AN EXPERIMENTAL INVESTIGATION ON PROPERTIES OF CONCRETE BY THE ADDITION OF POLYPROPYLENE FIBER

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Abstract: This experimental investigation on polypropylene fiber concrete by reducing the volume of river sand with and without admixture various type of fiber is used such as glass , carbon ,steel asbestos and polypropylene .This experiment presents the effect of polypropylene (PP) fibers on various properties of concrete such as compressive strength , tensile strength , workability and fracture properties with various contents of fiber (0% , 0.5% , 1.0% , 1.5%).The result of this investigation indicates that by adding of PP fiber shows maximum compressive and tensile strength.

Key words: ***polypropylene fiber, M25concrete, addition of polypropylene fiber, maximum strength, increasing post cracking response, improve energy absorption*.**

1. INTRODUCTION

Concrete has better resistance in compression while steel has more resistance in tension. Conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking. A good concrete must possess high strength and low permeability. Hence, alternative composite materials are gaining popularity because of ductility and strain hardening. To improve the post cracking behavior, short discontinuous and discrete fibers are added to the plain concrete. Addition of fibers improves the post peak ductility performance, pre- cast tensile strength, fracture strength, toughness, impact resistance, flexural strength resistance, fatigue performance etc.

The ductility of fiber reinforced concrete depends on the ability of the fibers to bridge cracks at high levels of strain. Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength.Concrete is by nature a brittle material that performs well in compression, but is considerably less effective when in tension. Reinforcement is used to absorb these tensile forces so that the cracking which is inevitable in all high-strength concretes does not weaken the structure.

For many years, steel in the form or bars or mesh (also known as "re-bar") has been used as reinforcement for concrete slabs that are designed to experience some form of loading, whether that loading would be carrying traffic, spanning a void or bearing another structure such as a wall. In many slabs, steel mesh has been used a crude (and often ineffective) method of crack control. Latest developments in concrete technology now include reinforcement in the form of fibers, notably polymeric fibers, as well as steel or glass fibers 1-5. Fiber-reinforcement is predominantly used for crack control and not structural strengthening. Although the concept of reinforcing brittle materials with fibers is quite old, the recent interest in reinforcing cement-based materials with randomly distributed fibers is quite old; the recent interest in reinforcing cement based materials with randomly distributed fibers is based on research starting in the 1960's. Since then, there have been substantial research and development activities throughout the world.

2. MATERIALS

2.1 CEMENT

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or withsand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

Cements used in construction are usually inorganic, often lime or calcium silicate based, and can be characterized as either hydraulic or non-hydraulic, depending on the ability of the cement to set in the presence of water.

2.2 FINE AGGREGATE

The fine aggregate sample taken for study and physical properties of fine aggregate. Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in High Performance Concrete as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water.

2.3 COARSE AGGREGATE:

Coarse aggregates are components found in many areas of the construction industry. They have structural uses such as a base layer or drainage layer below pavements and in mixtures like asphalt and concrete. This lesson explores the various types of coarse aggregates.

The coarse aggregate sample taken for study and the physical properties of coarse aggregate. For coarse aggregate, crushed 12mm normal size graded aggregate was used. The specific gravity and water absorption of coarse aggregate were found to be 2.68 and 1.0%, respectively. The grading of coarse aggregate conforms to the requirement as per IS: 383 – 1970.The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. By usage of mineral admixtures, the cement concrete becomes more homogeneous and there is marked enhancement in the strength properties as well as durability characteristics of concrete. The strength of High Performance Concrete may be controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete.

2.4 WATER

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete. From High Performance Concrete mix design considerations, it is important to have the compatibility between the given cement and the chemical/mineral admixtures along with the water used for mixing.

2.5 POLYPROPYLENE FIBER

Polypropylene fibers are new generation chemical fibers. They are manufactured in large scale and have fourth largest volume in production after polyesters, polyamides and acrylics.

Fig-1: Polypropylene Fiber

About 4 million tonnes of polypropylene fibers are produced in the world in a year. Polypropylene fibers were first suggested for use in 1965 as an admixture in concrete for construction of blast resistant buildings meant for the US Corps of Engineers.

Subsequently, the polypropylene fiber has been improved further and is now used as short discontinuous fibrillated material for production of fiber reinforced concrete or as a continuous mat for production of thin sheet components. Further, the application of these fibers in construction increased largely because addition of fibers in concrete improves the tensile strength, flexural strength, toughness, impact strength and also failure mode of concrete

These fibers are manufactured using conventional melt spinning. Polypropylene fibers are thermo plastics produced from Propylene gas. Propylene gas is obtained from the petroleum by products or cracking of natural gas feed stocks. Propylene polymerizes to form long polymer chain under high temperature and pressure. However, polypropylene fibers with controlled configurations of molecules can be made only using special catalysts. Polypropylene fibers were formerly known as Stealthe,. These are micro reinforcement fibers and are 100% virgin homopolymer polypropylene graded monofilament fibers. They contain no reprocessed Olifin materials. The raw material of polypropylene is derived from monomeric C_3H_6 which is purely a hydrocarbon. For effective performance, the recommended dosage rate of polypropylene fibers is 0.9 kg/m3, approximately 0.1% by volume.

Monofilament polypropylene fibers can be used in much lower content than steel fibers. The tensile strength and other mechanical properties are enhanced by subsequent multi stage drawing. These fibers have low density of 0.9 g/cc. They are highly crystalline, with high stiffness and excellent resistance to chemical and bacterial attack. The crystallinity of these fibers is about 70% while the molecular weight is 80,000 to 300,000 gm/mole.

2.6 NEED FOR POLYPROPYLENE FIBERS:

Concrete develops micro cracks with curing and these cracks propagate rapidly under applied stress resulting in low tensile strength of concrete. Hence addition of fibers improves the strength of concrete and these problems can be overcome by use of Polypropylene fibers in concrete.

Application of polypropylene fibers provides strength to the concrete while the matrix protects the fibers. The primary role of fibres in a cementitious composite is to control cracks, increase the tensile strength, toughness and to improve the deformation characteristics of the composite. The performance of FRC depends on the type of the fibers used. Inclusion of polypropylene fibers reduces the water permeability, increases the flexural strength due to its high modulus of elasticity. In the post cracking stage, as the fibers are pulled out, energy is absorbed and cracking is reduced.

Polypropylene fibers are versatile and widely used in many industrial applications such as ropes, furnishing products, packaging materials etc.

3. MIX DESIGN FOR M25 GRADE CONCRETE

Table-1: MATERIALS REQUIRED AS PER IS METHOD OF DESIGN

W/C RATIO	QUANTITY OF MATERIALS (Kg/m3)		
	CEMENT	FINE AGGREGATE	COURSE AGGREGATE
0.4	478.95	641.6	1074.7

The properties of materials used are

- Specific gravity of cement =2.87
- Specific gravity of fine aggregate =2.63
- Specific gravity of coarse aggregate =2.70

3.1 EXPERIMENTAL PROGRAMME

The following tests were made after 28 days curing:

- Workability test
- Compressive strength test
- Split tensile strength test,

3.1.1 Workability test

3.1.1.1 Slump cone test

The concrete slump test is an empirical test that measures workability of fresh concrete. The test measures consistency of concrete in that specific batch. It is performed to check consistency of freshly made concrete. Consistency refers to the case with test is popular due to the simplicity of apparatus used and simple procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner in which the test is performed. The slump test is used to ensure uniformly for different batches of concrete under field conditions, and to ascertain the effects of plasticizers on their introduction. Metal mould, in the shape of the frustum of a cone, open at both ends, and provided with the handle, top internal diameter 100mm, and bottom internal diameter 200mm with a height of 300mm.

Fig- 2: Slump test

The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as the true slump, shear slump or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indicated of too wet a mix or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having 10 -40mm are used for foundation with light reinforcement, medium workability mixes, 50 – 90 mm for normal reinforcement concrete placed with vibration , high workability concrete > 100mm.

3.1.2 Compressive strength test

This test method covers the deformation of cube compressive strength concrete specimen. The specimen is prepared by pouring freshly mixed concrete into lubricated cube moulds. Consolidation is done extremely over vibrating table for 1-2 minutes. After vibration and finishing, the moulds are kept at normal atmosphere conditions for 231/2 $\pm$ ½ hours after which demoulding is done. The specimen are then cured in water tank.

Fig -3: Compressive Strength Testing Arrangement

The test is conducted at surface dry condition. The specimen is tested at the age for 28 days of curing under the compression testing machine.

$$\text{Compressive strength} = \frac{\text{Maximum load at failure X1000}}{\text{Loaded surface area}}$$

The tests were carried out on a set of triplicate specimen and the average compressive strength values were taken.

3.1.3 Split tensile strength test

Splitting tensile strength test was conducted on concrete cylinders to determine the tensile nature of carbon black concrete. The wet specimen was taken from water after 28 days of curing. The surface of specimen was wiped out. The weight and dimensions of the specimen was noted. The cylinder specimen was placed on compression testing machine. The load was applied. The test consist of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive plates. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis.

Split tensile strength =2P /(Πdl)

Table 4: SPLIT TENSILE STRENGTH AT 28 DAYS

% of Polypropylene Fiber	Sample 1	Sample 2	Sample 3	Average
0%	2.82	2.97	3.04	2.94
0.5%	3.11	2.97	3.18	3.08
1%	3.25	3.32	3.11	3.23
1.5%	3.39	3.53	3.46	3.46
2%	3.53	3.61	3.67	3.60

Fig -4: Split Tensile Strength Testing Arrangement

4. RESULT AND DISCUSSION

Table 1: COMPRESSIVE STRENGTH AT 7 DAYS

% of Polypropylene Fiber	Sample 1	Sample 2	Sample 3	Average
0%	15.56	15.11	15.33	15.33
0.5%	19.78	19.55	19.11	19.48
1%	22.67	23.11	22	22.59
1.5%	24	24.22	23.55	23.92
2%	25.78	24.89	25.11	25.26

Table 2:COMPRESSIVE STRENGTH AT 28 DAYS

% of Polypropylene Fiber	Sample 1	Sample 2	Sample 3	Average
0%	28.89	28.44	29.11	28.8
0.5%	30.22	30.44	29.77	30.14

1%	33.33	32.89	33.55	33.25
1.5%	34.67	34.89	33.78	34.45
2%	36.44	36.67	36.44	36.52

Table3: SPLIT TENSILE STRENGTH AT 7 DAYS

% of Polypropylene Fiber	Sample 1	Sample 2	Sample 3	Average
0%	1.69	1.83	1.62	1.71
0.5%	1.84	1.69	1.76	1.76
1%	1.91	1.98	2.05	1.98
1.5%	2.12	2.19	1.98	2.09
2%	2.3	2.41	2.26	2.32

5. CONCLUSIONS

Based on the experimental investigation, the following findings are observed.

- Adding of polypropylene fiber 2% gives the maximum value
- 2% of polypropylene fiber improves the compressive strength values up to 21% when compared with the conventional concrete.
- 2% of polypropylene fiber improves the split tensile strength values up to 18% when compared with the conventional concrete.
- It shows the effective results so it reduces the cost of steel in construction
- From these results use of polypropylene fiber in low cost composites for civil infrastructure provide good mechanical properties at lower cost of polypropylene fiber.

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