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USE OF PLASTIC CHIPS AS PARTIAL REPLACEMENT OF COARSE AGGREGATE IN CEMENT CONCRETE

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Abstract - *The plastic consumption is rising every day, and numerous initiatives have been attempted to decrease it. Despite the fact that plastic is ubiquitous in our everyday lives. Daily a massive amount of plastic is dumped into the environment, causing pollution. As a result, it is critical to employ plastic as a substitute for engineering work. Plastic waste is a non-biodegradable component that is used to substitute coarse and fine aggregate in some cases. As complete replacement of natural coarse aggregate with plastic waste is not possible, only partial replacement is investigated in the present work. The plastic trash is employed as a partial replacement for coarse aggregate in this study. The plastic chips are used to substitute coarse aggregate in the four mix proportions: 0%, 10%, 15%, and 20%. The dry density, workability, compressive and splitting tensile strength of concrete are determined. High-density polyethylene (HDPE) or polyethylene high-density (PEHD) plastic waste is employed in this experiment. The experiment was carried out on M20 mix, and the tests were performed according to the prescribed technique and IS codes.*

Keywords: Plastic Chips, Concrete, Compressive strength, Split tensile strength.

1. INTRODUCTION

Plastics have a number of advantages when it is used as construction materials: such as longevity and durability, chemical, water, and impact resistance, excellent insulation characteristics, both thermally and electrically, production expenses are lower, at the freezing point, as the temperature rises, the bonding capacity increases. The most significant drawbacks of utilizing plastic in concrete are the strength of concrete is diminished due to the weak bonding qualities of polymers, compressive, tensile, and flexural strength are examples of these properties.

As plastic waste contains a variety of hazardous compounds that are harmful to the earth, air, and water. Plastic, being a non-biodegradable substance, protects cannot be used or thrown anywhere, it is critical to remove some plastic from the environment for use in roads, buildings, and other applications.

Polyethylene is the most common type of plastic trash, followed by polypropylene, polyethylene terephthalate (PET), and polystyrene. Because PET is substantially lighter than natural aggregate, it decreases the density of concrete. In the present study, plastic chips (approx. 10-12 mm) are used as a partial replacement to coarse aggregate in M20 grade of cement concrete. The effect of different percentage of plastic chips 0%, 10%, 15%, and 20% used in concrete are studied. The effect of varying percentage of plastic chips on dry density, workability, compressive strength and splitting tensile strength of concrete are investigated.

2. LITERATURE REVIEW

Rafat et al. (2008) presented a review of waste and recycled plastics and various waste management options. It also reviewed the published literature on the effect of recycled plastic on fresh and hardened properties of cement concrete. The effect of recycled and waste plastic on bulk density, air content, workability, compressive strength, splitting tensile strength, modulus of elasticity, impact resistance, permeability, and abrasion resistance properties were also discussed.

Hannawi et al. (2010) compared the flexural strength of mortar specimens containing up to 10% PET aggregates and up to 20% PC aggregates to a control mix, found no significant differences in flexural strength. However, for mixtures containing 20% and 50% PET aggregates, respectively, a drop of 9.5 percent and 17.9 percent was observed. A reduction of 32.8 percent was seen in mixtures containing 50 percent PC aggregates. The elastic nature of the plastic aggregate, and therefore its non-brittle features under loading, may have an influence on the measured flexural strength.

Kandasamy and Murugesan (2011) studied the impact of adding polythene fibres (domestic waste plastics) at a dosage of 0.5 percent by weight of cement in concrete. The properties of compressive and flexural strength were determined for M20 mix. The addition of 0.5 percent polythene (household waste polythene bags) fibre to concrete boosts cube compressive strength by 0.68 percent in seven days, cylinder compressive strength by 3.84 percent in 28 days, and split tensile strength by 1.63 percent.

Lakshmi and Nagan (2011) used E-plastic waste as part of the coarse aggregate was studied. The trash E-plastic particles came from electrical and electronic equipment that was no longer in use. The compressive strength of concrete using varying quantities of E-waste (4%, 8%, 12%, 16%, 20%, 24% and 28%) as coarse aggregate in the concrete has

been undertaken. The replacement of cement by fly ash (10% by weight) found to improve the properties of E-plastic waste concrete. Compressive strength, split tensile strength, flexural strength, sulphate and chloride attack were all investigated on E plastic concrete specimens. The E-plastic concrete demonstrated a substantial increase in compressive strength when compared to traditional concrete.

Thosar and Husain (2017) studied the industrial wastes made of polypropylene (PP) and polyethylene terephthalate (PET) as replacements to fine sand in concrete. For the concrete preparation, four replacement levels of aggregates were used: 20%, 40%, and 60% by volume of aggregates. According to the findings of this study, PP and PET may be utilised as a fine sand substitute in concrete containing 40% PP and PET by volume and produce good results. M20 concrete has a nominal compressive strength of 20 N/mm^2. When natural river sand is replaced with plastic waste material, the compressive strength of concrete is increased by 20% to 40%, up to a safe level.

Mahzuz and Tahsin (2019) used plastic trash as a partial replacement for coarse aggregate in concrete. For their research, they employed four volume-based mix proportions (1:1:1, 1:1.25:2.5, 1:1.5:3, and 1:2:4). The plastic was used to substitute stone in the following ratios: 0%, 25%, and 50%. The waste was made up of high-density polyethylene. After 28 days of curing, the compressive strength and unit weight were tested. The result revealed that compressive strength was up to 29.17%and 48.5% respectively. Green concrete was created by **Arivalagan (2020)** using e-waste as a partial substitute for coarse aggregate at 10%, 20%, and 30%, respectively, with a water-cement ratio of 0.45**.** The recycle metallic portions in the e-waste were utilized, to increases the mechanical properties of green concrete. The green concrete specimens compared with conventional concrete, shows 20% increase in compressive strength.

3. METHODOLOGY

The mix design for M20 grade concrete was done according to IS 10262-2019; Fig 3.1 shows the methodology adopted for assessment of compressive strength of concrete.

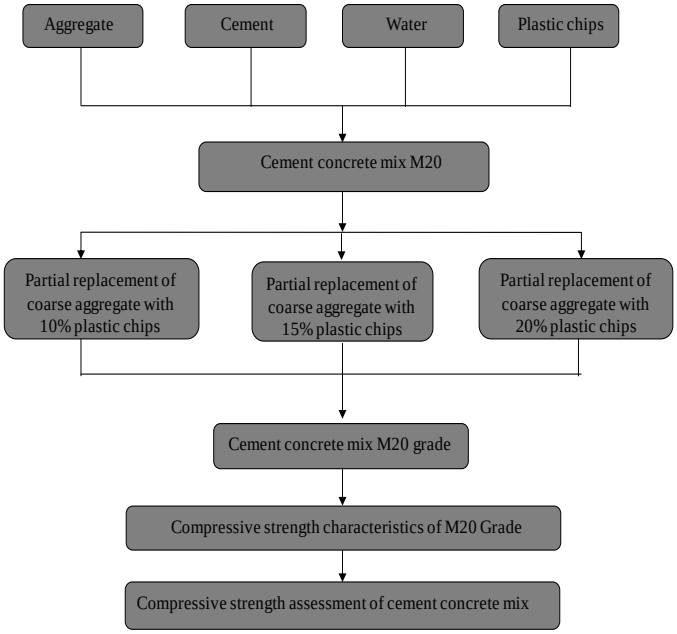

Fig. 3.1: Methodology for assessment of compressive strength with plastic chips

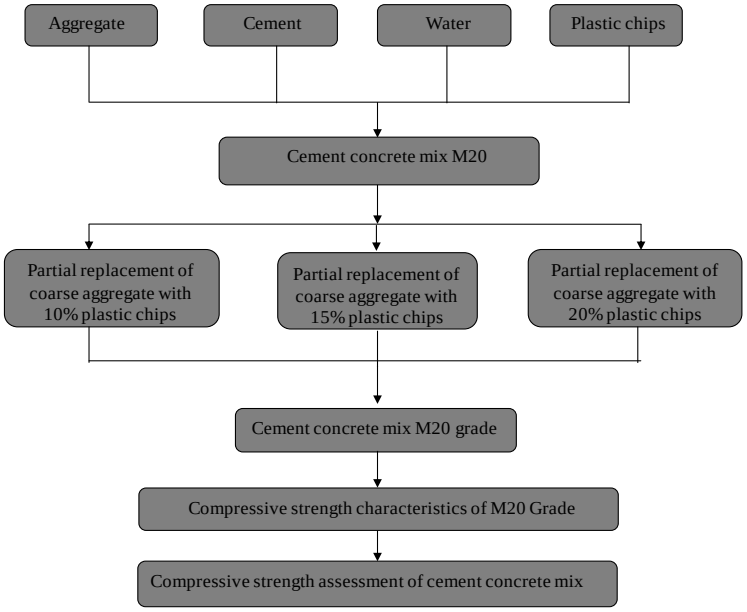

Fig. 3.2: Methodolgy for assessment of compressive strength with plastic chips.

Table 3.1 gives the properties of various materials such as cement, fine aggregates, coarse aggregates for M20 grade of concrete.

Table 3.1 Properties of materials

a) Cement used	OPC 43 grade
b) Specific gravity of cement (g/cc)	3.15
c) Chemical Admixture	Nil
d) Specific gravity of 1) Coarse aggregate	3.2

	2) Fine aggregate	2.8
e)	Water absorption 1) Coarse aggregate 2) Fine aggregate	 2.25% 0.36%
f)	Free surface moisture 1) Coarse aggregate 2) Fine aggregate	 Nil Nil

4. EXPERIMENTAL INVESTIGATION

This section details with the experiment that used discarded plastic chips to partially substitute natural coarse aggregates. The experimental investigation included dry density, workability, compressive and splitting tensile strengths of concrete are determined. In the concrete example, waste plastic chips were utilized to substitute coarse aggregate by 10%, 15%, and 20%, respectively. The plastic chips smaller than 12 mm in diameter are utilized. As indicated in Fig., 4.1 collected PET bottles were manually chopped into pieces with a 12 mm reduced size. After that, the plastic particles were sieved to provide a consistent grading according to ASTM C33-93.

Figure 4.1 Crushed plastic chips

Table 4.1 shows proportioning of M20 grade concrete without plastic chips.

Table 4.1 Mix proportion of M20 grade of concrete without plastic chips.

Grade designation	M20
Type of cement	OPC 43 Grade
Maximum nominal size of aggregate	20 mm
Minimum cement content	300 kg/m^3
Maximum water cement ratio	0.45
Workability	69.2 mm (slump)
Exposure condition	Moderate
Method of concrete placing	Non Pumped
Degree of supervision	Good
Type of aggregate	Crushed aggregate
Maximum cement content	410 kg/m^3

Table 4.2 Mix calculations per unit volume for M20 grade concrete

Volume of concrete	1 m^3
Volume of cement	0.130 m^3
Volume of water	0.162 m^3
Volume of all in aggregate	0.708 m^3

Table 4.3 Proportions of ingredients in the mixes for M20 grade of concrete with plastic chips

S. no.	Ingredients	Quantity (kg/m^3)
1.	cement	410
2	Coarse aggregate	10% replacement-1107 15% replacement-1045.5 20% replacement-984
3	Fine aggregate	615
4.	Water	162
5	Plastic chips	10% of coarse aggregate-123 15% of coarse aggregate-184.5 20% of coarse aggregate-246

Figure 4.1: Testing of concrete cube and cylinder

5. RESULTS AND ANALYSIS

The experimental findings on various design mixtures are discussed in this section. Workability tests, compressive

strength tests, and split tensile strength tests are all included in the results. In this investigation, a total of 36 cubes and 12 cylinders were cast and evaluated over the course of 7 days, 14 days, and 28 days. The comparison and findings are addressed in more detail in the following sections:

5.1 Dry density

For a 20 percent replacement of coarse aggregate with plastic chips, the minimum dry density of concrete is 20.30 kN/m³ in this investigation. Table 5.1 lists the dry density values together with the percentages of plastic. It is observed that as percentage of plastic chips increases the dry density of concrete decreases making it light weight.

Table 5.1 Dry density test results

Test	Percentage of plastic	Value
Dry density (kN/m³)	0%	22.10
	10%	21.22
	15%	20.68
	20%	20.30

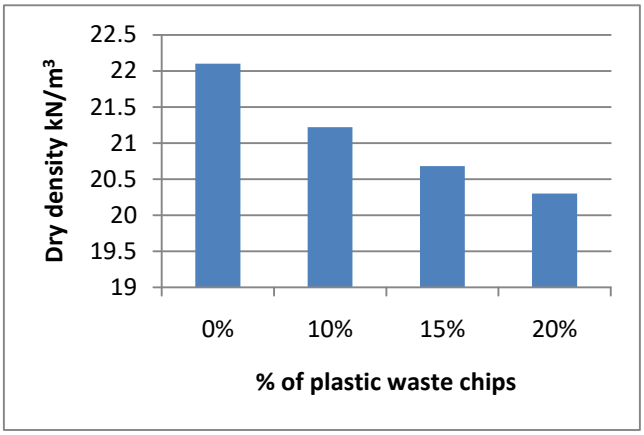

Figure 5.1 Dry density of concrete

5.2 Workability

The workability of M20 grade concrete with and without plastic chips is shown in Table 5.2. It can be observed that as the percentage of plastic chips in concrete mix increase the workability decreases. This decrease in workability of concrete with increase in plastic chips, this might be due to size and form of plastic chips used.

Table 5.2 Workability with and without plastic chips

Percentage of plastic chips	Slump value
0%	6.9 cm
10%	6.7 cm
15%	6.4 cm
20%	6.0 cm

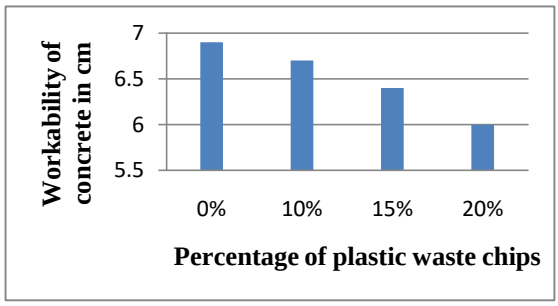

Figure 5.2: Workability of concrete with and without plastic chips

5.3 Compressive strength

The compressive strength of varying percentages of plastic chips added to concrete was measured using compressive strength after 7 days, 14 days, and 28 days, as shown in Fig. 5.3.

Table 5.3: Compressive strength with and without plastic chips

S no.	No. of days	% of Plastic chips	Average Compressive strength in N/mm²
	7 days	0%	24.26
	14 days	0%	27.88
	28 days	0%	30.26
	7 days	10%	23.15
	14 days	10%	25.52
	28 days	10%	27.55
	7 days	15%	20.42
	14 days	15%	23.98
	28 days	15%	27.32
	7 days	20%	17.52
	14 days	20%	21.75
	28 days	20%	26.11

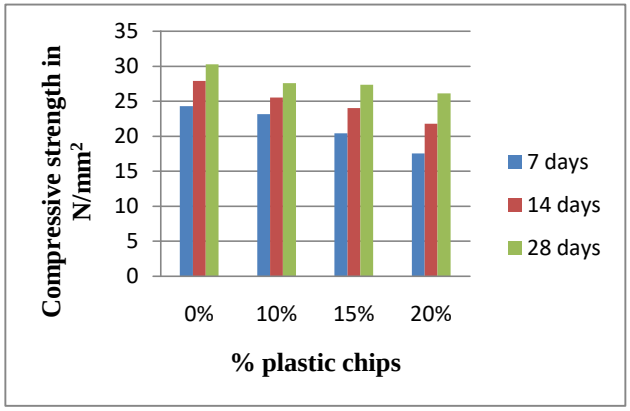

Figure 5.3 Compressive strength

It can be observed that the as the proportion of plastic chips increases the compressive strength of concrete decreases. When comparing strength in days, however, it can be seen that after 28 days, strength rises more than after 7 and 14 days.

5.4 Splitting tensile strength

Figure 5.4 shows the splitting tensile strength of varying percentages of plastic chips applied to concrete after 28 days

Table 5.4: Split tensile strength

No. of days	% of Plastic chips	Average tensile strength in N/mm²
28 days	0%	3.588
28 days	10%	2.952
28 days	15%	2.666
28 days	20%	2.132

From the test results, it can be observed that the tensile splitting strength also decreases with increase in percentage of waste plastic chips.

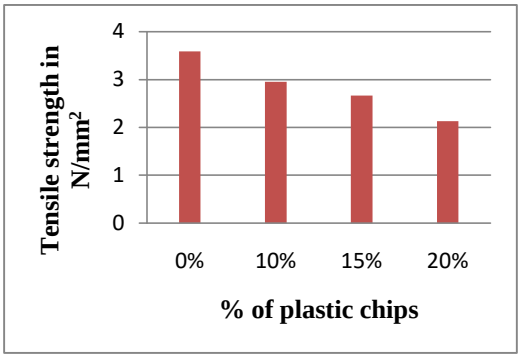

Figure 5.4: Split tensile strength at 28 days

6. CONCLUSIONS

The following conclusions are done based on the current study:

1. The dry density of concrete decreases with percentage increase in the waste plastic chips. For a 20 % replacement of coarse aggregate with plastic chips, the minimum dry density of concrete is 20.30 kN/m³. The reduction in dry density is observed to be 1.80%.
2. The workability of concrete containing plastic chips decreases with increase in percentage of waste plastic chips. This decrease in workability of concrete with increase in plastic chips, this might be due to size and form of plastic chips used.
3. The compressive strength of concrete decreases with increase proportion of plastic chips. The cconcrete prepared by substituting natural aggregate at a replacement level of 20% had compressive strength decreases of up to 4.15% when compared to normal mix (0% plastic chips).
4. The tensile splitting strength also decreases with increase in percentage of waste plastic chips. The decrease in tensile strength upto 1.456% when compared to normal mix (0% plastic chips).

REFERENCES

1. Arivalagan S. (2020), Experimental Study on the Properties of Green Concrete by Replacement of E-Plastic Waste as Aggregate, Procedia Computer Science, 172, 985-990
2. IS 10262:2019, Recommended Guidelines For Concrete Mix Design, Bureau of Indian Standard, New Delhi..
3. IS 2386 (Part-1) 1963, Methods of test for aggregates for concrete, Bureau of Indian standard, New Delhi.
4. IS 2386 (Part-3) 1963, Methods of test for aggregates for concrete, Bureau of Indian standard, New Delhi.
5. IS 2386 (Part-4) 1963, Methods of test for aggregates for concrete, Bureau of Indian standard, New Delhi.
6. IS 383-2016, Coarse and Fine aggregates for concrete-Specifications, Bureau of Indian Standard, New Delhi.
7. IS 4031 (Part-1) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
8. IS 4031 (Part-2) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
9. IS 4031 (Part-3) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
10. IS 4031 (Part-4) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
11. IS 4031 (Part-5) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
12. IS 4031 (Part-6) 1988, Methods of physical tests for hydraulic cement, Bureau of Indian Standard, New Delhi.
13. IS 456-2000 Specifications For Plain And Reinforced Concrete.
14. Kandasamy R. and Murugesan R. (2011), Fiber Reinforced Concrete (FRC) using domestic waste plastic as fibres, ARPN Journal of Engineering and Applied Sciences.
15. Kinda Hannawi, Kamali-Bernard Siham, William Prince (2010), Physical and mechanical properties of mortars containing PET and PC waste aggregates, Waste Management 30(11), 2312-20.
16. Lakshmi. R. S. and Nagan S (2011), Utilization of waste E plastic particles in cementations mixtures, Journal of Structural Engineering, 38(1), 26-35.
17. Mahzuz H. M. A., Tahsin Anika (2019) "Use of plastic as partial replacement of coarse aggregate for brick classifications, International Journal of Scientific and Technology Research 8(8), 883-886.
18. Nehdi, M. and Khan, A. (2001), Cementitious Composites Containing Recycled Tire Rubber: An Overview of Engineering Properties and Potential Applications, Cement, Concrete and Aggregates. CCAGDP, 23. http://dx.doi.org/10.1520/CCA10519J.

19. Sabarinathan A., Suresh S. (2016) An investigation on fresh and hardened concrete on M30 concrete with plastic fibres and M-sand", International Journal of Research and Innovation in Engineering Technology, 2(12), 64-70.
20. Saikia N, Brito J. (2013), Waste polyethylene terephthalate as an aggregate in concrete. Material Research. 16(2).

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