EFFECT OF NATURAL FIBRE AND INDUSTRIAL WASTES ON IMPROVING THE STRENGTH PROPERTIES OF CONCRETE

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Abstract – *This paper summarizes the research work on the experimental study on the effect of natural fibre and industrial wastes on improving the strength properties of concrete. Production of concrete leads to the emission of greenhouse gases in greater amounts and concrete being the most widely used construction material also raises the risk of environmental pollution and the depletion of natural resources. On the same hand, industries produce waste by-products of which the disposal is a serious issue in concern. Among such waste materials some can be effectively introduced in the field of construction; of some, due to their properties which are similar to that of the conventional materials and some due to which they can improve the desired properties of concrete. In the experiment coir is the natural fibre added. Coir fibre is added in varying percentages. Flyash and plastics are the waste materials used. 30% cement is replaced with cement and 1% plastic by weight of cement is added. The compressive strength, split tensile strength and flexural strength were determined using cube, cylinder and beam specimen after specified ages of curing.*

Key Words: Natural fibre, Industrial wastes, Greenhouse gases, Pollution, Strength properties

1. INTRODUCTION

Increase in technologies, industrialization and urbanization had put developments but certain problems were also rising along with it; environmental pollution and disposal of hazardous waste being two major problems in consideration. During the production of cement clinkers carbon-dioxide is emitted in greater quantities. Cement being an important ingredient of concrete, thus adds to pollution. Also increased demand of concrete has led to the depletion of natural resources why because conventional aggregates are of natural origin. From these points of view, taking a step forward to sustainable construction can be a matter of discussion. Most probably sustainable construction refers to a construction which is pollution free and which uses the minimum amount of natural occurring materials. A construction which is totally free from pollution is not possible but it is possible to reduce the extent of pollution with superior construction practices. But while thinking of the introduction of materials to concrete other than the conventional ones, it is very important to know about its properties. That means not any new material can be introduced into concrete but only those which satisfies the recommendations as per IS specifications.

Coir is a natural fibre obtained from the outer husk of coconut. It is the natural fibre with the greatest tensile strength. Usage of coir fibre in the field of construction can reduce the environmental pollution and also have the ability to bring some improvements in the characteristics of concrete. Coir fibre provides much resistance to sulphate attack and also reduces shrinkage. Flyash, also known as flue ash or pulverised fuel ash is a coal combustion product. It is composed of the type of particulates that are thrown out from coal-fired boilers along with the flue gases. Million tonnes of flyash are produced in the world annually. The disposal of this waste by-product is a major factor of concern. But flyash can be effectively used as a substitute for cement in concrete because of its pozzolanic nature. Usage of flyash in concrete does not have any significant negative alteration in the desired characteristics of concrete; rather, it can improve the strength properties. Disposal of used plastic is another important matter of consideration from the point of view of environmental pollution and damage. It is a remarkable fact that addition of plastic to concrete in limited quantities can make some improvements in the mechanical properties of concrete.

2. MATERIALS USED

Materials used in the work are OPC 53 grade, M sand, coarse aggregates, flyash, plastic granules and potable water. All the materials used in the work are tested in the laboratory to check whether they have property ranges as per IS recommendations.

2.1 OPC 53 Grade

Ordinary Portland cement is the most widely used cement for construction today. OPC is a type of hydraulic cement. When cement is added to dry ingredients and water, it starts to set, followed by a series of chemical reactions so as to produce mineral hydrates which solidify and hardens then. These mineral hydrates are not very water soluble. Drying out didn't make the concrete to set completely, but proper curing is required and is unavoidable so as to maintain the moisture content needed for the hydration reactions during the time of setting and hardening of cement. In the work conducted, Ordinary Portland cement of 53 grade confirming to IS 12269: 2013 was used. OPC 53 grade is high strength cement.

2.2 M sand

The aggregate which passes through 4.75mm IS sieve and which predominantly retains on 75μm IS sieve are called fine aggregates. Sand and crushed stone are usually used as fine aggregates. Fine aggregates fill the spaces between the larger coarse aggregates and also provide dimensional stability. It also reduces the cracks and shrinkages in concrete. In the work conducted, Manufactured sand (M sand) which confirms to IS 383: 1970 is used as the fine aggregates.

2.3 Coarse Aggregates

Coarse aggregates are the type of aggregates which will retain on 4.75mm IS sieve. Using the coarse aggregate with the maximum possible size within the limits can reduce the amount of cement and water needed thus making the concrete production more economical. Generally used coarse aggregates are crushed stone and gravel. In the work conducted, coarse aggregates confirming to IS 383: 1970 and of nominal size 20mm were used.

2.4 Flyash

Flyash is a finely divided by-product produced from the combustion of pulverized coal and is transported by the exhaust gases from the combustion chamber. Comparatively flyash is more fine powder than OPC. Every year, many million tonnes of flyash is being produced. It is a waste by product and its disposal is a great deal. But recently, flyash, due to its pozzolanic properties were incorporated in the construction filed as a partial substitute for conventional construction materials such as cement, as well as mineral additives. Along with being a solution for the disposal and environmental risks, using flyash in concrete can offer some benefits and can even improve the quality and performance of concrete. For the work, class F flyash is used, which is designated in ASTM C 618. Class F flyash has its origin from anthracite and bituminous coals. Major part of class F flyash is constituted of silica and alumina and it has a lower calcium content and higher loss of ignition than class C flyash. It also offers less heat of hydration and higher late compressive strength.

Fig- 1: Class F flyash

2.5 Coir Fibre

Coir fibre, simply known as coir, is a versatile natural fibre obtained from the outer husk of coconut. Coir fibre is known to have the highest tensile strength out of all natural fibres. Advantages of coir fibre include; resistance to fire, completely moth proof and has good resistance to fungi and rot, it is most probably unaffected by moisture and dampness, possess good tensile and ductile strengths, it is resilient and is very easy to clean. Using coir fibre in concrete can have many benefits that it can provide good tensile strength, reduce shrinkage, can offer good resistance to salt water and sulphate attack and can also provide durability. For the project work, processed brown coir fibres are bought from a local vendor. For the project work the fibres are cut in lengths of 2.5cm, corresponding to a diameter of 0.20mm and an aspect ratio of 125.

Fig- 2: Coir fibre

2.6 Plastic Granules

The properties including strength, resistance to weather, resistance to fire, durability, dimensional stability, chemical and thermal resistances, ductility, resistance to moisture, versatility, low cost etc., had made plastic one of the most demanded engineering material in use today. But after usage, the plastic material thrown away to earth is very dangerous because plastic contains toxic substances such as benzene and vinyl hydrochloride. Plastics are biodegradable and therefore if once it is thrown into the earth, it remains in the soil and causes pollution. In such a situation engineers worldwide had developed an idea of using the waste plastics in concrete in a harmless way and to improve some of the mechanical properties of concrete.

In the work conducted, the plastic used is high density polyethylene (HDPE) and it is added in the form of plastic granules. HDPE is a thermoplastic polymer produced from the monomer ethylene and it covers almost 34% of the global plastic market.

Fig- 3: Plastic granules

2.7 Water

Water is one of the main ingredients of concrete. Usually the quality of water used for construction is not always taken into consideration. But care must be taken not to use contaminated water. If the water taken contains impurities, those impurities may actively participate in the chemical reactions and can even put bad impact on the setting, hardening and the strength development of concrete. In the project work conducted potable water used for all purposes.

3. METHODOLOGY

The materials collected were tested in the laboratory to ensure whether they possess properties within the range specified by the standard specifications. Mix design is done for M40 grade concrete as per IS 10262: 2013. Cement is replaced with flyash at 30%. Coir fibre is added in varying percentages; 5%, 10%, 15% and 20% by weight of cement. Plastic granules are added at 1% by weight of cement. Specimens are cast using moulds of standard dimensions. The specimens cast are immersed in the water tank for curing. After completion of 7, 14 and 28 days of curing the specimens are taken out from the tank and are dried first. Later they were tested to find out the compressive strength, split tensile strength and flexural strength using cube, cylinder and beam specimen respectively.

4. RESULTS AND DISCUSSIONS

4.1 Cube Compressive Strength

The normal concrete mix obtained a maximum 28 days compressive strength of 40.10 N/mm^2. With the addition of 5% coir fibre, 30% flyash and 1% plastic granules, the compressive strength obtained is 41.42 N/mm^2, which is then increased to 41.86 N/mm^2 and 42.98 N/mm^2 with the addition of 10% and 15% coir fibre respectively with the percentage of flyash and plastic granules kept constant. The compressive strength is then decreased to 41.75 N/mm^2 by the addition of 20% coir fibre. Chart 1 shows the variation in compressive strength for different mixes.

Table- 1: Compressive strength values

Compressive strength in N/mm^2 after curing of	Mix designation				
	C-0	C-5	C-10	C-15	C-20
7 days	26.5	20.6	25.88	26.42	24.95
14 days	35.8	29.48	34.67	34.98	33.72
28 days	40.10	41.12	41.86	42.98	41.75

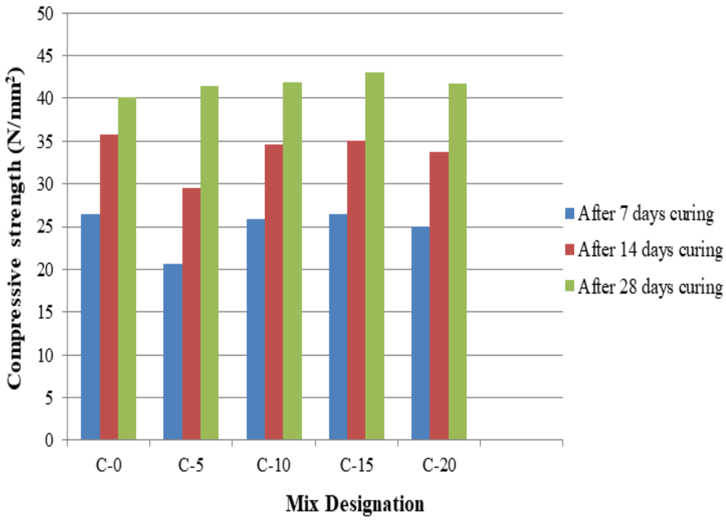

Chart- 1: Variation in compressive strength

4.2 Split Tensile Strength

The maximum split tensile strength obtained for 28 days curing is 5.41 N/mm^2. With the addition of 5%, 10% and 15% of coir fibre, the split tensile strength is increased to 6.52 N/mm^2, 6.83 N/mm^2 and 6.99 N/mm^2 respectively. This may be due to the addition of coir fibres which have good tensile strength and it could have acted like reinforcement. But later on when the percentage addition of tensile strength is increased to 20%, the tensile strength is reduced to 6.75 N/mm^2. Chart 2 shows the variation in split tensile strength for different mixes.

Table- 2: Split tensile strength values

Split tensile strength in N/mm² after curing of	Mix designation				
	C-0	C-5	C-10	C-15	C-20
7 days	2.18	1.86	2.122	2.14	2.08
14 days	3.26	2.92	3.14	3.23	3.10
28 days	5.41	6.52	6.83	6.99	6.75

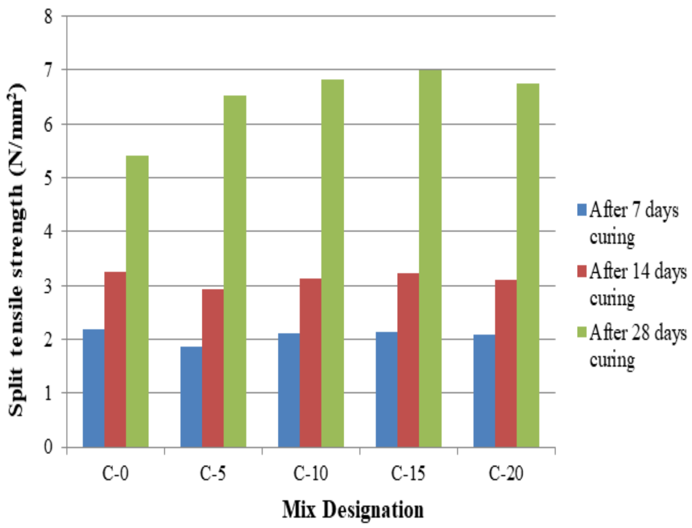

Chart- 2: Variation in split tensile strength

4.3 Flexural Strength

For the control mix, the maximum flexural strength of 28 days curing is 8.45 N/mm². The flexural strength of the non-conventional concrete is increased to 8.68 N/mm² and to 8.93 N/mm² with the addition of 5% and 10% coir fibre respectively. The maximum flexural strength obtained by the non-conventional mix is 9.12 N/mm² with the addition of 30% flyash, 15% coir fibre and 1% plastic granules. Later on with the addition of 20% coir fibre, the flexural strength is decreased to 8.76 N/mm² but this is greater than that obtained by the control mix. Thus the 28 days flexural strength obtained for all the non-conventional mixes is greater than that obtained for the normal concrete mix. When the compressive strength increases there are chances for the flexural strength to get reduced. But the addition of coir fibre and plastic granules could have makeover it. This may be because addition of coir fibre could have arrested the formation of cracks and the plastic granules could have provided enough ductility to the concrete mixes in which they are added, but only up to a certain extent. Chart 3 shows the variation in flexural strength for different mixes.

Table- 3: Flexural strength values

Flexural strength in N/mm² after curing of	Mix designation				
	C-0	C-5	C-10	C-15	C-20
7 days	2.51	1.98	2.34	2.45	2.31
14 days	5.3	3.6	5.19	5.28	4.97
28 days	8.45	8.68	8.93	9.12	8.76

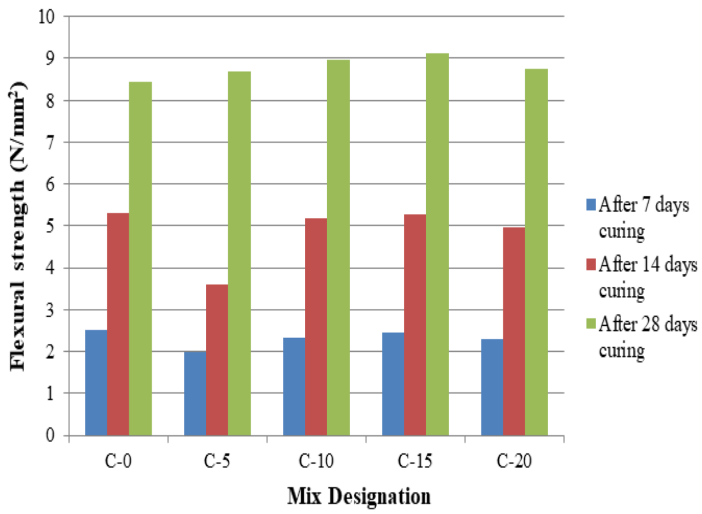

Chart- 2: Variation in flexural strength

5. CONCLUSIONS

The addition of flyash improved the workability of concrete along with the addition of coir fibre which made the concrete stiff. So a concrete with enough fluidity and stiffness is obtained. Due to the addition of flyash to concrete, the bonding between the ingredients get strong and it helped in increasing the compressive strength of concrete. The addition of coir fibre enhanced the tensile strength of concrete. Flexural strength of concrete is improved with the addition of coir fibre and plastic granules perhaps these additives could have makeover the reduction that may have occurred when the compressive strength get increased. This may be because addition of coir fibre could have arrested the formation of cracks and the plastic granules could have provided enough ductility to the concrete mixes in which they are added, but only up to a certain extent. The optimum percentage of coir fibre in concrete is 15%.

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