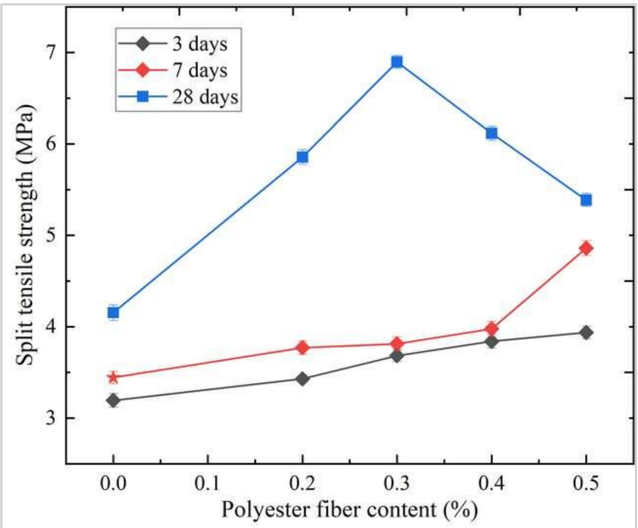

Fig.7. Results Of Split Tensile Strength Of High Strength Concrete

3.3 Empirical Formulations For Strength Properties

In order to properly predict the splitting tensile strength of concrete, it is crucial to consider a number of critical factors that affect this property of concrete. These elements include the type and quantity of aggregates, the inclusion of fibers or other additives, and the design of the concrete mix, including the water-to-cement ratio. Also, curing parameters like humidity and temperature are important for the hydration process and ultimately affect tensile strength. The two types of strength properties are not precisely proportionate, even though it is stated that they are closely related. Tensile strength is typically low but plays a vital role in the concrete's ability to resist stresses until cracks appear. These cracks alter the behavior of the structural component and have an impact on the concrete structure. However, previous research has suggested several empirical formulations appropriate for comparing the split tensile strength (f_{sp}) and compressive strength ($f_c^{'}$). The Eq. expresses and presents some of the empirical relationships from prior investigations, as reported by ACI 363 R-92(2004) [51], ACI-318-95(2004) , CEB FIP [52], Ahmed and Shah et al. [53], Nilson et al.[54], Wafa and Ashour et al. [55], Thomas and Ramasay et al. [56], respectively. Fig. 8a presents the experimental investigation carried out in this study, which investigates the relationship between compressive strength and splitting tensile strength. The investigation focuses on both the control sample of high strength concrete and the high strength concrete developed with the addition of polyester fiber. The Equation proposed by several authors for predicting tensile strength, as well as the Equation derived from the current investigation, are depicted in Fig. 8b. This Fig. demonstrates a well-established correlation between compressive strength and fracture tensile strength, with an estimated coefficient of variation R2 = 0.9122. Since the R2 value is around 1, the relationship is sufficiently strong despite being linear. Although most of the proposed relationships are nonlinear, some earlier scholars also proposed linear approximation, Nilson et al. [54] proposed that the compressive and tensile strengths of concrete have a linear relationship. To determine the relationship between the experimental compressive strength of fiber materials and the prediction of splitting tensile strength from the presented graph, an empirical equation is given in Table 3. The splitting tensile strength of concrete materials, theoretically and experimentally determined, is expressed as high strength concrete that can be made without fine Aggregate. In Table 3, the Equation obtained from the current investigation is presented together with a prediction function derived from the Equation. The experimental and theoretical splitting tensile strengths are highly correlated, as they both demonstrate comparable tensile strength values.

Table 4

The empirical Relation between experimental splitting tensile strength and compressive strength of high strength concrete incorporating polyester fiber

Fiber Content (%)	Experimental results f'_c	Experimental results f_{sp}	ACI 363 R-92 (2004) $f_{sp} = 0 \cdot 59\sqrt{f'_c}$	ACI-318-95 (2004) $f_{sp} = 0 \cdot 56\sqrt{f'_c}$	CEB FIP (1990) $f_r = 1.4\left(\frac{f'_c}{10}\right)^0$	Ahmed and Shah et al. (1985) $f_{sp} = 0 \cdot 46(f'_c)^{0.55}$	Nilson et al. (1987) $f_{spf} = 0 \cdot 62\sqrt{f'_c}$	Wafa and Ashour et al. (1992) $f_{sp} = 0 \cdot 58\sqrt{f'_c}$	Thomas and Ramasay et al. (2007) $f_{spf} = 0 \cdot 57\sqrt{f'_c}$
0	63	4.16	4.68	4.44	4.80	4.49	4.92	4.60	4.94
0.2	67.13	5.85	4.83	4.59	5.01	4.65	5.08	4.75	5.11
0.3	71.93	6.89	5.00	4.75	5.25	4.83	5.26	4.92	5.32
0.4	70.19	6.12	4.94	4.69	5.17	4.77	5.19	4.86	5.24
0.5	68.28	5.39	4.88	4.63	5.07	4.69	5.12	4.79	5.16

3.4. Relationship Between Compressive Strength And Flexural Strength

Table 4 illustrates a correlation between compressive strength and flexural strength of concrete. The flexural strength of concrete increases frequently along with an increase in compressive strength. The material's overall microstructure, content, and curing conditions all affect this relationship. The material's capacity to withstand bending or flexural stresses can be improved by higher compressive strength, which is typically indicative of greater bonding and density. While this pattern is widespread, its precise significance can vary based on individual mix designs and testing. To establish the correlation between flexural and compressive strength, flexural strength at 28 days was used. Previous research has employed several flexural strength predictions utilising empirical equations to compare compressive strength (fc'). and flexural strength (fr) as shown in Fig.8c. Various previous research studies and standards' empirical formulas are shown in Equation ACI 363 R-92(2004)[51], ACI-318-95(2004), CEB FIP (1990) [52], Ahmed and Shah et al. [53], Nilson et al. [54], Wafa and Ashour et al. (1992) [55], Thomas and Ramasay et al. [56] respectively.

Table 5

Empirical Relation between experimental flexural Strength and Compressive Strength of High strength concrete incorporating polyester fiber

Fiber content %	Experimental results f'_c	Experimental results f_{sp}	ACI 363 R-92 (2004) $f_r = 0 \cdot 94\sqrt{f'_c}$	ACI-318-95 (2004) $f_r = 0 \cdot 62\sqrt{f'_c}$	Ahmed and Shah et al. (1985) $f_r = 0 \cdot 44(f'_c)^{0.67}$	Nilson et al. (1987) $f_r = 0 \cdot 9\sqrt{f'_c}$	Oluokkun et al. (1991) $f_r = 0 \cdot 79\sqrt{f'_c}$	Wafa and Ashour et al. (1992) $f_r = 1 \cdot 03\sqrt{f'_c}$	Thomas and Ramasay et al. (2007) $f_r = 0 \cdot 79\sqrt{f'_c}$
0	63	4.16	7.46	4.92	7.06	7.14	6.27	8.18	6.27
0.2	67.13	5.85	7.70	5.08	7.37	7.37	6.47	8.44	6.47
0.3	71.93	6.89	7.97	5.26	7.72	7.63	6.70	8.74	6.70
0.4	70.19	6.12	7.88	5.19	7.59	7.54	6.62	8.63	6.62
0.5	68.28	5.39	7.77	5.12	7.45	7.44	6.53	8.51	6.53

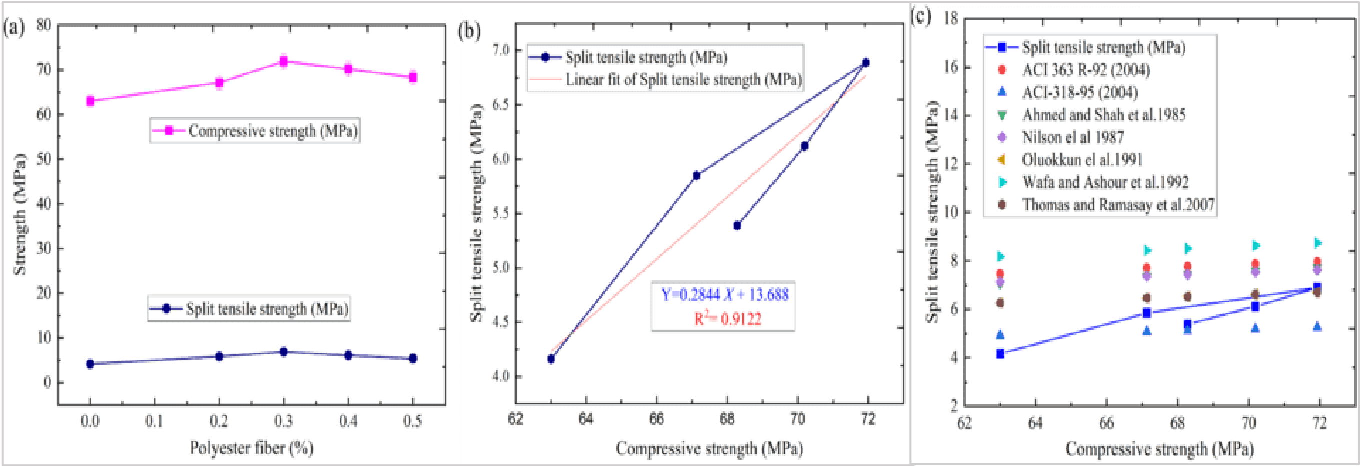

Fig. 8. Correlation Between Compressive Strength And Splitting Tensile Strength (Mpa) Of High Strength Concrete With The Addition Of Polyester Fiber

4. Conclusion

Based on the results of the experimental study, some general conclusions can be stated.

1) The addition of polyester fiber to high strength concrete (HSC) grade C60 results in a slump reduction of 14% to 57% when incorporating fiber contents of 0.2% to 0.5%. In contrast, concrete without polyester fibers maintains high workability and favourable slump characteristics across all mix proportions.

2) A control mix of high strength concrete C60 was developed using local materials. The compressive strength of the control mix with polyester fiber was assessed at ages 3, 7, and 28 days for fiber contents ranging from 0.2% to 0.5%. The maximum strength was observed at 0.3% fiber content, with a slight decrease at 0.5% compared to the 0.3% content, which exhibited a 14.17% improvement over the control mix without fiber.

3) The study focused on the development of splitting tensile strength in HSC with the addition of polyester fiber at various percentages. It examined the effects of 0.2% to 0.5% polyester fiber in C60 grade concrete at ages 3, 7, and 28 days. Results indicated that the splitting tensile strength improved with increasing fiber content, with enhancements of 40.63% at 0.2% and 65.68% at 0.3% after 28 days of curing.

4) Both the compressive strength and splitting tensile strength of high strength concrete with polyester fiber exhibited consistent improvement, demonstrating the beneficial effects of fiber incorporation.

5) The use of polyester fibers can reduce maintenance costs by mitigating the risk of microcracks and enhancing permeability, thereby improving durability. Additionally, polyester fibers have the potential to minimize bleeding and segregation in concrete mixes.

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