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Comparative analysis of mechanical properties of fibre mixed concrete.

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Abstract: Next to water, concrete is the most ubiquitous construction material worldwide. Due to the rapid depletion of natural resources, innovative substitutes are increasingly being used to boost concrete's strength and durability. Experimental research on the mechanical characteristics of concrete with three different types of fibres added is shown here. In the experiment, M25 concrete was used together with polypropylene fibres, basalt fibres, and steel fibres. Concrete's characteristics were investigated while still wet and after it had solidified. Compared to regular concrete, the results showed that the addition of fibres increased early strength gain by about 62%. When compared to regular concrete, the addition of polypropylene fibres raised the material's compressive strength by 24% and its tensile strength by 22%.

KEYWORDS: polypropylene fibre, basalt fibre, steel fibre.

1. Introduction

Concrete consists of four different components: coarse aggregate, fine aggregate, hydraulic cement, and water. Cement and water react chemically to generate a substance with the appearance of stone. This stone-like substance is brittle, with high compression strength and low-tension strength. When it comes to resisting cracking, impact, and abrasion, concrete falls short. The qualities of high strength and low permeability are essential in quality concrete. As a result, composite materials with improved ductility and strain hardening are becoming increasingly preferred as an alternative.

The major reason concrete fails is because cracks grow in it. Many efforts have been undertaken to boost the tensile strength of concrete. Adding steel reinforcement is a tried-and-true procedure with a long track record of success. However, steel bars only provided protection against localised compression in concrete. Rebar prevents cracks in reinforced concrete from propagating further. This calls for steel reinforcement in many directions and at close intervals. In all likelihood, that simply cannot happen. The issue can be fixed by using fibre reinforcement.

Fibres are being incorporated into concrete as a means of increasing its tensile strength. These fibres can be thought of as crack arrestors; they stop cracks from spreading.

These fibres are dispersed evenly and organised at random. Reinforced with fibres, this concrete is known by that name. The primary goals of incorporating fibres into the matrix of concrete are to increase the material's energy absorption capacity and apparent ductility after cracking has occurred, as well as to provide crack resistance and fracture management. It ai CEMENTds in the material's continued stability and cohesion as well. Many different types of material formulations that meet the criteria for Fibre Reinforced Concrete have been developed as a result of the first studies and the massive amount of subsequent studies.

CEMENT

Cement is a type of binder used in building; it is a chemical compound that sets, hardens, and adheres to other materials. Cement is typically used to hold aggregates like sand and gravel together rather than as a standalone material. Mortar for stonework is made by combining cement with fine aggregate, while concrete is made by combining cement with sand and gravel. After water, concrete is the most consumed resource on Earth due to its ubiquitous use. Cements used in building are typically inorganic, made from lime or calcium silicate, and are either hydraulic (the more frequent type) or non-hydraulic (less common). Portland cement is an example of a hydraulic cement, which hardens and becomes adhesive as a result of a chemical interaction between its dry constituents and water. The mineral hydrates produced by the process are not highly water-soluble, making them exceedingly stable in water and resistant to chemical attack. The less prevalent non-hydraulic cement does not harden in damp environments or when submerged in water. Instead, it hardens when exposed to air and interacts with carbon dioxide. After it hardens, it can withstand chemical assaults.

FINE AGGREGATE

Concrete and mortar can't be made without the granular ingredient known as Fine Aggregate. The granular material is so fine that it easily passes through a 4.75mm sieve. Its primary function is to boost the density of concrete; hence it sees extensive application in the building trades. Save money by using this fundamental component of concrete, which is usually composed of sand or crushed stone from the earth. The hardened properties of concrete are significantly affected by the fine aggregate density and quality. Selecting fine aggregate based on grading zone, particle form and surface texture, abrasion and skid resistance, absorption and surface moisture, and cost can make the concrete or mortar mixture more long-lasting, stronger, and more cost-effective. Clean, rigid, robust fine aggregates that have not absorbed chemicals or been coated with clay or other fine materials are essential for a high-quality concrete mix. The deterioration of concrete can be attributed to a lack of awareness of these features.

COARSE AGGREGATE:

According to a correct definition of coarse aggregate, it is an essential component of concrete that is utilised to provide bulk to the mixture and minimise shrinkage. Roughly

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seventy percent to eighty percent of the concrete's total volume comes from the coarse particles. Coarse aggregates are used in many different construction applications, such as a granular basis under a slab or as a component in a combination like asphalt or concrete. Typically, the size and shape of coarse particles are used to classify them. They range from round to angular to flaky to elongated forms. Furthermore, gravels, cobble, and boulders can all be included in the category, depending on the size of the coarse material. Coarse aggregates in the range of 4mm to 256mm are suitable for use in both regular strength and high strength concrete.

WATER

Water is a crucial raw material in concrete mixtures since it contributes to the material's workability and facilitates cement hydration. The amount of water can alter all qualities of fresh and hardened concrete, which is why it is both sensitive and vital. Clean water is essential for making concrete, as it dilutes the detrimental effects of other ingredients such chloride, sulphate, acid, sugar, organic pollutants, industrial waste, oil, clay, and slit. Up to 25% of cement's weight is needed for the hydration process. Any more water utilised will simply serve to improve its workability. This, over time, removes the core of the concrete, leaving behind an empty shell. The bigger the amount of water in the mixture, the larger the hollows, which has a detrimental impact on the concrete's strength and durability.

POLYPROPYLENE FIBER

Polypropylene chemical fibres are novel. Mass-produced after polyesters, polyamides, and acrylics. Polypropylene fibre production is 4 million tonnes worldwide. In 1965, the US Corps of Engineers proposed blast-resistant concrete using polypropylene fibres. After improvement, polypropylene fibre is utilised as a short discontinuous fibrillated material for fibre reinforced concrete or a continuous mat for thin sheet components. Concrete fibres improve tensile, flexural, toughness, impact, and failure mode, making them more useful in construction. Melt spinning makes these fibres. Propylene gas filaments. Cracking petroleum or natural gas yields propylene gas. Pressure and heat produce propylene chains. Controlled molecular polypropylene requires catalysts. Polypropylene hides. Virgin homopolymer polypropylene graded monofilament micro-reinforcing fibres. No Olifin. Hydrocarbon monomeric C_3H_6 polypropylene. 0.9 kg/m3, or 0.1% volume, polypropylene fibre dosage is optimal. Steel fibres are denser. Multistage drawing strengthens. 0.9 g/cc. Stiff, crystalline, chemical- and bacterial-resistant. 70%-crystalline fibres weigh 80,000–300,000 gm/mole.

Fig. (1) Polypropylene Fibre

Table. (1) Properties Of Polypropylene Fibre

Properties	Values
Polymer	100% Virgin Polypropylene Homo-polymer
Length	10-12 mm
Diameter	18 micron
Modulus (young's)	4.0 kN/mm^2
Specific gravity	0.91
Absorption	Nil
Colour	Natural
Thermal & Electrical Conductivity	Low

BASALT FIBRE

Basalt is a naturally occurring, igneous volcanic rock that is extremely tough, dense, dark brown to black in colour, and originates hundreds of kilometres below the surface of the planet. The substance known as basalt fibre is created from extremely finely ground basalt, which is made up of the minerals plagioclase, pyroxene, and olivine. It is comparable to fibre glass, although it is substantially less expensive than carbon fibre despite possessing improved physic and mechanical qualities in comparison to fibre glass. The obtained basalt fibre has a length of 12 millimetres, a density of 2650 kilogrammes per cubic metre, and a tensile strength of 4150 to 4800 megapascals.

Fig. (2) Basalt Fibre

Table. (2) Properties of Basalt Fibre

Properties	Values
Fibre type	Chopped
Length	12mm
Filament Diameter	7 to 15 µm
Density	2650 kg/ m^3
Elastic modulus	10000 to 11000 kg/ mm^2
Tensile Strength	4150 to 4800 Mpa
Elongation	3.2%

STEEL FIBRE

Reinforcing metals like steel fibre. Short, discrete lengths of steel fibre with an aspect ratio (ratio of length to diameter) between 20 and 100, with varying cross section, and small enough to be randomly dispersed in an unhardened concrete mixture via the usual mixing procedure constitute steel fibre for reinforcing concrete. When steel fibre is added to concrete, the material undergoes qualitative changes, enhancing its resistance to creaking, impact, fatigue, and bending as well as its tensile strength, durability, and other attributes. The extracted steel fibre is straight, hook-ended, deformed, 0.3 to 0.7 mm in diameter, 25 to 30 mm in length, aspect ratio 55, 7900 kg/m3, young's

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modulus 2.1 × 105 n/mm2, specific gravity 7.90, and 500 to 2000 n/m2 in tensile strength.

Fig. (3) Steel Fibre

Table. (3) Properties of Steel Fibre

Properties	Values
Fibre type	Straight , hook- end
Length	30mm
Filament Diameter	0.3-0.7mm (max 1mm)
Density	7900 kg/m^3
Young's Modulus	2.1 x 10^5 N/mm^2
Tensile Strength	500-2000 N/mm^2
Elongation	5-35 %

Details of the Experiment

The preparation of the concrete mixture occurred during the stage of specimen manufacturing, which was the same for all of the specimens. According to the ACI-211 mixing plan, the weights of the various components. For each type of fibre (Polypropylene Fibre, Basalt Fibre, and Steel Fibre), the values 0.25, 0.5, 0.75, and 1.00 have been chosen as the appropriate modifications. In the subsequent phase, the fibres and concrete were combined using a hand mixer at room temperature for a few minutes in order to produce a flawless and homogenous concrete mixture for each individual specimen.

Fresh Concrete Test Results

There are a variety of tests that may be performed on freshly mixed concrete to determine its quality. Consistent testing allows for the identification of subtle changes in concrete that may have an impact on its durability. Complete fresh concrete testing, including concrete air content, is discussed in this post, along with its significance, its function in ensuring compliance with QC/QA criteria, and some helpful hints and tools. Here The table below displays the outcomes of a Slump Cone Test and a Compaction Factor Test.

Fig. (4) Slump Cone Test and Compaction factor test

Table. (4) Slump value and Compaction factor test results for different Mix

Mix	SLUMP VALUE (mm)			COMPACTION FACTOR		
	Polypropylene fibre	**Basalt fibre**	**Steel fibre**	**Polypropylene fibre**	**Basalt fibre**	**Steel fibre**
CC	105	105	105	0.89	0.89	0.89
F 0.25	97	98	95	0.86	0.87	0.85
F 0.50	94	93	90	0.84	0.83	0.8
F 0.75	86	88	86	0.81	0.79	0.78
F 1.00	84	85	80	0.77	0.75	0.74

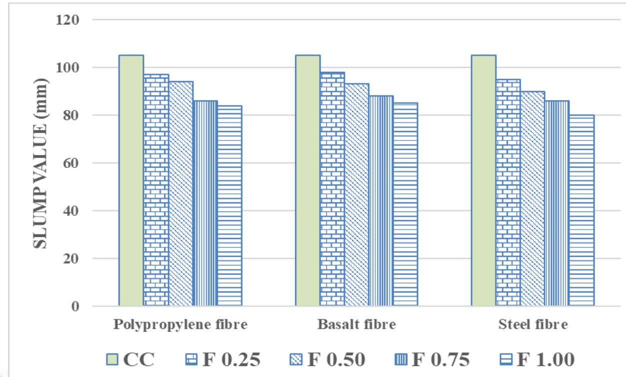

Fig. (1) Comparison of Slump Value b/w PF, BF and SF

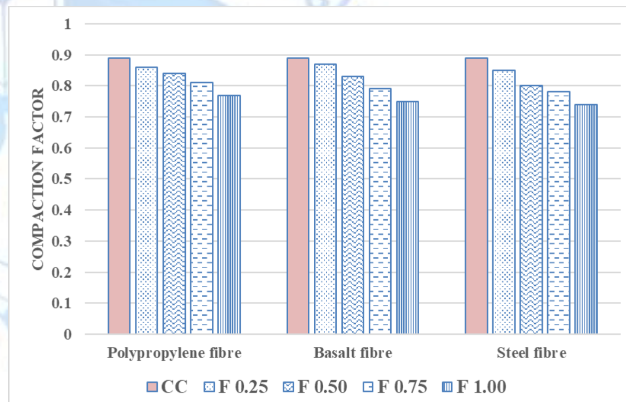

Fig. (2) Comparison of compaction factor b/w PF, BF and SF

HARDENED CONCRETE TEST RESULTS

Hardened concrete gains strength with time and testing these hardened concrete for quality check is important for structures. Different types of tests are available to check different properties of hardened concrete which are discussed.

COMPRESSIVE STRENGTH test Results

The concrete cubes used in the tests were exactly 150mm on a side. After wiping away any surface moisture, all the samples were examined in a saturated surface dry condition. The viability of each blend was

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determined by analysing three replicate samples taken at 7, 14, and 28 days of age. The equipment used in the test was a 120-ton compression testing machine. Until the specimen broke, it was subjected to a force of 140kg/cm2/min. The highest force exerted on the specimen before it broke. The ultimate cube compressive strength is equal to the ultimate load divided by the specimen's cross-sectional area.

Table. (5) Compressive Strength Test Results

MIX	Polypropylene fibre			Basalt fibre			Steel fibre		
Days	7	14	28	7	14	28	7	14	28
CC	9.45	16.73	23.8	9.45	16.73	23.8	9.45	16.73	23.8
F 0.25	10.68	19.48	27.86	9.95	17.65	23.4	10.49	18.8	24.14
F 0.50	12.28	22.59	28.25	10.05	19.2	25.62	12.01	20.23	26.25
F 0.75	14.54	23.92	28.95	12.32	22.5	27.82	13.62	21.21	28.45
F 1.00	15.33	24.26	29.74	14.78	23.22	28.41	15.67	23.35	29.22

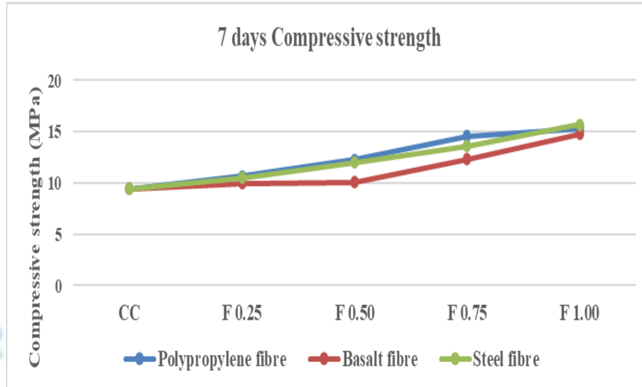

Fig. (3) COMPRESSIVE STRENGTH 7 DAYS

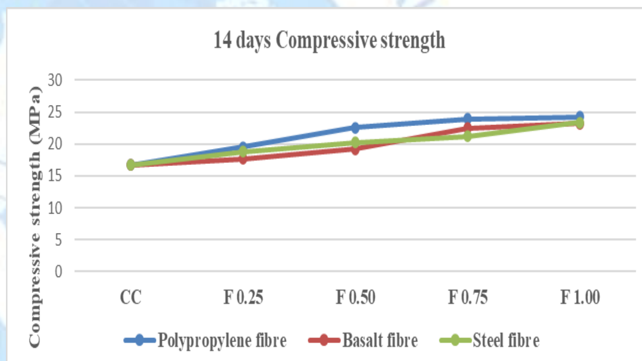

Fig. (4) COMPRESSIVE STRENGTH 14 DAYS

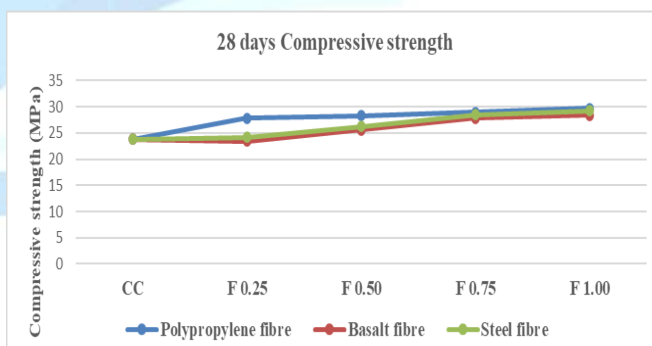

Fig. (5) COMPRESSIVE STRENGTH 28 DAYS

SPLIT TENSILE STRENGTH ON CONCRETE

The tensile strength of cylindrical specimens is evaluated in this indirect test. Concrete cylinder specimens (150 mm in diameter and 300 mm in height) were tested for splitting tensile strength at 7 and 28 days of age using a 1200 kN compression testing machine in accordance with IS: 5816-1970. The cylindrical specimens were stored between the wooden strips to prevent any direct load from being applied to the specimen. The specimen was subjected to an increasing load until it broke, at which point the results were recorded.

Table. (6) Split Tensile Strength Test Results

MIX	Polypropylene fibre			Basalt fibre			Steel fibre		
Days	7	14	28	7	14	28	7	14	28
CC	1.13	1.4	2.66	1.13	1.4	2.66	1.13	1.4	2.66
F 0.25	1.37	1.76	3.08	1.34	1.67	3.03	1.39	1.53	3.17
F 0.50	1.98	2.11	3.23	1.63	2.01	3.33	1.77	2.76	3.25
F 0.75	2.09	2.57	3.46	2.01	2.37	3.43	2.11	2.87	3.48
F 1.00	2.26	2.98	3.6	2.18	2.68	3.57	2.35	3.02	3.65

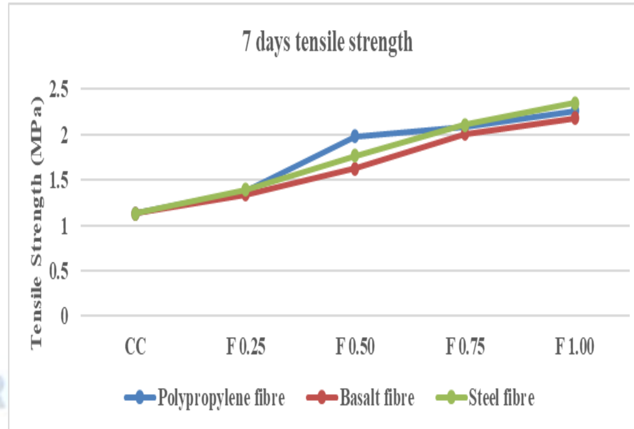

Fig. (6) SPLIT TENSILE STRENGTH 7 DAYS

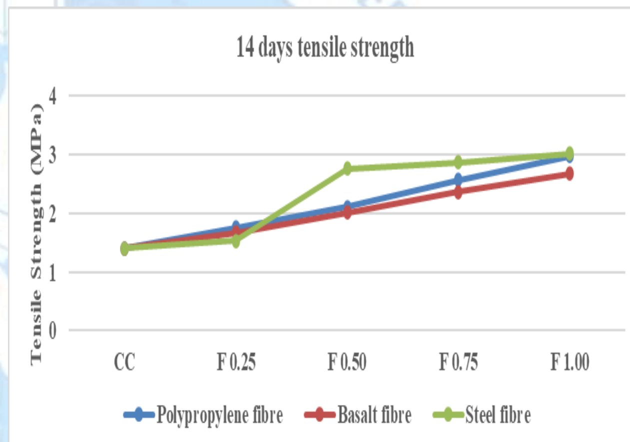

Fig. (7) SPLIT TENSILE STRENGTH 14 DAYS

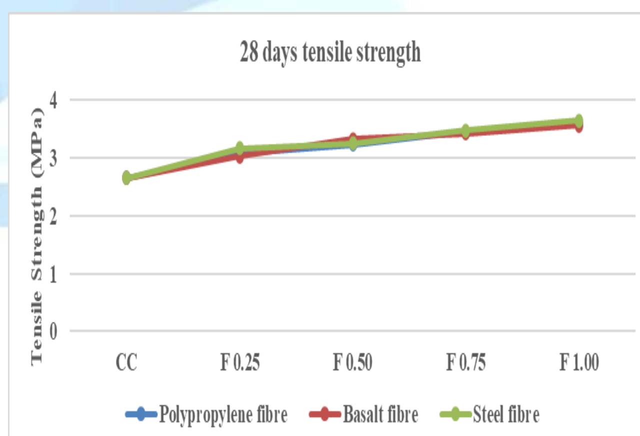

Fig. (8) SPLIT TENSILE STRENGTH 28 DAYS

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Conclusion

The purpose of these studies is to ascertain whether or not fibre addition improves the properties of the concrete. To optimise the properties of these hybrid concretes made from polypropylene fibres, basalt fibres, and steel fibres, the values 0.25, 0.5, 0.75, and 1.00 were selected. Different mix proportions were put through the Fresh Concrete test and the harden concrete test. Here is a quick rundown of what we learned from this study:

The fibre-added slump value can be seen in the test results for newly mixed concrete. All three fibres were somewhat reduced in hybrid concrete compared to the control concrete. However, the hybrid concrete behaves similarly to the control concrete across all three fibre types in the Compaction factor test.

Both the Compressive Strength Test and the Split Tensile Test reveal that the addition of fibres to M25 graded concrete increases its strength. All three fibres benefit from an increase in strength to a similar extent.

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