EXPERIMENTAL INVESTIGATION OF WASTE PLASTIC FIBER IN REINFORCED CEMENT CONCRETE USING RECYCLED COARSE AGGREGATE

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ABSTRACT

This study is aimed at investigating the shear strength and work ability characteristics of Fiber Reinforced High Strength Concrete (FRHSC) which use recycled coarse aggregates that have originated from demolished construction wastes. Different mixes were taken with 20%, 40% replacement of natural coarse aggregate with recycled coarse aggregate. To improve the ductility and performance, 1% steel fiber is also added to the concrete. The concrete has main advantage that it has a better compressive strength. The compressive strength of concrete can be represented as cube or cylinder compressive strength. The compressive strength of concrete is depending on size and shape of the test specimens. In this study, the conventional concrete was reinforced by the plastic fibers obtained from waste plastic bottles. The cube and cylinder compressive strength of conventional concrete and plastic fibers reinforced concrete were determined in the laboratory. The M30 grades of concrete and two fiber geometry at volume fractions 0.0 % to 3.0 % were used in the experimentations. All specimens were tested after curing age 28 days. In this paper the relationship between cube and cylinder compressive strength for conventional and plastic fibers reinforced concrete were established and compared with standards.

Keywords: Experimental, Investigation, Waste Plastic Fiber, Reinforced Cement Concrete, Recycled Coarse Aggregate

1. INTRODUCTION

Since the large demand has been placed on building material industry especially in the last decade owing to the increasing population which causes a chronic shortage of building materials, the civil engineers have been challenged to convert the industrial wastes to useful building and construction materials. This experimental study which investigates the potential use of waste plastic fibre for producing a low-cost and light weight composite as a building material. These alternatives were made with plastic fibre. Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. The use of recycled aggregates from construction and demolition wastes is showing prospective application in construction as alternative to primary (natural) aggregates. Research on the usage of waste construction materials is very important since the materials waste is gradually increasing with the increase of population and increasing of urban development. The reasons that many investigations and analysis had been made on recycled aggregate are because recycled aggregate is easy to obtain and the cost is cheaper than virgin aggregate.

2. METHODOLOGY

The methodology for the research is explain in pictorial representation in the flow chart.

Figure1 Methodology chart

3. MATERIAL COLLECTION

Introduction

The material collection is following cement, fine aggregate, recycled aggregate & paper.

Cement

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world 53 grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989.

Fine Aggregate

Concrete produced from a mixture of fine aggregate (sand), a binder (cement), and water. Fine-aggregate concrete is similar to building mortars in its composition and certain properties. It is used mainly for making thin-walled and conventional rein-forced-concrete structural components and products.Fine-aggregate concrete is used in highway and airfield construction because of the high tensile strength that results from its fine-grained structure. The absence of coarse aggregate (crushed stone or gravel) substantially facilitates the preparation, transport, and placing of the concrete, particularly when concrete pumps are used. A disadvantage of fine-aggregate concrete is the increased consumption of binder compared to other types of concrete and the associated greater shrinkage and creep. The quantity of binder in the concrete can be reduced by pulverizing some of the sand, by the use of plasticizers, or by autoclaving of products.The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60.

Coarse Aggregate

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS: 383 – 1970. Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

Recycled Aggregate

Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 per cent of concrete is made of aggregates. In that case, the aggregates considered are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. The enormous quantities of demolished concrete are available at various construction sites, which are now posing a serious problem of disposal in urban areas. This can easily be recycled as aggregate and used in concrete. Research & Development activities have been taken up all over the world for proving its feasibility, economic viability and cost effectiveness. Buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes.(Figure.2). There are many advantages through using the recycled aggregate. The advantages that occur through usage of recycled aggregate are listed below.

a) Environmental Gain
b) Cost
c) Job Opportunities
d) Sustainability

Plastic Fibre

Plastic is also is a waste and this waste is using for many works as recycle products. Among the plastics family Polyethylene Terephthalate (PET) is one of the major products using by the society in the form of various articles. In this connection a review is presenting below related to PET fibres and RAC. Conducted the experimentation on concrete with plastic waste. The plastic material was used as sand substitution in the concrete. The results showed that the use of plastic bottle waste was effective and it attracts as low cost material.(Figure.3)

Figure 2 Recycled Aggregate

Figure 3 Waste Domestic Plastics Are Made In To Fibre

4. MATERIALS PROPERTIES

Introduction

Materials properties like Properties of cement, Setting time, Consistency, Soundness and properties of fine & recycled aggregate

Properties Of Cement

Physical Properties Of Cement

Table 1 shows the Physical Properties Of Cement

Table 1 Physical Properties Of Cement

S.NO	PROPERTY OF CEMENT	VALUE
1	Fines of cement	7.5%
2	Grade of cement	53 Grade(OPC)
3	Specific gravity of cement	3.15
4	Initial setting time	30min
5	Final setting time	60min
6	Normal consistency	35%

Setting Time

- Cement paste setting time is affected by a number of items including: cement fineness, water-cement ratio, chemical content (especially gypsum content) and admixtures. Setting tests are used to characterize how a particular cement paste sets.
- For construction purposes, the initial set must not be too soon and the final set must not be too late. Normally, two setting times are defined:
- Initial set. Occurs when the paste begins to stiffen considerably.
- Final set. Occurs when the cement has hardened to the point at which it can sustain some load.
- Setting is mainly caused by C_3A and C_3S and results in temperature rise in the cement paste.
- False set :No heat is evolved in a false set and the concrete can be re-mixed without adding water
- Occures due to the conversion of unhydreous/semi hydrous gypsum to hydrous gypsum ($CaSO_4.2H_2O$)
- Flash Set: is due to absence of Gypsum. Specifically used for under water repair.

Consistency

- The consistency is measured by the Vicat apparatus using a 10mm diameter plunger.
- A trial paste of cement and water is mixed and placed in the mold having an inside diameter of 70mm at the base and 60mm at the top, and a height of 40mm.
- The plunger is then brought into contact with the top surface of the paste and released. Under the action of its weight the plunger will penetrate the paste. The depth depending on the consistency.

Soundness

- When referring to Portland cement, "soundness" refers to the ability of a hardened cement paste to retain its volume after setting without delayed expansion. This expansion is caused by excessive amounts of free lime (CaO) or magnesia (MgO). Most Portland cement specifications limit magnesia content and expansion.
- The cement paste should not undergo large changes in volume after it has set. However, when excessive amounts of free CaO or MgO are present in the cement, these oxides can slowly hydrate and cause expansion of the hardened cement paste.
- Soundness is defined as the volume stability of the cement paste.

Properties Of Fine Aggregate

Absorption, Porosity, And Permeability

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid. Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

Surface Texture

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or portland cement concrete. Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of portland cement concrete. Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category.

Strength And Elasticity

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle. High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

Hardness

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness. Weak particles have poor cementation. Neither type is acceptable. The Mohs Hardness Scale is frequently used for determination of mineral hardness.

Properties Of Coarse Aggregate

The shape and texture of aggregate affects the properties of fresh concrete more than hardened concrete. Concrete is more workable when smooth and rounded aggregate is used instead of rough angular or elongated aggregate. Most natural sands and gravel from riverbeds or seashores are smooth and rounded and are excellent aggregates. Crushed stone produces much more angular and elongated aggregates, which have a higher surface-to-volume ratio, better bond characteristics but require more cement paste to produce a workable mixture. The surface texture of aggregate can be either smooth or rough. A smooth surface can improve workability, yet a rougher surface generates a stronger bond between the paste and the aggregate creating a higher strength. The grading or size distribution of aggregate is an important characteristic because it determines the paste requirement for workable concrete. This paste requirement is the factor controlling the cost, since cement is the most expensive component.

It is therefore desirable to minimize the amount of paste consistent with the production of concrete that can be handled, compacted, and finished while providing the necessary strength and durability. The required amount of cement paste is dependent upon the amount of void space that must be filled and the total surface area that must be covered. The moisture content of an aggregate is an important factor when developing the proper water/cementitious material ratio. All aggregates contain some moisture based on the porosity of the particles and the moisture condition of the storage area. The moisture content can range from less than one percent in gravel to up to 40 percent in very porous sandstone and expanded shale. Aggregate can be found in four different moisture states that include oven-dry (OD), air-dry (AD), saturated-surface dry (SSD) and wet. Of these four states, only OD and SSD correspond to a specific moisture state and can be used as reference states for calculating moisture content. In order to calculate the quantity of water that aggregate will either add or subtract to the paste, the following three quantities must be calculated: absorption capacity, effective absorption, and surface moisture.

The density of the aggregates is required in mixture proportioning to establish weight-volume relationships. Specific gravity is easily calculated by determining the densities by the displacement of water. All aggregates contain some porosity, and the specific gravity value depends on whether these pores are included in the measurement. There are two terms that are used to distinguish this measurement; absolute specific gravity and bulk specific gravity. **A**bsolute

Specific **G**ravity (ASG) refers to the solid material excluding the pores, and **B**ulk **S**pecific **G**ravity (BSG), sometimes called apparent specific gravity, includes the volume of the pores.

Properties Of Recycled Aggregate

The crushing characteristics of hardened concrete are similar to those of natural rock and are not significantly affected by the grade or quality of the original concrete. Recycled concrete aggregates produced from all but the poorest quality original concrete Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This paste reduces the specific gravity and increases the porosity compared to similar virgin aggregates. Higher porosity of RCA leads to a higher absorption.In terms of composition, recycled aggregates, obtained from crushed waste concrete, consist of original aggregates and adhered mortar. Two factors which need to be taken into consideration in the use of these recycled materials in the production of new concrete is their structural behavior and durability. It is the percentage of recycled aggregate used, which influences the structural behavior of the new concrete. Also, durability of the recycled aggregate concrete depends on the heterogeneity of the recycled particles. Hence it is important to identify the mechanical, physical and chemical properties of the original coarse aggregates, as well as the original fine aggregates present in adhered mortar, to understand their suitability in the production of recycled concrete. The research involved experiments to analyze the structural behavior of recycled aggregate concrete, using different percentages of recycled aggregates.Construction and demolition waste control becomes indispensable from the moment that statistics refer to the waste's volume approaching an unsustainable level. The utilization of waste material as secondary raw material is the solution to the problem of an excess of waste material, not forgetting the parallel trend of improvement of final product quality. A systematic use of waste materials involves the classification of the mentioned waste materials according to their strength capacity, durability and utility. The basic components obtained from construction and demolition waste in concrete, masonry and mortar. Secondary raw aggregates are obtained from the waste crushed concretes. From a quality point of view, the original aggregates are heterogeneous in composition being derived from different minerals and adhered mortar. Primary raw coarse aggregate (granite) and sand (crushed limestone) were used indifferent concrete mixes.

Properties Of Water

Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6

Properties Of Plastic Fiber

Usually replacement of only 10% to 30% virgin sand is used for new concrete. Is approved using 100% recycled coarse aggregate produces acceptable quality concrete. Use of recycled fines, however, in a new mix requires close examination. Recycled fine aggregate is angular, with a high porosity and low specific gravity. The particles of crushed brick are generally more porous and have a lower density when compared to natural and recycled concrete aggregates. It is found that concrete made with crushed brick generally has comparable compressive and tensile strengths compared to those of conventional concrete. However, the modulus of elasticity, shrinkage, creep, initial surface absorption and chloride diffusion are inferior compared to those of natural concrete. Though, successful applications of crushed brick as the aggregates in the production of concretes are possible.

Fresh Concrete Properties

Workability

With the addition of furnace slag, the slump loss with time is directly proportional to increase in the slag content due to the introduction of large surface area in the concrete mix by its addition. Although the slump decreases, the mix remains highly cohesive.

Segregation And Bleeding

Furnace slag reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the furnace slag and hence the free water left in the mix for bleeding also decreases. Furnace slag also blocks the pores in the fresh concrete so water within the concrete is not allowed to come to the surface.

Hardened Concrete Properties

Compression Test On Concrete Cubes

The determination of the compressive strength of concrete is very important because the compressive strength is the criterion of its quality. Other strength is generally prescribed in terms of compressive strength. The strength is expressed in N/mm^2. This method is applicable to the making of preliminary compression tests to ascertain the suitability of the available materials or to determine suitable mix proportions. The concrete to be tested should not have the nominal maximum size of aggregate more than 20mm test specimens are either 15cm cubes or 15cm diameter used.

At least three specimens should be made available for testing. Where every cylinder is used for compressive strength results the cube strength can be calculated as under.
Minimum cylinder compressive strength = 0.8 x compressive strength cube (10 cm x 10 cm) The concrete specimens are generally tested at ages 7 days and 28 days.

Split Tensile Test On Cylinder

Concrete is strong in compression but weak in tension. Tension stresses are likely to develop in concrete due to drying shrinkage, rusting of reinforcement, temperature gradient etc.
In concrete road slab this tensile stresses are developed due to wheel loaded and volume changes in concrete are available to determine this. Split test is one of the indirect methods available to find out the tensile strength.

Flexural Test On Beams

It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced 6x6 inch concrete beams with a span three times the depth (usually 18 in.). The flexural strength is expressed as "Modulus of Rupture" (MR) in psi. Flexural MR is about 12 to 20 percent of compressive strength.

5. TESTING PROCEDURE

Introduction

The following test done by the concrete compressive strength of cube, flexural strength of beam & split tensile strength for cylinder

Compressive Strength Test

When a specimen of material is loaded in such a way that it extends it is said to be in tension. On the other hand if the material compresses and shortens it is said to be in compression. On an atomic level, the molecules or atoms are forced apart when in tension whereas in compression they are forced together. Since atoms in solids always try to find an equilibrium position, and distance between other atoms, forces arise throughout the entire material which oppose both tension and compression. The phenomena prevailing on an atomic level are therefore similar.The "strain" is the relative change in length under applied stress; positive strain characterises an object under tension load which tends to lengthen it, and a compressive stress that shortens an object gives negative strain. Tension tends to pull small sideways deflections back into alignment, while compression tends to amplify such deflection into buckling. Compressive strength is measured on materials, components, and structures. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a compressive test. The apparatus used for this experiment is the same as that used in a tensile test. However, rather than applying a uniaxial tensile load, a uniaxial compressive load is applied. As can be imagined, the specimen (usually cylindrical) is shortened as well as spread laterally. At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may calculated by using below formula. Figure. 4 shows Compression Test.
Compressive Strength = Load / Area
Size of the test specimen=150mm x 150mm x 150mm

Split Tensile Test

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. Figure.5 shows Split Tensile Test The formula used for calculation.

$$\text{Split tensile strength} = 2P/\mu dl$$

Flexural Strength Test

During the testing, the beam specimens of size 7000mmx150mmx150mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. Figure 6 shows Flexural Strength Test The fracture indicates in the tension surface within the middle third of span length. The flexural strength was obtained using the formula (R)
Where,

$$R = Pl/bd^2$$

R = Modulus of rupture (N/mm^2)
P = Maximum applied load (N/mm^2)
l = Length of specimen (mm)
b = Width of specimen (mm)
d = depth of specimen (mm)

Figure. 4 Compression Test

Figure.5 Split Tensile Test

Figure 6 Flexural Strength Test

6. TEST RESULTS

Introduction

The test result taking for mix design by M30 for as conventional as well as recycled concrete & plastic fibre concrete.

For M30 Grade Concrete

RATIO –I

Recycled Aggregate – 100 % by replacement of Coarse Aggregate

RATIO - II

Plastic Fibre – 20 % by replacement of Recycled Aggregate

RATIO –III

Plastic Fibre – 40 % by replacement of Recycled Aggregate

6.2. Compressive Strength

Table 2 shows Compressive Test results. Figure 7 shows Graph of Compressive Test

Table 2 Compressive Test

Control Mix		Compressive Strength in N/mm^2			
		CC (0%)	RECYCLED AGGREGATE	VARIOUS % OF PLASTIC FIBRE	
			40%	20%	40%
M30	7 DAYS	16.2	9.20	32	28.5
	14 DAYS	23.8	20.2	40	34.5
	28 DAYS	28.6	23.95	49.6	41.8

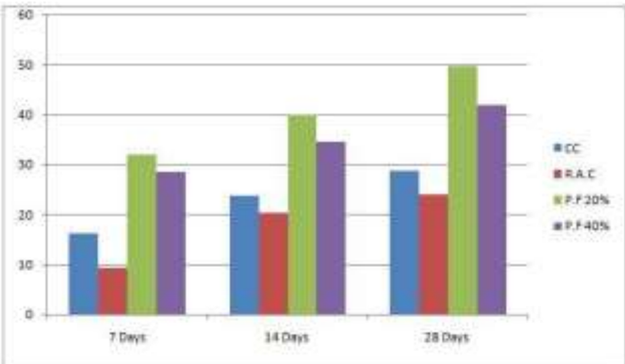


Figure 7 Compressive Test

Split Tensile Strength Of Concrete

Table 3 Split Tensile Strength Figure. 10 Graph Shown Split Tensile Strength

Table 3 Split Tensile Strength

Control Mix		Split Tensile Strength in N/mm²			
		CC (0%)	RECYCLED AGGREGATE 40%	VARIOUS % OF PLASTIC FIBRE 20%	VARIOUS % OF PLASTIC FIBRE 40%
M30	7 DAYS	1.78	2.26	2.46	2.15
	14 DAYS	1.98	2.67	2.78	2.37
	28 DAYS	2.68	3.28	3.1	2.6

Figure 8 Split Tensile Strength

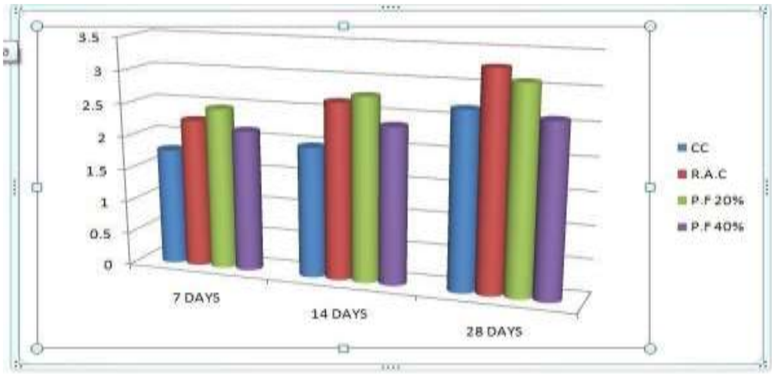


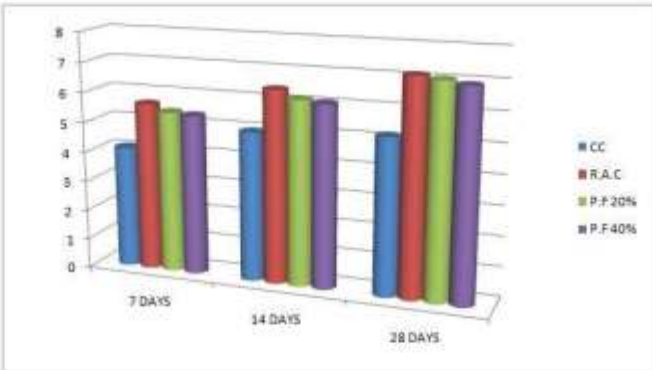
Table 6 Flexural Strength

Flexural Strength On Beam

Table 6 shows Flexural Strength. Figure.9 shows Graph of Flexural Strength

Control Mix		Flexural Strength in N/mm^2			
		CC (0%)	RECYCLED AGGREGATE	VARIOUS % OF PLASTIC FIBRE	
			40%	20%	40%
M25	7 DAYS	4.1	5.64	5.42	5.36
	14 DAYS	4.98	6.42	6.15	6.08
	28 DAYS	5.2	7.15	7.06	6.95

Figure 9 Flexural Strength



CONCLUSION

- The behavior of green concrete under slump and compaction factor tests shows that workability is reduced in PFRC. It was due to resistance offered by the fibers to the movement of aggregates. The dry density is also reduced in PFRC but it is beneficial to reduce dead weight of concrete.
- Utilisation of fibres in plastic concrete in various proportions to improve the strength.
- Plastic fibres along with steel fibres can be used to improve the strength of concrete.
- This preliminary study has thus shown that the relationships between compressive strength, as used in European standard for plain concrete, can be applied to concrete containing PET-fibers.
- The relationship between cube and cylinder compressive strength is linear.
- In Our Project We Discuss 100% Of Recycled Aggregate With Various Percentage Of plastic fibre as 20%, 40%.
- Replacement Level Of 40% Recycled Aggrgate in concrete mixes was found to be the optimum level to obtain higher value of the strength at the age of 28 days.
- The Optimum Level Of Compressive Strength Is 49.6 N/mm^2 With The Replacement Of 40% plastic fibre.
- This preliminary study has thus shown that the relationships between compressive strength, as used in European standard for plain concrete, can be applied to concrete containing PET-fibers.

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