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Reuse of Plastic Waste as Replacement of M Sand in Concrete

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Abstract: A substantial growth in the consumption of plastic is observed all over the world in recent years, which has led to huge quantities of plastic-related waste. Recycling of plastic waste to produce new materials like concrete is one of the logical method of disposing wastes, due to its economic and ecological advantages. Several works have been performed or are under way to evaluate the properties of concrete containing plastic waste. In this work a study on the partial replacement of M sand with High Density Polyethylene powder is carried out. A comparison between conventional concrete and concrete with HDPE powder is carried out to study the strength and durability parameters. In this work 5, 10, 15 and 20 percentage replacement of M sand with HDPE powder is experimented.

Keywords: HDPE Powder, M sand

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I. INTRODUCTION

Concrete is the most widely used man made construction material in the world. It is mainly composed of cement, fine aggregate, coarse aggregate and water. The cement is used to bind the materials in concrete. Fine aggregate and coarse aggregate will fill the most of the spaces in concrete. There are numerous materials that can replace each constituents in concrete. Each constituent in concrete can be partially or fully replaced by different materials. Numerous waste materials are generated from manufacturing processes, service industries and municipal solid wastes. The disposal of wastes is one of the major problem related to the environment. The solid waste management is the main problem due the availability of land area. Many research works are carried out by inclusion of waste products in concrete. Such waste products include discarded tires, plastic, glass, steel, burnt foundry sand, and coal combustion by-products (CCBs). These waste products effects the properties of fresh and hardened concrete. The use of waste products in concrete helps in its disposal and it also make economical. Reuse of these wastes in bulk quantity is considered as the best environmental alternative for solving the problem of disposal.

Fine aggregate can also be replaced by different material. Plastic is one of such material that can replace fine aggregate.The development of new construction materials using recycled plastics is important to both the construction and the plastic recycling industries. The disposal of plastic is very difficult job. So recycling of plastic is more advantageous and it will reduce the pollution due the plastic wastes. The plastic themselves contribute approximately 10% of the total discarded waste. So introduction of plastic waste in concrete is one of the logical method to reduce the plastic waste problems.

II. PLASTICS

The different types of plastic materials are Polyethylene Terephthalate (PET or PETE), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE), Polypropylene (PP), Polystyrene (PS), Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS). In this work HDPE powder is used.

III. OBJECTIVE

The main objectives of the present experimental work are discussed below:

- To study the behaviour of concrete in which fine aggregate is partially replaced by HDPE powder by 5, 10, 15 and 20%.
- To perform the fresh concrete test - slump test.

- To evaluate the various strength parameters like compressive strength, split tensile strength, flexural strength test and non-destructive test of hardened concrete.
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IV. MATERIALS USED

Cement: The type of cement used is Ordinary Portland Cement of specific gravity 3.15 (IS 4031-1988 part II). The different tests done on cement are fineness, consistency and setting time test.

Table 1: properties of cement

Properties	Values
Fineness	1%
Specific gravity	3.15
Consistency	31%
Initial setting time	122 minutes
Final setting time	329 minutes

Fine Aggregate: In this work M sand is used as fine aggregate. Clean and dry M sand is used. M Sand passing through IS 4.75mm Sieve is used for various tests.

Table 2: properties of coarse aggregate

Properties	Values
Fineness modulus	2.98
Specific gravity	2.82
Zone	II

Coarse Aggregate: The coarse aggregate used in this work is gravel whose maximum size is 20mm. The gravel is obtained from local sources.

Table 3:properties of coarse aggregate

Properties	Values
Fineness modulus	3.89
Specific gravity	3.128
Water absorption	2%

Water: Potable water which is used for drinking is used for casting and curing. The water should be free from organic matter, acids and chemicals.
High Density Polyethylene (HDPE) Powder: HDPE powder is used for the partial replacement of fine aggregate in this project. HDPE powder is known for its large strength to density ratio.

Figure 1: HDPE powder

MIX DESIGN FOR M20 CONCRETE: Based on properties of cement, coarse aggregate and fine aggregate, M20 concrete is designed as per IS 10262-2009. The mix proportion is given in table.

Table 4: Mix proportion of M20 concrete

Water	Cement	Fine aggregate	Coarse aggregate
197 L	394 kg	726.544 kg	1314.88 kg
0.5	1	1.84	3.33

V. RESULTS AND DISCUSSIONS

5.1 Workability

Workability tests are performed using Slump moulds as it is the quick measure of workability of concrete mixes.

Fig 2: Workability Testing

The workability test is conducted for concrete with 0, 5, 10, 15, 20% HDPE powder as replacement of fine aggregate. The results of workability test are discussed below.

Table 5: Slump values and workability of concrete

Percentage of plastic replacing fine aggregate	Slump Value (mm)	Workability
HDPE 0% (Control Specimen)	90	Medium Workable Mix
HDPE (5%)	130	Highly Workable Mix
HDPE (10%)	110	Highly Workable Mix
HDPE (15%)	60	Medium Workable Mix
HDPE (20%)	30	Low Workable Mix

From the results obtained, it is found that workability decreases with increase in HDPE powder. The workability is optimum in case of 5% replacement of fine aggregate by HDPE powder. For 5 and 10% replacement of fine aggregate by HDPE powder, highly workable mix is obtained.

5.2 Compressive strength test

Cubes of specimen of size 150 mm x 150 mm x 150 mm are prepared for each mix. After 24 hours the specimens are demoulded and cured in water for 7 and 28 days until testing. The compressive strength reported is the average of three results obtained from three identical cubes.

Table 6: Compression Test Results

Percentage Of Plastic Replacing Fine Aggregate	7^{th} Day Strength (N/mm^2)	28^{th} Day Strength (N/mm^2)
HDPE (0%)	19.25	30.11
HDPE (5%)	22.24	35.11
HDPE (10%)	21.14	32.88
HDPE (15%)	19.55	29.33
HDPE (20%)	18.07	27.11

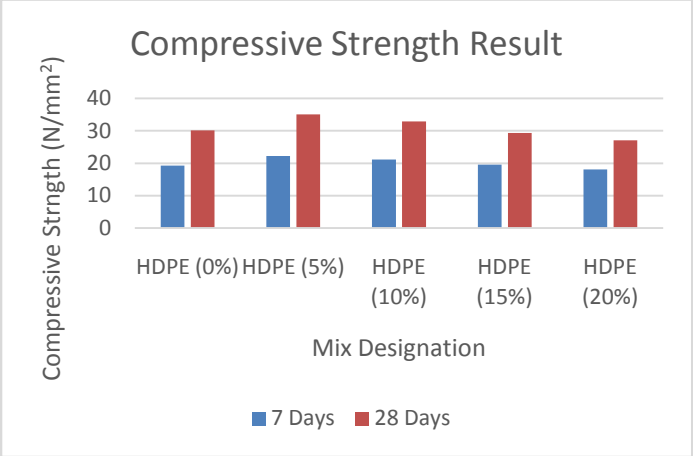

Figure 3: Comparison of compressive strength

From the results obtained it is found that compressive strength increases for 5 and 10 % replacement of HDPE powder when compared to control specimen. The compressive strength decreases with increase in HDPE powder. The maximum compressive strength is obtained at 5% replacement of HDPE powder. The compressive strength increases by 16.6% for 5% replacement of HDPE powder.

5.3 Split tensile strength test

Cylinders of specimen size 150 mm x 300 mm are prepared for each mixes. The tensile strength reported is the average of three results obtained from three identical cylinders.

Table 7: Split Tensile Strength Results

Percentage Of Plastic Replacing Fine Aggregate	**28th Day Strength (N/mm²)**
HDPE (0%)	3.2
HDPE (5%)	3.93
HDPE (10%)	3.28
HDPE (15%)	3.16
HDPE (20%)	3.09

From the results obtained, it is found that split tensile strength decreases with increase in percentage of HDPE powder. The optimum value is obtained for 5% replacement of fine aggregate by HDPE powder. Split tensile strength increases up to 22.815% for 5% replacement of HDPE powder.

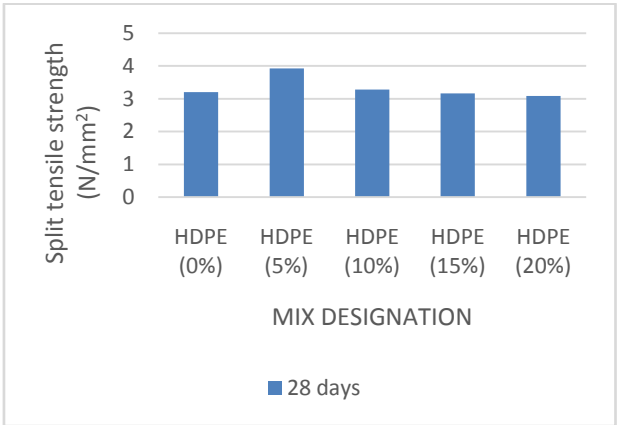

Figure 4: Comparison of split tensile strength

5.4 Flexural strength test

The flexure test is done on a beam of 100mm×100mm×500mm size prism loaded at the centre of the span.

Table 8:Split Tensile Strength Results

Percentage Of Plastic Replacing Fine Aggregate	28th Day Strength (N/mm²)
HDPE (0%)	5.125
HDPE (5%)	7.5
HDPE (10%)	6.75
HDPE (15%)	5.75
HDPE (20%)	5.5

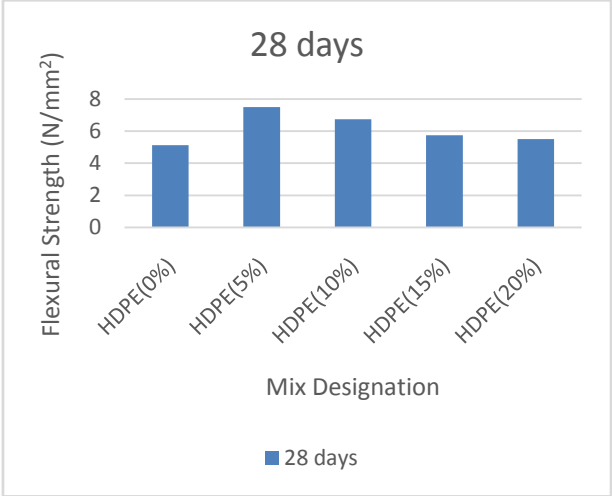

Figure 7: Comparison of flexural strength

From the results obtained, it is found that flexural strength decreases with increase in percentage of HDPE powder. The optimum value is obtained at 5% replacement of fine aggregate by HDPE powder. Flexural strength increases up to 46.34% for 5% replacement of HDPE powder. The flexural strength is more than control specimen even at 20% replacement of fine aggregate by HDPE powder.

5.5 Ultrasonic Pulse Velocity (UPV) test

The UPV test is conducted for concrete with 0, 5, 10, 15 and 20% HDPE powder as replacement of fine aggregate. The results of UPV test are discussed below.

Table 9: UPV Test Result at 28 Days

Percentage Of Plastic Replacing Fine Aggregate	Direct transmission		Semi direct transmission	
	Time (µs)	Velocity (m/s)	Time (µs)	Velocity (m/s)
HDPE (0%)	27.8	5235	17.2	8200
HDPE (5%)	28.9	5190	18.9	7937
HDPE (10%)	29.8	5037	20.4	7353
HDPE (15%)	32.9	4559	21.8	6998
HDPE (20%)	33.1	4532	22.6	6535

Pulse velocity m/s	Quality
> 4500	Excellent
3500 to 4500	Good
3000 to 3500	Medium
< 3000	Poor

Table 6: General condition as per IS: 1311 (Part I)-1992

The velocity of cubes with HDPE powder is less than that of control specimen. But the obtained value of velocity of cubes with HDPE powder partially replaced by fine aggregate is within the excellent quality.

VI. CONCLUSION

Based on the results and observations of the experimental work conducted, the following conclusions are drawn:

- It is identified that plastic waste can be disposed by using them as a construction material in concrete.
- Workability property of concrete is effected by the addition of HDPE. Workability decreases with increase in HDPE powder.
- Compressive strength, flexural strength and split tensile strength of concrete decreases with increase in HDPE powder.
- The optimum percentage of replacement by HDPE powder in terms of workability and strength is obtained as 5%.
- Compressive strength increases up to 16.6% for 5% replacement of HDPE powder.
- Split tensile strength increases up to 22.815% for 5% replacement of HDPE powder.
- Flexural strength increases up to 46.34% for 5% replacement of HDPE powder.
- Density of cube decreases with increase in HDPE powder.

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