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Experimental Investigation on Steel Fibre Reinforced Concrete Made Pet Waste Pet Waste with Partial Replacement of Coarse Aggregate

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***Abstract:* - Concrete is a composite material consisting of mortar and coarse aggregate.An existing problem of concrete is formation of crack.In this study feel fibres are added in concrete to control the concrete 1,1.5,2%of steel fibre is added in concrete, which is the efficient percentage of addition in reinforced concrete. In addition to that to overcome the scarcity of conventional coarse aggregate now-a-days usage of (PET)poly ethylene terephthylate is highly recommended. A conventional method is proposed by using (PET)poly ethylene terephthlate as partial replacement of coarse aggregate to its weight with addition of 1,1.5,2% of steel fibre to the volume of concrete in specimen. Cube of size 150 x 150 x 150 mm is casted and tested, which is designed according to Indian standard codes. The flexural properties of the cube are compared between control specimen and 5%, 10%,15% and 20% partially replaced (PET)poly ethylene terephthalate as coarse aggregate specimens**

INTRODUCTION:

Concrete is known as a brittle material with low bearing capacity for deformation under tensile stress. The development of these tensile stresses are mechanical loading, harmful reactions and environmental loading. Cracks which affect the structural performance of the concrete are caused mainly due to this stress. In order to control the formation of and development of these cracking fibre are introduced in concrete.

Use of steel fibre concrete has steadily increased during the past years. Considerable developments have taken place in the field of steel fibre reinforced concrete. The current field of application of steel fibre reinforced concrete in highway and airfield pavement, bridge decks, hydraulic structures, tunnel linings etc. There are many research works done on adding steel fibre in concrete to increase the structural properties of the concrete.

It is proved that addition of steel fibres in concrete increas-es many of the engineering properties in mortar and con-crete. Flexural strength, fatigue strength, tensile strength and the ability to resist cracking and spalling are also en-hanced.

The most suitable volume fraction values for concrete mix-es are 0.5% to 2.5% by volume of concrete. The most opti-mum percentage of mix to be added in concrete is 1% as addition more amount of steel fibre increases the efficiency but the workability of concrete is reduced.

Among different waste fractions, plastic waste deserves special attention on account non-biodegradable property which is creating a lot of problems in the environment. In India approximately 40 million tons of solid waste is produced annually. This is increasing at a rate of 1.5 to 2% every year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. The PET bottles cannot be disposed of by dumping or burning, as they produce uncontrolled fire or contaminate the soil and vegetation.

Considerable researches and studies were carried out in some countries like USA and UK on this topic. However, there have been very limited studies in India on plastics in

Concrete.

Hence an attempt on the utilization of waste Poly-ethylene Terephthalate (PET) waste and steel fibre granules[1] as fine aggregate is done and its mechanical behaviour is investigated.

ABOUT THE PROJECT

A. *Objectives of the Proposed Project*

The main objectives of this research proposal are to evaluate the possibility of using granulated plastic waste materials. The following were also proposed.

- As partial substitute for the coarse aggregate in concrete composites
- To investigate the structural behavior of such replaced concrete components
- To investigate the mechanical behavior of the components by using fibers.
- To determine the percentage of plastic fibre which gives more strength when compared to control concrete.

B. *Importance of the present project*

The problem of disposing and managing solid waste materials in all countries has become one of the major environmental, economical, and social issues. A complete waste management system including source reduction, reuse, recycling, land-filling, and incineration needs to be implemented to control the increasing waste disposal problems.

Typically a plastic is not recycled into the same type of plastic products made from recycled plastics are often not recyclable. The use of biodegradable plastics is increasing. If some of these get mixed in the other plastics for recycling, the reclaimed plastic is not recyclable because the variance in properties and melt temperatures.

The purpose of this project is to evaluate the possibility of using granulated plastic waste materials to partially substitute for the fine aggregate (sand) in concrete composites.
Recently, these aggregates started to be used for intermediate utility applications, such as foundations for buildings and roads. The advantages of recycling construction and demolition waste are it reduces the amount of construction and demolition waste entering landfill sites; and it reduces the use of natural resources in construction, contributes to the environment, provides a renewable source of construc-tion material, and, if used in situ, reduces haulage costs. For economical and environmental reasons and because of the increased amount of Re-Cycled Aggregates, there has been a growing global interest in maximizing the use of Re-Cycled Aggregates in construction. In view of the increased volumes of construction, demolition waste, and industrial by-products such as fly ash (FA) and the advan-tages offered by the use of admixtures in modern concrete, it is considered very beneficial from different prospects with similar performance characteristics to natural aggre-gate concrete. When proved successful, recycled aggregate concrete (RCA) can be substituted for natural aggregate concrete in many concrete applications. In this study an at-tempt is made to experiment the flexural behaviour of the steel reinforced concrete slabs with a replacement in aggre-gate with Re-Cycled aggregates.

2. EXPERIMENTAL PROGRAM:

2.1 MATERIALS USED:

2.1.1 CEMENT

Cement is a powdered material that serves as a binder in mortar or concrete after reactions of lime or lime com-pounds have taken place with appropriate medium-usually water. Portland cement is one of such materials, composed largely of calcium and aluminum silicates, in which the former upon reaction with water produces the new com-pound capable of imparting stone like quality to the mix-ture. While the specific gravity of Portland cement ranges from 3.12 to 3.16, its unit weight varies with the degree of compaction. The chemical, physical and mechanical prop-erties of cement are attributed to the basic constitutive compounds, the fineness to which the cement is ground and the ambient condition during the hardening process. In cement chemistry, it is customary to report the results of the chemical analysis in terms of the oxides of the ele-ments present, although such compounds do not occur as oxides, nor do the oxides form the unit cell of the crystal- line structure of the major cement compound. The basic constitutive elements are lime (CaO), silica (SiO_2), alumina (Al_2O_3), iron (Fe_2O_3 or FeO), gypsum ($CaSO_4.2H_2O$), magne-sia (MgO), and alkalies (Na_2O and K_2O). The characteristic compounds in Portland cement are shown below. The rela-tive composition of the chemical compounds in Portland cement results in different types of cement such as normal Portland cement, high-early-strength cement, sulfate resist-ing cement etc, which could be meant for different purpos-es

Properties	OPC 53 values
1) Lime saturation factor	0.9
2) Alumina Modulus	1.23
3) Insoluble residue (%)	0.25
4) Magnesia (%)	1.1
5) Sulphuric anhydrideSO3 (%)	1.5
6) Loss on ignition (%)	0.8
7) Chloride (%)	0.002
8) C3A Content	7
9) Humidity (%)	65±5

2.1.2 Aggregates

Aggregate is one component of FRC, which is connected into a cohesive whole by means of binding materials-the cement paste. Aggregates are usually inert materials or ar-tificially manufactured from industrial products, which are added to cement paste in order to improve strength, du-rability and structural performance of concrete. Those ag-gregates from natural sources are conventionally adopted as concrete materials, and those from artificial ones are either light in weight or high density, developed for spe-cific structural applications and also for solving part of the problems related to the shortage of naturally occurring ag-gregates. Aggregates can be explained with respect to pet-rological (rock type), mineralogical, and geological exami-nations, of which the later two basis are of great helpful in recognizing properties and qualities of aggregates for our purpose.

2.1.3 Fine Aggregate

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. The most com-mon of sand is Silicon di- Oxide, usually in the form of

Quartz. Normally river sand is used as fine aggregate for preparing concrete. An Individual particle in this range is termed as sand grain. These sand Grains are between Grav-el (2 mm – 64mm) and silt (0.004mm – 0.0625mm). Ag-gregate most of which passes 4.75mm IS sieve is used. Lo-cally available river sand Zone III having a specific gravity of 2.62, fineness modulus of 2.75 is used.

2.1.4 Coarse Aggregate

Aggregates are the most mined material in the world. Ag-gregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinfor cement to add strength to the overall composite materi-al. Gravel of Size 20mm is sieved and used. Crushed gran-ite coarse aggregate of maximum size 20 mm and having a specific gravity of 2.387, fineness modulus of 6.64 is used.

2.1.4PET(polyethylene terephthalate)

Type Semi crystalline polymer
Specific gravity 1.35
Tensile Strength 190-260GPa
Tensile Modulus 2-4GPa
Specific Heat 1200$JK^{-1}Kg^{-1}$
Melting point 260^{0}C
Young Modulus of Elasticity 2.5x10^{9}Nm^2
Glass transition Temperature 75^{0}C

2.1.5Superplasticizer

Table: 3 Properties of SMOF

CAS NO	64787-97-9
Appearance	Pale Yollwish liquid
P^H Value	8 to 10
Solubility	Completely soluble in water
Solid	40%
Specific gravity	1.236

2.1.5 Water

In the production of concrete, water is used for mixing, wash-ing of aggregate and curing of the final concrete product. Mixing water should contain no substances that can have an appreciably harmful effect on the process of hydration or upon the durabil-ity of concrete during its service period. Water having appreci-able amounts of impurities-silt, oil, acids, alkalies, salts of al-kalies, organic matter and sewage may have an injurious effect upon concrete. The reduction in strength of concrete through the use of water suspected of undesirable substances could be as high as 10% [29]. The effect of same amount of impurities in water for washing aggregate is much greater than that of mixing water. Such water if used for washing aggregate causes deleterious coat-ings (silts, salts or organic materials) on the surface of aggregate particles. Water containing sufficient amount of acidic or organic substances should be regarded with suspicion to be used for cur-ing of concrete.

2.1.6 Steel Fibre

Steel fibre is one of the most commonly used fibre. Gener-ally round fibres are used. The diameter may vary from 0.25 to 0.75mm.The steel fibre sometimes gets rusted and lose its strength. But investigations have proved that fibres get rusted only at surfaces. It has high modulus of elasticity. Use of steel fibres makes significant improvements in flexure, impact and fa-tigue strength of Concrete. It has been used in various types of structures.

Fibre properties	Quantity
Average fibre length (mm)	50
Diameter (mm)	1
Aspect ratio	50
Tensile strength (MPa)	1100
Specific Gravity	7.85

2.2 Mix Design:

M25 grade concrete was used for the study. The ratio attained from the mix design is 1:1.67:2.41. The mix design was obtained according to the IS code method. The water cement ratio is taken as 0.5. The quantity arrived for per cubic meter of concrete is given below

Mix ID	Cement (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)	Aggregate (kg/m^3)	PET (kg/m^3)	Steel Fibre (%)
M	380	830	148	1130	0	1
M1	380	830	148	11299.43	0.667	1
M2	380	830	148	1138.86	1.334	1.5
M3	380	830	148	1138.29	1.805	1.5
M4	380	830	148	1127.73	2.278	2

1.1. H. Casting details

Fresh concrete was cast in steel moulds and compacted on a vibrating table. The specimen prepared in this study were; 150 mm cubes for compressive strength as per IS 516-1999 (13) and 150 mm x 300 mm cylinder for split tensile strength as per IS 5816 – 1999 (14)

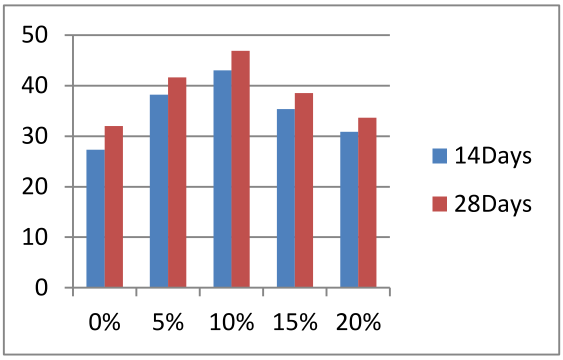
1.2. Test Methods

Six specimens each were casted and tested in the case of compressive strength and split tensile. The normal moist curing was adopted for 28 days. The cube specimens were left in the moulds for 24 hour. After remolding, the specimens were transferred into the water for curing until the age of test. The strength test was performed on a universal testing machine.

III.RESULT AND DISCUSSION

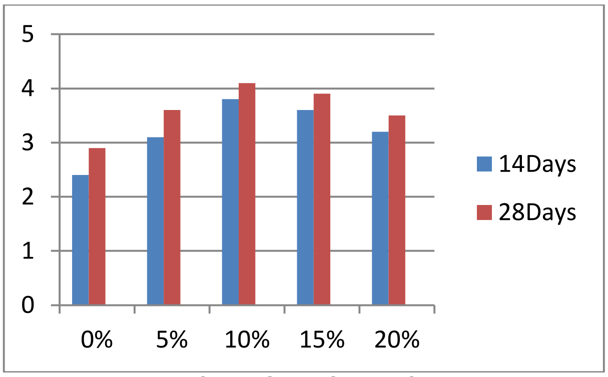
A. Compressive Strength

It was noticed that the compressive strength increased up to1.5%steel fibre replacement of the fine aggregate with PET bottle fibres and then decreased for 4% and 6% replacements as in figure a. Hence replacement of fine aggregate with 2% replacement will be reasonable [5]. So, in general for given w\c ratio, the use of plastics reduces compressive strength. But for a particular PET aggregate content, compressive strength decreased with w/cratio. The effect of w/c ratio in strength development is not important in this case as plastic aggregate reduce the bond strength of concrete and sometime becomes the reason of its failure.



b. Split tensile strength

It was observed that the split tensile strength gradually increased up to 5% replacement of the fine aggregate with PET bottle fibres and it decreased for 4% and 6%replacements as in figure b. Hence, the replacement of the fine aggregate with 2% replacement will be reasonable with high split tensile strength compared to the other specimens casted and tested.



Chat 2 split tensile strength
% PET replacement
%Steel fibre

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