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Methods To Improve Properties of Concrete while Using Plastic as Partially Replaced Coarse Aggregate

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***Abstract* -- Recycling of plastic waste by using them as aggregates in concrete appears as one of the best solution for disposal of plastic waste, due to its economic and ecological advantages. Several works have been performed or are under way to evaluate the properties of cement composites containing various types of plastic waste as aggregate, filler or fiber. The main issue while using plastic as an aggregate is its low bonding strength with other components. This would become a serious issue as sufficient bonding between mortar and plastic aggregates is very much necessary. This issue is handled by different methods and the best method is investigated. As 100% replacement of natural coarse aggregate with plastic coarse aggregate is not feasible, partial replacements at various percentages were examined and optimum percentage is investigated.**

Keywords -- Plastic In Concrete, Coarse Aggregate, Bonding, Concrete

1. INTRODUCTION

The material plastic is a widely used synthetic polymer all over the globe. Plastic has many varieties of uses as well as it causes some hazardous problems to the environment. Approximately 90% of solid waste constitutes of plastic and efficient disposal of the waste plastic is the major problem faced today around the globe. Plastic can be disposed by the conventional 3-R method such as Reduce,Reuse, and Recycle.Among this Recycling is the commonly adopted one.

These methods only provide some temporary solution to the plastic disposal problems. Searching for a permanent disposal method, we arrived at an idea of incorporating the waste plastic in concrete, which can be used for construction purpose of permanent structures. If it is possible to replace any constituent of concrete by plastic without altering or changing the desirable properties of concrete then there lies a solution for the permanent disposal of waste plastic. The extreme durability of plastic defies the natural recycling process of the biosphere. Chemically, it is the most non-biodegradable material man has ever produced. Therefore, it is beyond any sort of biodegradation, though weathering and ultraviolet light can fragment large chunks. Although plastic, as a finished product, is non-toxic, the production process involves many dangerous and toxic chemicals. Therefore, burning of plastics is considered very dangerous. It is also known that the break down products from plastics is toxic contaminants.

2. MAJOR RAW MATERIALS AND PROPERTIES

Cement: The main properties of OPC with a strength grade of M20 are given in table 1.

Natural Sand: The main properties of natural sand are given in table 2.

Natural Coarse Aggregate: The main properties of natural coarse aggregates are given in table 3.

Plastic Aggregates: Plastic aggregates of Poly Propylene (PP) are used and the main properties of PP aggregates are given in table 4.

Table1: Main properties of PPC

Setting time (min)		Compressive strength (MPa)		Specific gravity
Initial	final	3d	28d	
30	600	16	33	2.87

Table 2: Main properties of natural sand

Physical property	Bulk density[g/cm3]	Moisture content [%]	Range of plastic size [mm]	Fineness modulus	Grain grading
Natural sand	1.70	0.35	0.15-4.75	2.22	Well graded

Table 3: Main properties of natural coarse aggregate

Physical property	Bulk density [g/cm3]	Water absorption [%]	Impact value [%]	Los Angeles Test	Specific gravity
Natural coarse aggregate	1.45	1.9	20.2	17.4	2.87

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Table 4: Main properties of poly propylene (PP) aggregates

Specific gravity	Impact value [%]	Crushing value [%]	Water absorption [%]
0.91	0.9	0.95	0.008

3. EXPERIMENATL PROCESS

3.1. Preparation Of Plastic Aggregates

The first stage consists of collecting various plastic wastes and sorting out polypropylene plastics. Polypropylene was selected because of its desirable properties as aggregate i.e., its crushing and impact values are very low.

Then the collected PP plastics are heated to molten state and through Plastic Recycling Machine it is converted to 20 mm sized cubic blocks. A mould was designed to prepare the plastic aggregate of unique size and shape .Fig (1) shows the picture of the mould. Equipments used are Sorting Equipment, Size Reduction Machines, Washing Equipment,Separating Equipmentand Pelletizing Machines.

3.2. Making Specimens

M20 mix concrete was prepared for testing various properties of concrete. The concrete mix was prepared with various amount of replacement of ordinary coarse aggregate with treated and untreated plastic aggregates. Concrete mixes with 30% replacement of coarse aggregate with plastic aggregate was prepared. Slump value was checked for each mix. For each mix 3 cubes, 2 cylinders and one beam were casted. Tests for various strength properties were conducted on each specimen.

4. PROPOSED METHODS

4.1 Surface Etching

It is the process of making the surface of plastic rough by using various chemicals. The chemicals used are: Benzene, Gasoline, Concentrated Hydro chloric acid, Mixture of Potassium dichromate and concentrated Sulphuric acid. The mixture of Potassium dichromate and concentrated Sulphuric acid is the most efficient surface etching agent. This mixture is heated and stirred well and plastic aggregate is introduced in to it. Roughness is checked after 1, 2,4,8,12,24 hrs. Fig (2) shows the process.

4.2. Sand Treatment Method

In this method sand is heated to a temperature of 150-200 degree Celsius and plastic is introduced in to it. It is mixed well for one or two minutesand then allowed forcooling. The sand particles get adhered to the aggregate surface. The main drawback while using plastic aggregate untreated is that, it has very low specific gravity. So the plastic aggregate might tend to segregate while mixing and as a result uniform mixture will not be obtained. By sand treatment, the specific gravity of aggregate will increase so that, more uniform mixture can be obtained. Fig (3) shows the picture of sand treated plastic aggregates and ordinary plastic aggregate.

Fig 1. Mould

Fig 2.surface etching

Fig 3. Sandtreated and ordinary aggregate

5. ANALYSIS ON EXPERIMENTAL DATA

5.1 properties of aggregates

Properties of untreated, surface etched, sand treated PP coarse aggregates such as specific gravity, impact value, crushing value and water absorption evaluated by means of respective testes and results are tabulated on the table 5.

5.2. Slump

Test for slump value was conducted on each mix. Concrete was filled in slump cone in 3 layers. After each layer it should be compacted by 25 blows of a tamping rod. Then take off the cone in upper direction carefully and note the slump. The test results are given in table (6).

Slump Value of normal concrete = 82 mm

5.3. Compressive Strength: Cube

Concrete mix of M20 was prepared and compressive strength test was conducted on concrete cubes of size 15cmx15cmx15cm. The concrete was casted in mould and after one day the mould was removed and the cubes were immersed in water for 28 days. Test was conducted by using compression testing machine for 28 day compressive strength. So after 28 days, the cubes were taken out of the water and tested in compression testing machine. The test results are given in table (7) below. Compressive strength of normal concrete with 0% replacement is 35.5 MPa.

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5.4. Compressive Strength: Cylinder

Concrete mix of M20 was prepared and compressive strength test was conducted on concrete cylinders of diameter 15cm and height 30cm. The concrete was casted in mould and after one day the mould was removed and the cylinders were immersed in water for 28 days. Test was conducted by using compression testing machine for 28 day compressive strength. So after 28 days, the cylinders were taken out of the water and tested in compression testing machine. The test results are given in table (8) below. Compressive strength of normal concrete with 0% replacement is 18.6 MPa.

5.5. Split Tensile Strength

Concrete mix of M20 was prepared and split tensile strength test was conducted on concrete cylinders of diameter 15cm and height 30cm. Test was conducted by using compression testing machine for 28 day compressive strength. The test results are given in table (9) below. Split tensile strength of normal concrete with 0% replacement is 2.65 MPa.

5.6. Weight Density Of Concrete Specimen

Weight of various specimens with various amount of plastic aggregate was taken and density was found. There is considerable reduction in weight with increase in percentage replacement. The results are given in the table (10) below.

Weight density of 0% replaced concrete specimen -2445 Kg/m^3.

Table 5: Properties of untreated and treated aggregates

Aggregate	Specific gravity	Impact value [%]	Crushing value [%]	Water absorption [%]
Untreated	0.91	0.9	0.95	0.008
Surface etched	0.91	0.8	1.1	0.009
Sand treated	1.2	5.9	5.4	0.012

Table 6: Slump values of untreated and treated aggregates-results

	Untreated	**Surface etched**	**Sand treated**
Slump of 30% replaced concrete (mm)	55	53	64

Table 7: Compressive strength of cubes-results

	Untreated	**Surface etched**	**Sand treated**
Compressive strength of cube (30% replaced concrete) (MPa)	24.59	25.5	28.8

Table 8: Compressive strength of cylinder-results

	Untreated	Surface etched	Sand treated
Compressive strength of cylinder (30% replaced concrete) (MPa)	12.45	13.1	14.7

Table 9: Split tensile strength-results

	Untreated	Surface etched	Sand treated
Split tensile strength (30% replaced concrete) (MPa)	1.55	1.61	1.98

Table 10: Weight density of concrete specimen-results

	Untreated	Surface etched	Sand treated
Weight density (30% replaced concrete) (Kg/m3)	2260	2256	2293

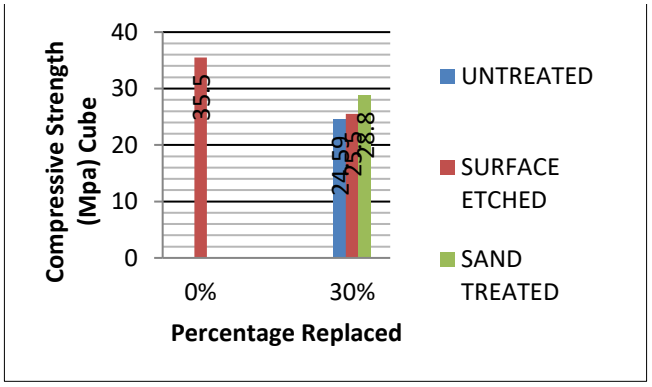

Fig 4.Compressivestrength (cube) results

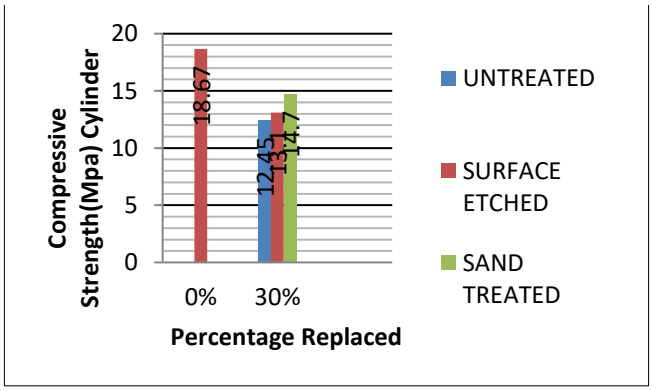

Fig5. Compressive strength (cylinder) results

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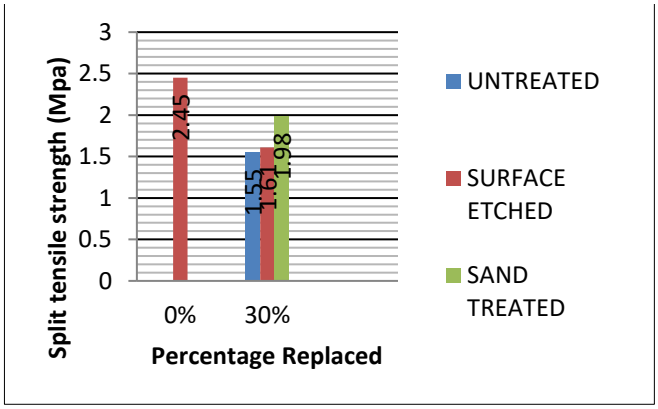

Fig 6. Split tensile strength results

6. DISCUSSION AND CONCLUSION

6.1. Discussions

The slump values obtained for different percentage replacement are within the range of 50 to 100 mm, which is very desirable. Within this range the concrete provides sufficient workability for placing and compacting.

The compressive strength for cube was tested after 28 days of curing. Since M20 concrete was used, the target strength was 26.5 MPa. For 30% replaced concrete, only sand treated aggregate showed the desired compressive strength. The other two methods were found to be insufficient.

The compressive strength for cylinder was tested after 28 days of curing. For 30% replacement, sand treated aggregate showed the desired strength.

The split tensile strength for cylinder was also tested. Unlike other properties, split tensile strength depends mainly on the bonding strength between aggregate and cement. The sand treated aggregate for all percentage replacement was found to give sufficient split tensile strength. For other two types of aggregates due to their low bonding strength, sufficient split tensile strength was not achieved.

6.2. Conclusions

A study was conducted to determine the suitability of Plastic Aggregate for structural concrete. With regard to its tensile behaviour the bonding strength of Plastic aggregate increased with sand treatment.

Large amount of plastic waste can be economically recycled to plastic aggregates & can be used for construction purposes.

More percentage replacement is possible by sand treatment method.

High compressive strength value is obtained so it can be used for compression members.

Split tensile strength & cylinder comp strength are within the limit.

Crushing value, impact value & water absorption are found to be very low.

Weight of concrete reduced considerably, so it can be used in light weight concrete members

7. ACKNOWLEDGEMENT

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