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# Experimental Investigation of Using Recycled Plastic Aggregates in Concrete with OPC 53 Grade

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***Abstract:*** ***Plastic pollution is one of the greatest causes of global warming. Disposal of large quantity of plastic waste products causes environmental & health issues .This report will discuss a solution to plastic pollution by conducting to recycle the plastic and reuse in concrete, so the waste plastic is recycled into plastic aggregates. This paper aims to enhance the concrete mechanical properties by replacement of natural coarse aggregate with recycled plastic aggregates and by adding polypropylene fibers in combination with high performance cement as a partial replacement of cement. This both combinations in concrete gave excellent values of compressive strength and tensile strength. Replacement of coarse aggregate weight by 5%, 10%, 15%, 20%, 25% of recycled plastics and for each replacement percentages polypropylene fibres of 0.5%, 1.0%, 1.5%, 2.0% with partial replacement of cement were conducted. In literature reported that the addition of recycled plastic causes the reduction of strength due to poor bonding between concrete and plastics, to overcome this problem the addition of polypropylene fibres which has a good bonding property will improve the concrete strength were added. Result shows that 15% replacement of natural aggregates with plastic aggregate achieves the maximum strength of concrete.***

***Keywords****: Re-cycled plastic aggregates, polypropylene fibres, high performance cement, compressive strength, split tensile strength.*

## I. INTRODUCTION

Concrete is that the most used man-made material and second is that water because the most utilized thing in the world. In simple words it's defined as a mix of four ingredients as coarse aggregate that forms the largest proportion of the combination, fine aggregates like sand that acts as filler material within the voids, binding material like lime or Portland cement that binds together and water that reacts with binding material. The mixture of those four materials gives as a paste. At this stage, it's called fresh concrete and gets hardened because the water reacts with binding material. This reaction is termed hydration of concrete. In fresh state concrete are often casted into any desired shape by placing it in forms. This property of concrete can helps in using the concrete in best manner. The potential application of industry by-products in concrete are as partial aggregate replacement or as partial cement replacement, affects on their chemical composition and grain size. the employment of those materials in concrete comes from the environmental constraints within the safe disposal of those products.

Big attention is being focused on the environment and safeguarding of natural resources and waste materials. Lot of works concerning, the utilization of several sorts of urban wastes in building materials. Many researches are extended to check new sorts of wastes to analyze deeply particular aspects. The addition of wastes, other than the environmental benefits, also produces good effects on the properties of ultimate products obtained.

One of the waste materials utilized in the concrete is recycled plastic waste. Among the waste materials, plastics have received plenty of attention because they're generally not biodegradable. Reuse of plastic in concrete industry is taken into account as a most feasible application. Plastic consumed annually has been growing steadily becomes a heavy problem. From different points it's important to reuse plastic waste. It helps to save lots of and sustain natural resources specified decrease the pollution of the environment. Use of plastic isn't only solving the matter but also cost of fabric is low. That the use of waste materials as aggregatesin concretecan deeply affect the quantity of waste materials. Many recycling process of plastic it'll lose their strength specified its minimum recycle process utilization as coarse aggregates. Plastic will be separated into two types. the primary type is thermoplastic, which may be melted for recycling within the plastic industry. These plastics are polyethylene, polypropylene, polyamide, polyoxymethylene, polytetrafluoroethylene, and polyethyleneterephthalate. The second type is thermosetting plastic. This plastic cannot be melted by heating because the molecular chains are bonded firmly with messed crosslink. However, these processes are costly. If the thermosetting plastic waste will be reused, the pollution that's caused by the burning process is reduced. However, the plastics have many good characteristics which include versatility, lightness, hardness, good chemical resistance.

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### *A. Plastic Recycling*

Recycling is the process of converting waste materials into new materials and objects. Recycling can prevent the waste of potentially used materials. Firstly it preserves the precious natural resources; secondly prevents pollution by reducing the need to collect new raw materials and also reduces the amount of waste sent to landfills. Plastic can be recycled by chemical modification, mechanical recycling, thermal reprocessing and fillers.

### *B. Advantages of Using Plastic*

*1)* Lighter weight than competing materials.
*2)* Durability and longevity.
*3)* Resistance to chemicals, water and impact.
*4)* Excellent thermal and electrical insulation properties.
*5)* Comparatively lesser production cost.

By adding polypropylene fibers into the concrete, the plastic shrinkage cracks of concrete at the early age reduced and it can also reduce the surface bleeding and settlement of aggregates of fresh concrete, which can prevent the formation of setting cracks.

## II. MATERIALS AND THEIR PROPERTIES

In this project, recycled plastic waste materials were effectively used to produce structural concrete. The following materials were used in this investigation.

### *A. Materials Used*

The quality of concrete depends on the proper mix proportions of selected materials and proper handling techniques.

#### *1) Cement and Its Properties*

Specific gravity of cement = 3.02
Fineness of cement = 95.11%
Standard consistency of cement paste is 33%
Initial setting time of cement is 49 minutes

#### *2) Fine Aggregate and Its Properties*

Specific gravity2.585
Grading of sand Zone-III
Fineness modulus 2.397

#### *3) Coarse Aggregate and Its Properties*

The specific gravity of coarse aggregate obtained is 2.91 and water absorption is 0.25% and the procedure followed according to IS383-1970.

#### *4) Properties of Plastic Aggregates*

Recycled plastic was used to replace coarse aggregate for making concrete specimens. Plastic collected from the disposal area were sorted to get the superior one. These were crushed into small fraction and then it was heated to a particular temperature. After extrusion the molten plastic was collected approximately. These plastic boulders were crushed to the size of aggregates. The process of grinding the plastic materials plays a significant role in the beginning by improving mechanical properties of concrete.

Fig.1Plastic aggregates

TABLE I
PHYSICAL PROPERTIES OF PLASTIC AGGREGATES

| Properties | NCA | PCA |
|---|---|---|
| Specific gravity | 2.74 | 0.9 |
| Density | 3.14 | 0.81 |

Therefore, from the above table NCA indicates Natural coarse aggregate and PCA indicates plastic coarse aggregates.

*5) Polypropylene Fiber*

Polypropylene fiber is a synthetic fiber formed from a polypropylene melt. It has lower wear resistance. It displays good heat – insulating properties and is highly resistant to acids, alkalies, and organic solvents. Polypropylene is the lightest of all fibers and is lighter than water.

Fig.2Polypropylene fiber

*6) Water*

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregates together. In general, water that is fit for human consumption is acceptable for use as mixing water. The role of water is important because the water to cement ratio is the most critical factor in the production of perfect concrete.

## III. MIX DESIGN AND MIX PROPORTIONS

*A. General*

Concrete mix is the way by which we choose the different constituents used in the concrete and determining their amount and by taking care about the economy and various properties of the concrete like workability, slump value, strength criteria etc. For designing the concrete mix we followed IS:10262-2009. A design of M30 grade of concrete was prepared and trail mixes were prepared to check the mix design and to adjust amount of admixture and water cement ratio. The following parameters were used for mix design.

*B. Requirements for Conventional Concrete*

Following are the specifications provided for the concrete mix.

| | |
|---|---|
| Grade designation: | M30 |
| Type of cement: | OPC 53 GRADE |
| Nominal size of aggregate | 20mm |
| Minimum cement content | 320kg/m$^3$ |
| Water to cement ratio | 0.45 |
| Workability | 100mm (slump) |
| Exposure condition | moderate |

*1) Test Data for Materials*

| | |
|---|---|
| Specific gravity | 3.15 |
| Coarse aggregate | 2.75 |
| Fine aggregate | 2.69 |
| Water absorption for coarse aggregate | 0.54 |
| Sieve analysis | |
| Fine aggregate | zone-III as per IS 383 table no 4 |

*C. Mix Proportions*

Cement =447kg/$m^3$
Fine aggregate=756kg/$m^3$
Coarse aggregate=1001kg/$m^3$
Water = 197kg/$m^3$
Water-cement ratio=0.47
Mix proportion by weight=1:1.69:2.23
Here there are different mixes were adopted in this project along with conventional mix concrete differentiate the results.

## IV. EXPRERIMENTAL METHODOLOGY

*A. Methodology*

The recycled plastic waste was added in different mixes ranging from 0% plastic to 25% plastic and polypropylene fibers of 0.5%, 1%, 1.5%, 2% were used. For the purpose of this experiment cement, fine aggregate, coarse aggregates, recycled plastic aggregates, polypropylene fibers, and water contents were have been used. As the plastic waste percentages increase per mix, the weight of the coarse aggregates usage decreased.

*B. Preparation of Concrete*

The representation of concrete from mixing to compaction depends upon workability. The test procedure comprised of casting cubical and cylindrical specimen and then testing these specimens for compressive strength and splitting tensile strength respectively. The specimens were selected mixed casted and cured and finally conducting the test.
The following procedures were adopted for preparing concrete:

1) *Batching:* The process of measuring different concrete materials such as cement, coarse aggregate, sand, water for the making of concrete batching can be done in two different ways. In volume batching the measurements of concrete materials are taken by volume & on the other hand the measurements are taken by weight in weight batching.
2) *Mixing:* In this process, all the materials are thoroughly mixed in required proportions until the paste shows uniform color and consistency. Hand mixing and machine mixing are the two different methods of mixing .such that hand mixing was been chosen.
3) *Transportation:* When the mixing is done properly the freshly made concrete is then transported to the moulds without any delay.
4) *Casting and Curing:* For casting, all the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage out of slurry. Careful procedure was adopted in the batching, mixing and casting operations. The coarse aggregates and fine aggregates were weighted first. The concrete mixture was prepared by hand mixing on a watertight platform. On the watertight platform, the coarse and fine aggregates were mixed thoroughly. To this mixture cement was added. These were mixed to uniform. Then water is added carefully so that no water was lost during mixing. Clean and oiled moulds for each category were then placed on the vibrating table respectively and filled in three layers. Vibrations were stopped s soon as the cement slurry appeared on the top surface of the mould.

*C. Fresh Properties of Concrete*

1) *Workability of Concrete:* Slump test was done to determine the workability of concrete.
2) *Slump Test:* Concrete slump test or slump cone test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the quality of construction.

*D. Tests on Hardened Concrete*

The concrete specimens were casted and the testing of specimens done at 7 days and 28 days of curing. The tests are conducted compressive strength test, split tensile strength, and flexural strength test. The tests are carried out based on the IS 516-1959.

*E. Compressive Strength*

Compressive strengths are used to determine the material behavior under a load. The maximum stress a material can sustain over a period under a load (constant or progressive) is determined. Compression testing is often done to break (rupture) or to a limit.

*1)* Remove the specimen from the water after specified curing time and wipe out excess water from the surface.
*2)* Clean the bearing surface of the testing machine.
*3)* Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
*4)* Align the specimen centrally on the base plate of the machine.
*5)* Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
*6)* Apply the load gradually.
*7)* Record the maximum load and note any unusual features in the type of failure.

Compressive strength (C) = P/A

Where P=maximum applies load in Newtons

A=Area of cross section of cube in $mm^2$

Fig.3 Compressive Strength

*F. Split Tensile Strength*

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures .It is necessary to determine the load at which the concrete members may crack.

*1)* The sample is taken out from the curing tank and set for drying for 1 to 2 hours.
*2)* On either side of cylinder of specimens draw the diametrical lines to make sure that the lines represents on the same axial place.
*3)* Place the plywood strips on the lower plate of CTM and fix the cylinder over it.
*4)* After the load gradually over the cylinder without any sudden moments until the specimens cracks.
*5)* As per IS 456-2000 the tensile capacity of concrete is $0.7\sqrt{fck}$.

Split tensile strength=$PD/\pi DL$

P=load at failure

D= Diameter of specimen

L=Height of specimen

Fig.4Split tensile strength

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## V. RESULTS

TABLE II
Slump test values for different mixes

| S. No | Plastic (%) | Slump value |
|---|---|---|
| 1. | 0 | 78 |
| 2. | 5 | 73 |
| 3. | 10 | 69 |
| 4. | 15 | 63 |
| 5. | 20 | 57 |
| 6. | 25 | 53 |

TABLE III
Compressive strength of concrete(N/MM2)

| Mix names | 7 days | 14 days | 28 days |
|---|---|---|---|
| M1 | 21.2 | 27.6 | 30.5 |
| M2 | 22.57 | 27.8 | 30.63 |
| M3 | 25.45 | 28.9 | 32.5 |
| M4 | 24.42 | 27.1 | 29.86 |
| M5 | 19.84 | 25.98 | 28.74 |

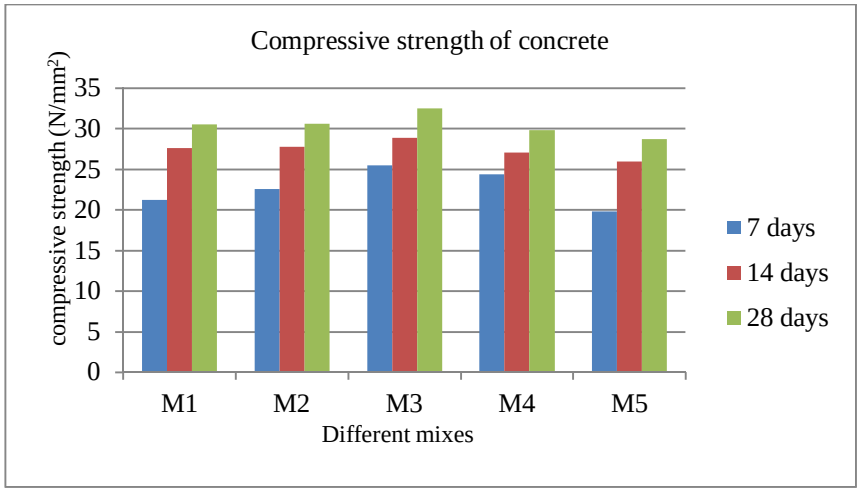


Fig.5 Compressive strength of concrete for different mixes

TABLE IV
Split tensile strength of concrete (N/MM2)

| Mix names | 7 Days | 14 Days | 28 Days |
|---|---|---|---|
| M1 | 2.01 | 2.72 | 2.98 |
| M2 | 2.47 | 2.86 | 3.12 |
| M3 | 2.51 | 2.91 | 3.19 |
| M4 | 2.33 | 2.79 | 3.04 |
| M5 | 2.1 | 2.68 | 2.97 |

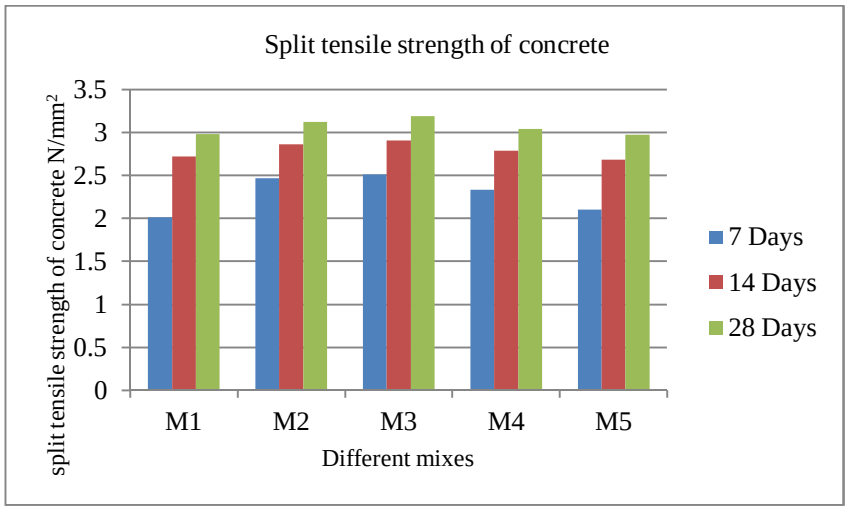


Fig.6 Split tensile strength of concrete for different mixes

## VI. CONCLUSIONS

Plastic was added to concrete in replacement of coarse aggregate by proportion 0%, 5%, 10%, 15%, 20%, 25%, 30% on the basis of the results from the present study, the following conclusions were drawn:

*A.* Specific gravity of plastic was lesser than that of aggregates.
*B.* Workability increases as the content of coarse recycled waste plastic aggregate increases.
*C.* Like the mechanical strength, the addition of waste plastic also contributes to the higher shrinkage and water absorption.
*D.* It was observed while experiment that compressive strength of concrete initially increase at 15% plastic coarse aggregate and further replacement of plastic coarse aggregate compressive strength gradually decreasing.
*E.* With the waste plastic replacement the usage of natural aggregates will be reduced.
*F.* Flexural strength shows similar values that obtained of compressive strength.
*G.* Tensile strength will show better results at 28 days.
*H.* It can be concluded that there is decrease in strength of concrete as the replacement % of natural coarse aggregate with plastic aggregate increases.
*I.* According to results obtained 15% replacement can be conclude as the optimum replacement percentage to achieve the maximum tensile and flexural strength of plastic aggregate concrete.
*J.* As it was observed that with the addition of polypropylene fibers it will act as a bonding property of light weight recycled plastics.

The optimum percentage of 1.5% replacement of fibers the strength will starts to increase and then again it starts to decrease.

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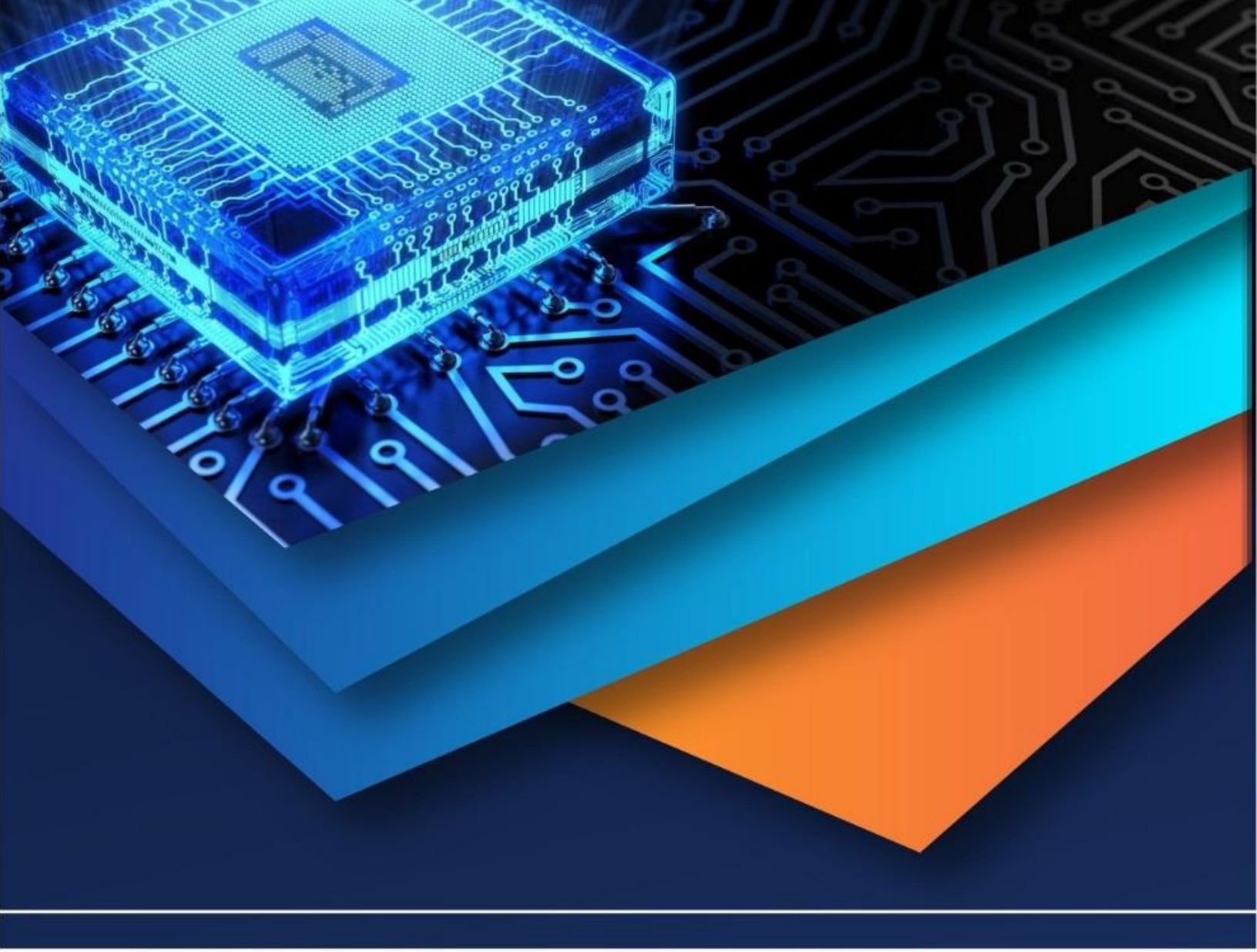

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