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AN EXPERIMENTAL STUDY OF MECHANICAL PROPERTIES OF HYBRID FIBRE REINFORCED CONCRETE

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Abstract

Present day world is witnessing the enhancement and exigency in Construction Engineering. Through pioneering materials, Civil Engineers are creating worldwide significant infrastructure and creating wonders. It is mandatory to pioneer new materials and create innovative systems for the construction world. This is the right time to concentrate on amalgamation of new materials in concrete, as concrete is unavoidable due to its cost effectiveness when compared to rest of the materials used now a days in the construction industry. The addition of small closely spaced and uniformly dispersed fibres to concrete would act as crack resist and would substantially improve its properties. This type of concrete known as fibre reinforced concrete. In this study, we use steel, glass and polypropylene fibres. Fibres mainly belongs to two categories. Steel and glass fibres belongs to category 1.which have higher moduli value. Polypropylene belongs to category 2 with lower moduli value. Fibres have been used to reinforce materials that are weaker in tension than in compression. Steel, glass and polypropylene are used as hybrid fibres. They can be added to concrete with different proportions as 0.5%, 1%, 1.5%, 2% and 2.5% in this study. Experiments were conducted to study the effect of steel fibre and polypropylene fibre in different proportions in hardened concrete. Compressive strength tests on cube and split tensile strength tests on cylinders were carried out to study the properties of hardened concrete. A composite can be termed as Hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that drives benefits from each of its individual fibres and exhibits a synergetic response. Addition of short discontinuous fibres place a important role in the improvement of Mechanical properties of concrete. It increases elastic modulus, decreases brittleness, controls cracks, initiation and its subsequent growth and propagation. Deboning and pull out of the fibre require more energy absorption, resulting in a substantial increase in the toughness and fracture resistance of materials to the cyclic and dynamic loads.

Keywords: Strength, Concrete, Mechanical Properties, Hybrid

1. INTRODUCTION:

During the last few decades, with the possibility of strengthening the concrete with fibre reinforcement to a great advantage, the concrete construction field has experienced an increased attention. Among the different fibres, namely, steel, synthetic, glass and natural fibres, in use at present, steel fibre is the one that has been mostly investigated in depth. It is the commonly used reinforcement in civil engineering construction. Fibre reinforcement today is used mainly in applications such as industrial floors, overlays and sprayed concrete, although other application areas do exist. Some of the prospective benefits of fibres in concrete are enhanced crack control and the possibility of designing more slender structures. However, the extent of the crack control depends to a large extent upon the type and volume of fibres added. Combining concrete with isolated “fibres” consisting of left over steel grains was patented in 1874 by A. Berard, thus creating, a highly ductile, new material. Today, steel and synthetic fibres are used for both nonstructural and structural purposes. Synthetic fibre (e.g. polypropylene and nylon) is being used mainly to control the early cracking (plastic-shrinkage cracks) in slabs. Normally, addition of fibres to concrete mainly enhances the post-cracking properties in terms of a more ductile behaviour and reduced crack width. However, prediction of enhanced mechanical properties with practical awareness for integrating into design methods is still to be investigated.

2. LITERATURE REVIEW:

Ali Elloze et al (2010) have investigated the effect of adding steel fibres to concrete, on the mechanical behavior of steel fibre concrete slabs. The compressive force of SFC improved up to 25% compared to plain concrete, while the splitting tensile strength tests showed an enhancement of up to 45% of the steel fibre concrete compared to plain concrete. The optimum size of the steel fibres suggested to act on the elastic zone (strength and cracking) or plastic zone (ductility and deformation) are diverse. In the elastic zone, the fibres must be abundant and small, while in the plastic zone, the fibre length must be large enough to ensure their proper anchorage in the matrix. Vikrant S Vairagade et al (2012) has carried out an experimental investigation for M-20 grade of concrete to study the compressive strength, and tensile strength of steel fibre - reinforced concrete (SFRC), containing fibres of 0% and 0.5% volume. Fraction of hook end Steel fibres of 50 and 53.85 aspect ratio have been used during this investigation. The test results have shown that the addition of 0.5% hook end steel fibres increases compressive strength of concrete up to 10%. The split tensile strength of fibre reinforced concrete was dependent on length of fibre used. By addition of longer length fibre, the split tensile strength increases. Use of 50 mm long fibre with same volume of fraction gives 20% extra split tensile strength over fibre 35 mm in length. Addition of steel fibre in the concrete affect the workability of concrete. Addition of 0.5% steel fibre reduces the slump value of fresh concrete. This problem of workability and flow property of concrete can be overcome by using suitable admixtures such as superplasicizers. It has also been observed that the compressive strength for M20 grade of concrete from two different dimensional fibres at same volume fraction shows nearly same results with minor increase. Gopalarathanam et al (1986) have discussed the effect of strain rate on the flexural behavior of unreinforced matrix, and three different fibre reinforced concrete (FRC) mixes. The objective was to study the properties of steel fibre reinforced concrete subjected to impact loading. A conventional charpy impact machine was modified and instrumented to facilitate tests on FRC specimens at different impact velocities. Smooth brass coated steel fibres of lengths 25.4mm and diameter 0.41mm has been used. Three different volume fractions of fibres 0.5, 1.0 and 1.5 have been used. The test results have shown that the inclusion of fibres in the matrix enhances the compressive strength and the corresponding strains. Plain matrix had a compressive strength of 30.44mm while 1.5 percent FRC has strength of 40.98 MPa. The value of strain at peak stress for the 1.5 percent FRC specimen has been observed to be 3750 micro strains compared to 2700 micro strains for the unreinforced matrix. Narayanan et al (1987) have done investigations of the behavior of steel fibre reinforced concrete beams subjected to preeminent shear. The report establishes that the inclusion of steel fibres, in reinforced concrete beams, results in a sustained increase in shear strengths. Beams when reinforced with one percent of volume fraction, have no increase in ultimate shear strength, while those reinforced with stirrups have shown an increase in shear strength as the volume of stirrups is increased. The pattern of cracks developed in fibre reinforced concrete beams subjected to shear was found to be generally similar to those observed in the corresponding reinforced concrete beams with conventional stirrups. When the cube strength is increased from 42MPa to 62MPa (about 50 percent), there is an increase in shear strength from 1.97MPa to 3.23MPa (about 64 Percent). The effectiveness of dowel resistance increased with an increase in the fibre factor. This has indicated that the presence of fibres improved the tensile strength of the concrete in the splitting plane along the reinforcement.

3. MIXDESIGN

Concrete mix proportion is created for specific and desirable properties. Mixing various amounts of Portland cement, water, sand, and coarse aggregate and graphite, steel fibers produces different samples with altered characteristics of homogeneous mix. The method adopted for identifying mix proportion was in reference to the amount of the material in an unit of fully compacted concrete. The method resulted in specifying mix constituents in terms of weights in kilograms necessary to get the required volume of concretes.

MIX PROPORTION BY MASS:

C: F.A :C.A= 1 :1.56:3.21

4. EXPERIMENTAL STUDY

4.1INTRODUCTION:

In the experimental investigation, the main objective is to study the strength and properties of the conductive concrete. Concrete and the testing of hardened concrete with addition of graphite and steel fibers.

4.2 PROCESS OF MANUFACTURING OF CONCRETE:

a) Batching

The quantities of cement, fine aggregate, natural coarse aggregate, graphite powder, steel fibers, water for each batch were measured by a weighing balance according to the mix proportions obtained by the mix design.

Figure 6.1 **Batching**

b) Mixing:

The object of mixing is to coat the surface of all aggregate particles with cement paste and to blend all the ingredients of concrete into a uniform mass. The mixing should homogeneous, uniform in colour and consistency. In this study, the process of hand mixing.

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CASTING OF SPECIMENS:

The cast iron moulds of size 150mm×150 mm×150 mm are cleaned of dust particles and applied with mineral oil on all sides before concrete is poured in to the moulds. The moulds are placed on a level platform.

The strength criteria and durability criteria for severe environmental exposure is completely based on mix design. The quotient weight of cement, fine aggregates and coarse aggregate are obtained and mixed thoroughly in dry condition. In order to attain a through mix 50% of water required is added to the dry mix and remaining water added to the mixture. Then concrete is filled in moulds each layer is compacted with tampering rod, for 25 blows each time. The well mixed concrete is filled in to the moulds. Excess concrete was removed with trowel and top surface is finished level and smooth.

CURING:

The cast specimens were removed from the moulds after 24 hours from the time of adding the water to the ingredients. The specimens then marked for identification. These specimens were then stored in clean water for the required period of curing.

Figure 6.4 **Curing**

TESTS ON FRESHCONCRETE:

The suitability of fresh concrete starting from mixing to compaction depends mainly on the property called workability. It can also be defined as a term which consists of the following four main properties namely mix ability, transportability, mould ability and compatibility.

5.1 SLUMP CONE TEST:

Slump cone test the most commonly used test of measuring the consistency of concrete. This test has been used extensively in site work to detect variations in the uniformity of mix of given proportions. Place the slump mould on a smooth flat and non-absorbent surface. The mixed concrete is filled in the mould to about one-fourth of its height. Each layer is compacted with tamping rod, for 25 blows each time. The well mixed concrete is filled in to the moulds. Excess concrete was removed with trowel and top surface is finished level and smooth. The mould is removed from the concrete immediately by raising it slowly in the vertical direction. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.

Slump cone test is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. An increase in slump may mean that the moisture content of aggregate has increased or a change in grading of the aggregate, such as the deficiency of fine aggregate. Too much or too low slump gives an immediate warning and enables the mixer operator to remedy the situation.

6. TESTS ON HARDENED CONCRETESPECIMENS:

6.1COMPRESSIVESTRENGTH:

Compression strength of a material is defined as the cube reached ultimate stress when the material fails completely. In this investigation, the cube specimens of size 150 mm x 150 mm x 150 mm of are casted for tested concretes for the design mix.

Concrete specimens are removed from the mould and cure it under water for period of testing and the cubes are removed from the curing tanks and cleaned to wipe off the surface water. It is placed on the machine such that the load is applied centrally. The smooth surfaces of the specimen are placed on the bearing surfaces. The top plate is bought in contact with the specimen by rotating the handle. The oil pressure valve is closed and the machine is switched on.

In each case the cube was positioned in such a way that the load was applied perpendicularly to the direction of casting with a loading rate of 140 kg/cm2/min was maintained and it was continued till the specimen fails, i.e. with further increment of load, no resistance was offered by the specimen, that maximum load was recorded. The compression test is done at the desirable ages of 7days, 28days, 56 days. For strength computation, the average load of three specimens is considered as the maximum load.

Fig.6.6 Compressive strength

7. TEST RESULTS AND DISCUSSIONS

In this chapter the properties of concrete in fresh and hardened state are discussed and presented. The experimental study is carried out to find out the workability of hardened concrete in comparison with the normal conventional concrete to fibrous concrete added in percentages of 0.5%,1%,1.5%,2%,2.5% to known the strength values at each percentages.

7.1COMPRESSIVESTRENGTH TEST

The compressive strength of the concrete was done on 15cm x15cm x 15cm cubes. The compressive strength values are taken as the average of the three test results. The results of compressive strength of specimens are presented in the tabular forms. Also the graphical representation of compressive strength of concrete cubes of various mixes.

Figure 7.1**Compressive strength test**

Test Results of Conventional Concrete:

Tests conducted	**Results obtained for average value of 3 specimen**
1.Compressive test for cubes for 28 days curing	25.69N/mm²
2.Split tensile test for cylinders for 28 days curing	3.21N/mm²

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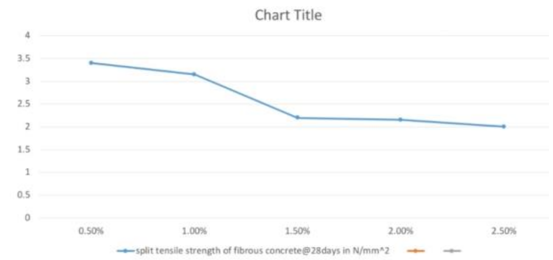
Test Results for Fibrous Materials:

Fiber added in %	Compressive strength(N/mm^2)	Split tensile strength (N/mm^2)
0	25.69	3.21
0.5	27.46	3.44
1	23.03	3.15
1.5	21.69	2.22
2	17.6	2.15
2.5	17.32	2.06

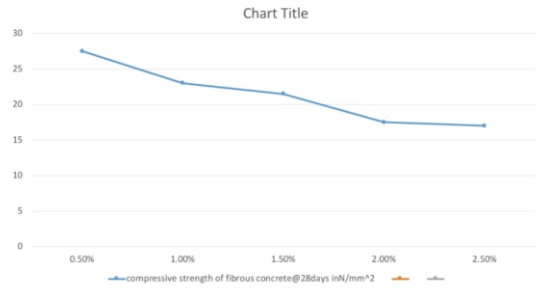
7.4 CRACKS IN CUBES AND CYLINDERS

Cubes and cylinders are tested in compression testing machine for compressive strength and tensile strength respectively. After the ultimate load is reached, cubes and cylinders fails showing cracks on the faces. Compression testing machine shows negative rate of loading after the test specimen fails and the ultimate load shown is recorded for calculating strength of concrete. The cracks formed in our test specimens is as shown in figure .

Fig . 7.2 Cracks formed in the specimen



For split tensile strength of fibrous concrete the optimum percentage of fibers is obtained at 0.5%.



For the compressive strength of fibrous concrete the optimum percentage obtained is 0.5%

CONCLUSION:

By increasing the percentage of fibers in the concrete the strength of concrete is decreasing. So, the optimum percentage of fiber content added is 0.5%. In the future scope the percentage of fibers added by the 0.1,0.2,0.3,0.4,0.5 percentages. By adding the minimum percentage of the fibers, we obtain the maximum strength and these type of concrete is useful to resist the cracks produced by the vibrations. This will result in reduction of secondary reinforcement at some levels and make structure economical. It prevents spalling of concrete which result in better protection of reinforcement cover. HFRC can be used to resist seismic effect in structures, the floors additionally act as foundation slab that is bracing and carrying the entire building.

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