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Experimental Study on Concrete with Plastic Plate Fibre Reinforcement

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Abstract : Concrete plays a critical role in design and construction of the nation's infrastructure. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to the propagation of such micro crack, eventually leading to fracture of the concrete. Rehabilitation and strengthening of concrete structures with FRP(Fiber Reinforced Polymers) has been a useful technique since last few years the influence of fiber content on the structural characteristics of fiber reinforced specimens having different fiber volume fractions is investigated in this study. The parameter of investigation includes compressive strength, split tensile strength and flexural strength. FRP sheets or plates are very suitable for strengthening not only because of their strength, but also due to the simplicity in the application. In this project, different strengthening techniques using FRP like varying the thickness of fiber and loading conditions are studied experimentally.

Introduction

Concrete is a composite material composed of granular materials like coarse aggregate embedded in a matrix and bound together with cement or binder which fills the space between the particles and glues those together. Concrete is the most widely used material on earth after water. Many aspects of our daily life depend directly or indirectly on concrete. Plain cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to the propogation of such cracks, eventually lading to brittle fracture of the concrete. Addition of small closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fibre Reinforced Concrete. Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete.

2.1 Plastic fiber reinforced concrete

Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Since concrete is acknowledged to be a relatively brittle material when subjected to normal stress and impact loads, where tensile strength is only approximately one tenth of its compressive strength. Due to this characteristic, concrete elements could not withstand such loads and stresses that acts on concrete beams and slab. The introduction of fibres was brought in as a solution to develop concrete in view of enhancing its flexural and tensile strength which are a new form of binder that could combine Portland cement in the bonding with cement matrices.

2.2 Effect of plastic fibres in concrete

Fiber reinforced concrete is a composite material comprised of Portland cement, aggregate and fibres. Normal unreinforced concrete is brittle with a low tensile strength and strain capacity. The function of irregular fibres distributed randomly is to fill the cracks in the composite. Some type of fibres creates greater impact, abrasion and shatter resistance in the concrete. Usually fibres do not rise the flexural strength of concrete. The quantity of fibres required for concrete is normally determined as a percentage of the total volume of the composite materials. The fibres are bonded to the material and allow the fiber reinforced concrete to withstand considerable stresses during the post-cracking stage. The actual effort of the fibres is to increase the concrete toughness.

2.3 Application

A list of application for fiber reinforced concrete

- Floors, driveway and walks to reduce shrinkage and cracking problems are desirables.
- Increase of toughness in fiber reinforced concrete id ideal for building and pavements subject to shatter, impact, abrasion, and shear.
- It is used in crack control and shrinkage for water retaining and reservoir structures to reduce the permeability and freeze-thawing conditions.
- Its replacement for temperature steel in sanitary sewer tunnels prevents corrosion and improves ductility
- Runways are made more resistant to fuel spills with less permeable and shatter resistance fiber reinforced concrete
- Pumped concrete project gets easy and safe with fiber, making concrete more cohesive and prevent segregation

3. Materials

3.1 Ordinary Portland Cement (Opc)

This is by far the most common cement in use. The process of manufacture of cement consists of grinding the raw materials mixing the intimately in certain proportions depending upon their purity and composition and burning them in a kiln at a temperature of about 1300^0C to 1500^0C, at which temperature, the material sinters and partially fuses to form modular shaped clinker. The clinker is ground to a fine powder with addition of about 2% to3% of gypsum. The product formed is called ordinary Portland cement.

3.2 Aggregates

Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However, it is now known that the type of aggregate used for the concrete can haveconsiderable effect on the plastics and hardened state properties of concrete. They can form 80% of the concrete mix so their properties are crucial to the properties of concrete.

Aggregates can be broadly classified into four different categories these are heavy weight, normal weight, light weight, ultra light weight aggregates. Howeverin mot concrete practice only normal weight and light weight aggregates are used. The other types of aggregate are for specialist uses, such as nuclear radiation shielding provided by heavy weight concrete and thermal insulation using light weight aggregate.

3.2.1 Classification of aggregates

The alternative used in manufacture of good quality concrete, is to obtain the aggregate in at least to size groups

1. Fine aggregates often called sand (BS 882; 1992) not larger than 5mm in size (BS 882, aggregates from natural sources for concrete, 1992).
2. Course aggregates, which comprises material at least 5mm in size.

All natural aggregate particles originally formed a part of large mass. This may have been fragmented by natural processes of weathering and abrasion or artificially by crushing. Thus many properties of the aggregates depend entirely on the properties of the parent rock. E.g. chemical and mineral composition, petrol logical character, specific gravity, hardness, strength, physical and chemical stability, pore structure and colour.

3.2.2 Fine Aggregate

By selecting different sizes and types of aggregates and different rations of aggregate to cement ratios, a wide range of mortar can be produced economically to suit different requirements. Important properties of an aggregate which affect the performance of the concrete.

3.3 Water

Water is a key ingredient in the manufacture of mortar and concrete. Water used in mortar and concrete mixes has two functions.

The first is to react chemically with the cement, which will finally set and harden, and the second function is to lubricate all other materials and make the mortar and concrete workable. Although it is an important ingredient of mortar, it has little to do with the quality of mortar. One of the mast common causes ofpoor quality mortar is the use of too much mixing water. Fundamentally “the strength of mortar is governed by the nature of the weight of water of the weight of cement in the mix, provided that is plastic and workable, fully compacted, and adequately cured”.

It has been said that there is much more bad mortar and concrete made through using too much good quality water than there is using the right amount of poor quality water. The rule of thumb for water quality is “if you can drink it, you can work mortar with it”. A large fraction of mortar is made using municipal water supplies. However, good quality concrete can be made with water that would not pass normal standards for drinking water.

3.4 Fiber reinforced plastic

Fiber-reinforced plastic is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, or aramid, although other fibressuch as paper or wood or asbestos have been sometimes used. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.

3.5 Polypropylene resin

Polypropylene (PP) resins designed to meet the demanding performance requirements of a variety of automotive, appliance, rigid packaging, consumer and industrial product applications. With over 50 years of commitment to the industry, our proven record in technological innovation and application expertise enables us to meet customer needs in a growing market. ExxonMobil^{TM}homopolymer (hPP), impact copolymer (ICP) and random copolymer (RCP) PP resins have a wide range of physical properties. They are manufactured to high standards worldwide, providing you with the reliability and quality consistency that successful businesses look for. In addition, our PP resin portfolio includes grades that can be used neat or as compound formulations.

4.Testing Methodology

4.1 Hardened concrete test

4.1.1 Compressive strength test

Compression test as per IS code clause 6.2 of IS456-2000

- The required quantity of ingredients was weighed and were prepared cubes with the help of moulds and cured for 7 days and 28 days.

- At the end of curing period, the cube was placed in between the compression plates of the universal testing machine and apply load gradually. The reading was noted at the time of first crack and at the time of failure
- The compressive strength can be calculated by ratio of compressive load and area of the cube.

4.1.2 Split Tensile Strength Test

- The required quantity of ingredients was weighed and were prepared cylinders with the help of moulds and cured for 7 days and 28 days.
- At the end of curing period, the cylinders were placed in between the compression plates of the Universal Testing Machine and apply load gradually.
- The reading was noted at the time of first crack and at the time of failure
- The tensile strength can be calculated by using formula 3.3 Tensile strength

$=2P/\pi xDxL\ N/mm^2$

Where

P-compressive load, D-Dia of cylinder mould, L-Length of cylinder

5. Result And Discussion

5.1 Compressive strength results

Each of the results was the average of three test specimens. The tests are conducted by varying the loading conditions with changing the application of resin.

Table 1: Compressive strength results of concrete specimens while loading Parallel to fiber while coated with resin

	Single Layer	Double Layer	Triple Layer
7 days	9.16	11.02	12.44
14 days	10.84	12.36	14.04
28 days	12.04	13.56	14.84

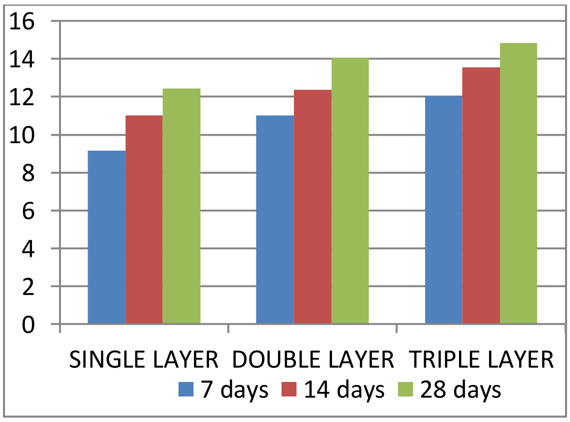


Table 2: Compressive strength results of concrete specimens while loading Parallel to fiber without resin coating

	Single Layer	**Double Layer**	**Triple Layer**
7 days	12.27	13.69	14.09
14 days	16.40	18.27	19.11
28 days	23.38	25.73	26.71

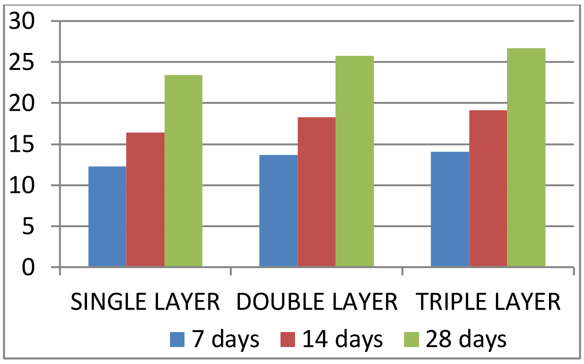


Table 3: Compressive strength results of concrete specimens while loading Perpendicular to fiber while coated with resin

	Single Layer	**Double Layer**	**Triple Layer**
7 days	11.38	13.29	14.00
14 days	15.29	17.91	18.98
28 days	22.93	24.76	26.62

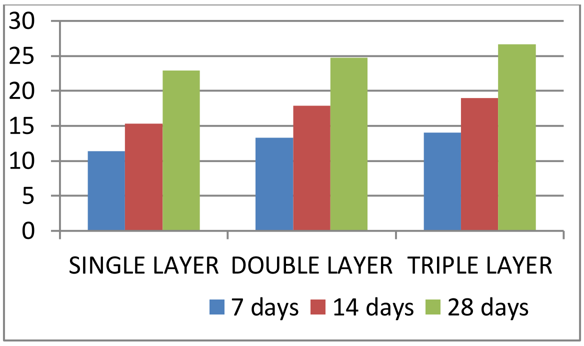
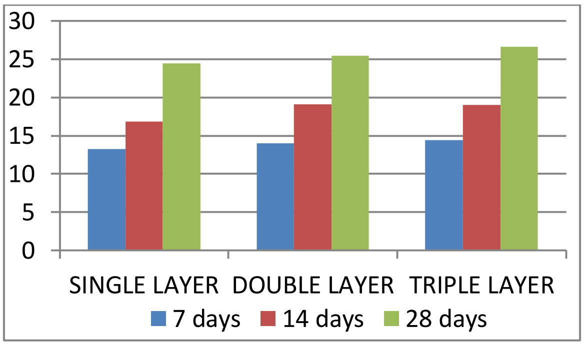


Table 4: Compressive strength results of concrete specimens while loading Perpendicular to fiber without resin coating

	Single Layer	**Double Layer**	**Triple Layer**
7 days	13.29	14.04	14.40
14 days	16.80	19.11	19.02
28 days	24.44	25.42	26.58



5.2 Split tensile strength results

Each of the results was the average of three specimens. Enhancement is split tensile strength of the specimen is noticed while placing fiber at outer side of the specimen. Results of the tensile strength are show below.

Table 5: Split tensile strength results of concrete specimens using plastic fiber Coated with resin

	Control Sample	Fiber Inside Concrete	Fiber Outside Concrete
7 days	4.76	4.58	5.38
14 days	7.24	6.04	8.27
28 days	9.69	8.18	10.53

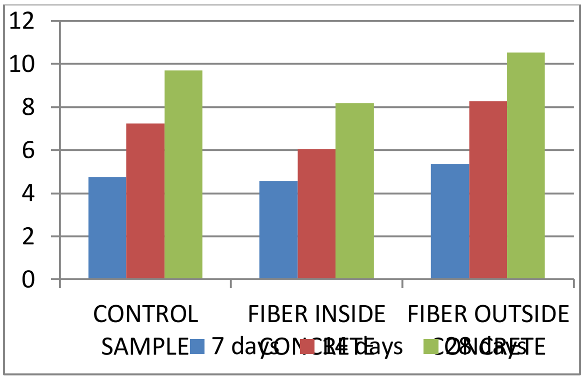
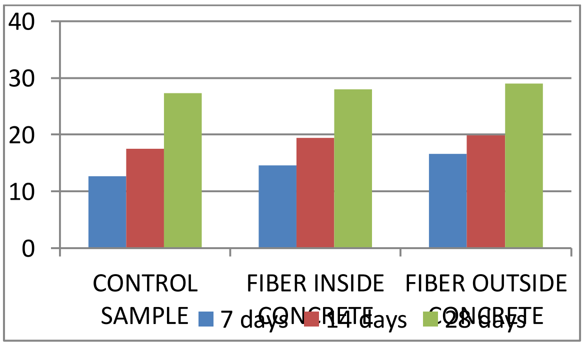


Table 6: Split Tensile Strength Results Of Concrete Specimens Using Plastic Fiber Without Resin Coating

	Control Sample	Fiber Inside Concrete	Fiber Outside Concrete
7 days	12.62	14.58	16.62
14 days	17.47	19.38	19.87
28 days	27.33	28.00	28.98



6. Conclusion

It is found that, the compressive strength are increased while the placing only the fiber. The split tensile strength has been increased while using plastic fibre sheet at the outer side of the specimen.

Benefits of using fiber-reinforced concrete are;

- Improve mix cohesion, improving pump ability over long distances
- Improve freeze-thaw resistance
- Improve resistance to explosive spalling in case of severe fire
- Improve impact resistance and abrasion resistance
- Increase resistance to plastic shrinkage during curing
- Improve structural strength
- Reduce steel reinforcement requirements
- Improve ductility
- Reduce crack width and control the crack widths tightly, thus improving durability

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