EXPERIMENTAL STUDIES ON HIGH STRENGTH CONCRETE WITH SHREDDED PLASTIC WASTE AS REPLACEMENT TO FINE AGGREGATE

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ABSTRACT

Increasing consumption of various types of plastic products is one of the most recent challenges in environmental protection. Large quantities of plastic waste and the low biodegradability of these quantities negatively affect the environment. All kinds of plastic used by humans in daily life eventually become waste; several tons of these plastic wastes require large areas of land for storage and cannot be fully recycled at once.Graded plastic trash comes in five different variations: M1 to M5. Five specimens serve as the test objects for each variant. High strength concrete is gaining popularity over normal strength concrete in the design of various structural components because of its advantageous nature. The findings of the data analysis demonstrate that changes in plastic waste replacement have an impact on compressive strength at the same time. As the percentage of plastics added rises, the compressive strength falls. At variations of M1 and M5, the maximum compressive strength is at 70 MPa and 72 MPa, respectively. Using plastic waste in the materials industry is an environmental solution to minimize the proportion of landfills used in waste incineration. Studies have shown that plastic can be used in concrete; this type of material has become a major research subject in recent years.

Keywords: High strength concrete; compressive strength; concrete; Plastic ; waste

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1.INTRODUCTION

Waste from plastic bottles is among today's more prevalent ecological issues. Plastics is a substance that takes up to 50–100 years to degrade. Due to the prevalence of foam manufacturing, the quantity of waste plastic bottles generate grows every year. However, fewer individuals are aware that the recycling of plastic bottle waste is not the best method behind the usage of plastic materials. Some individuals turn used plastic bottles into vases, bags, and furniture to recycle trash and make it usable again. The survey's findings on the reuse of plastic bottle waste in the Sumenep region, though, are all still scant.There are numerous studies employing plastic bottle waste as a research subject in the realm of materials and construction. Plastic trash pollution can lessen the harm done to the environment through using plastic bottle waste as building materials. Throughout this study, plastic bottle waste is utilized in place of cement content and is molded so that the grading resembles that of sand, which is a common combination of cement.

The primary component used to replace cement is sand. Black sand, which is more suited to new structures than other forms of sand, is indeed the type the sand used in the cementitious material. The remaining elements in the concrete mixture work well as a bond with the black sand concentration. A very serious issue develops in spite of the great utilisation of black sand in building construction. Uncontrolled mining of black sand (illegal mining) near the sand mining area frequently results in land degradation. Environmental activists have lost their lives in recent years in mining regions, particularly the Ranipet District area, due to disputes. Without even any limitations, black sand mining is done daily in the Ranipet District region to satisfy customer demands. Black sand resources for transportation infrastructure are not available in Sumenep. Sumenep Regency imports its black sand from outside the city. As a result of the great demand, it is not unexpected that black sands is priced fairly high in Sumenep Regency. As a consequence, many private corporations and organizations have been established in Sumenep Regency that focus on exploiting black sand as a construction material for coarse aggregates.

Numerous studies [1–11] have indeed been done on using plastic trash as a replacement for fine aggregate. Guendouz et al[1] .'s investigation focused on the utilisation of two different types of plastic scrap bearing the PET and LDPE logos in the production of fine aggregate for structural concrete. The impact of introducing plastic fibres to paving stones on compressive strength, shock resistance, and water absorption was studied by Diana and Depriyanto [2]. By incorporating 15%, 30%, and 45% LDPE plastic waste into normal-strength concrete, Karimah [3] evaluated the compressive capacity of the material. By including 20%, 40%, and 60% ABS plastic waste to concrete, Alvine [4] examined the compression strength of the concrete.

In the past, research has substituted plastic trash for concrete mixtures by combining it with other elements. On the hardening qualities of concrete block and stone dust are two of these elements, as are polycarbonate waste and polycarbonate waste used as ecologically acceptable aggregates in concrete mixes [9, 10]. Plastic debris was used by Adela, Behanu, and Gobena [11] as a substitute for natural aggregate. Numerous studies [9–11] have demonstrated that adding various plastic wastes to the concrete mix might lower the quality of the concrete produced. On the basis of the prior research, more study is required about the utilization of plastic waste in concrete mixtures. Variations in the way plastic trash is processed and the addition additional additives are examples of study.

Table 1 Survey of Literature

Ref	Types of Plastic	Geometry	level of Replacement	Replacement of aggregate	Utilization
[1]	Plastic waste	Powder	10%, 20%, 30%	Fine aggregate	concrete

[2]	Plastic waste	Fibers	0%, 0.25%, 0.50%, 0.75%,	Coarse aggregate	Block
[3]	E-plastic waste	Flakes	0%, 5.5%, 11%	Coarse aggregate	Concrete
[4]	E-plastic waste	Irregular flakes	0%, 10%, 20%, 30%	Coarse and fine aggregate	Concrete
[5]	Plastic bags	Irregular	0%, 25%, 35%	Coarse aggregate	Concrete

The plastic debris utilized in earlier experiments is displayed in Table 1 in a variety of kinds and shapes. According to the background information provided above, only a small number of researchers in Ranipet District have substituted plastic trash for fine aggregate in concrete mixtures. Based on the findings of research conducted by Fansuri et al. [12], this study focuses on the use of graded plastic bottle trash (the plastic type is PET) as a replacement for fine aggregate and uses the regional recycled aggregate originating from Ranipet District.

2. Materials and Methods

- The primary historical context is the current era's trash issue with plastic bottles. Plastic is a material that takes 50 to 100 years to break down and is difficult to compost. Because practically everyone uses plastic-based packing every day, the quantity of waste plastic bottles generate grows every year. To transform plastic pollution into building materials, creativity is required (see introductory section for detailed explanations).
- The cement used in this study, Ordinary Portland Cement (OPC) of 53 Grade which conforms to IS 12269.
- Fine aggregate passing through 4.75 mm IS sieve conforming to grading zone II of IS 383:1970 and having a specific gravity of 2.6 was used in this study. Crushed aggregate available from local sources with a maximum size of 12.5 mm and conforming to IS2386:1963 (part I, II and III) was used as coarse aggregate in this study. The specific gravity of coarse aggregate is found out as 2.7.
- Potable water was used in the experimental work for both mixing and curing purposes.
- For proper mixing of high strength concrete, a poly-carboxylic ether based super plasticizer is added with concrete mix mainly to prevent the segregation for various mixes
- The waste plastic represents the discarded waste from plastic containers that were collected from various collecting zones located in Ranipet District. After collection of waste plastic, Plastic aggregate is obtained by crushing the plastic waste.
- Figure 1 shows the flow chart of the experimental methodology of in this research approach.

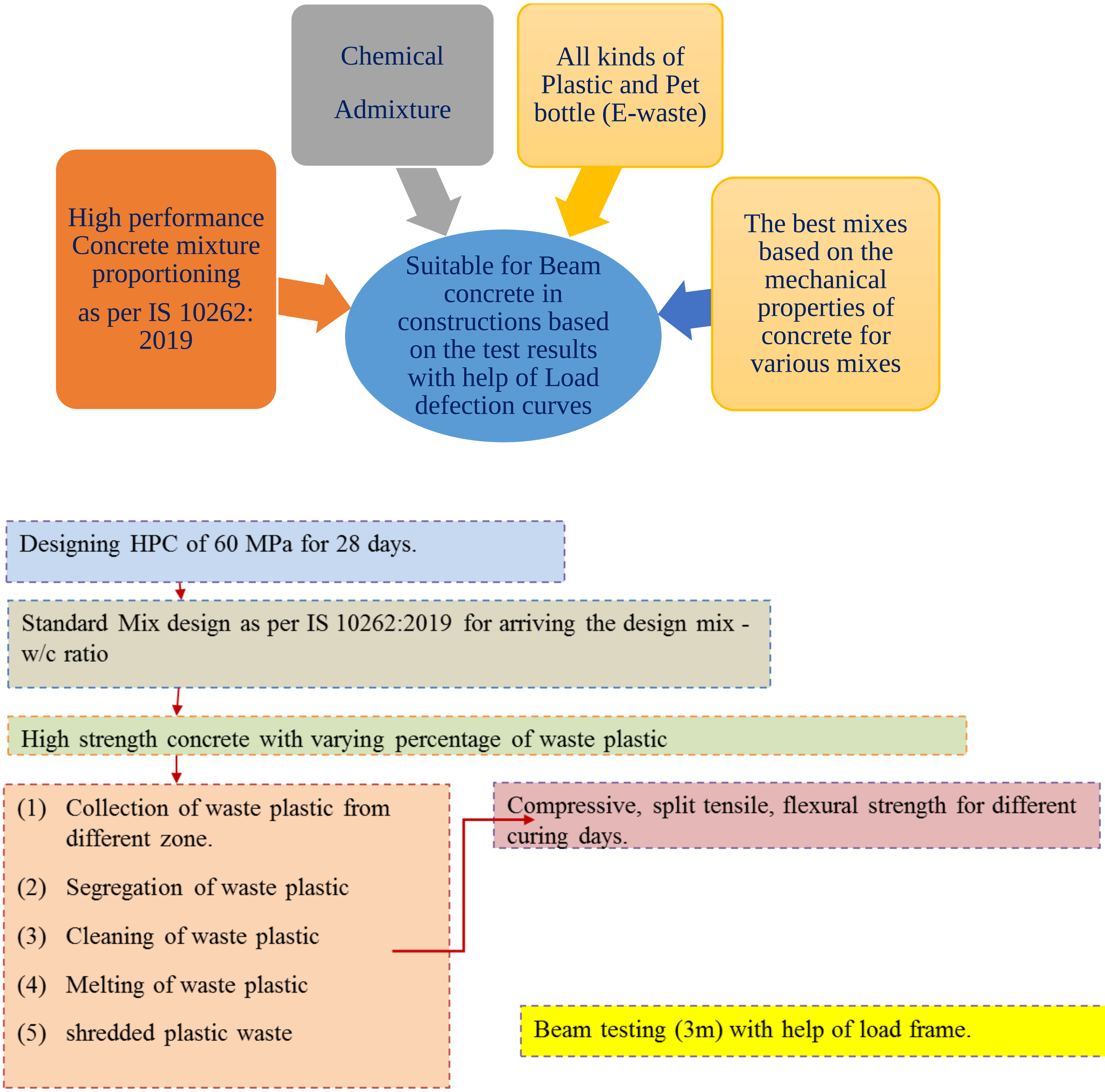

Figure 1: Experimental Methodology

3. RESULTS AND DISCUSSION

The study's findings are a collection of concrete mixture findings (fine and coarse aggregate). The Civil Engineering Laboratory conducts compressive strength tests on concrete, and Statistical tool is used to evaluate the results. Below is a description of the study's findings**.**

3.1 Properties of Cement

The most popular building material worldwide and one that is conveniently accessible locally is cement. To meet the needs of the building sector, hundreds of tonnes of cement are manufactured annually. Cement has replaced lime and volcanic ash as the most popular adhesive substance used in construction today. It is used to build both large structures and smaller ones, such as houses.Typically, cement is used to create mortar or concrete, and it aids in their final setting to give them strength. In addition to giving mortar or concrete more strength, good cement will also aid in the structure's long-term resistance to moisture. Therefore, you must first understand the characteristics of cement before you can comprehend the characteristics of mortar or concrete or their purposes. The properties of cement show the Table 2.

Table 2 Properties of Cement

Sl.No	Characteristics	Values obtained	Standard values
1	Standard Consistency Test	31%	26% - 32%
2	Specific gravity	3.15	3.12-3.19
3	Fineness test	2930 cm^2/g	>2250 cm^2/g
4	Initial Setting Time	32 minutes	Not less than 30 minutes
5	Final Setting Time	260 minutes	Not more than 600 minutes
6	Soundness	3 mm	Less than 10 mm

3.2 Properties of coarse aggregate

The condition of the regional coarse aggregate in Ranipet District, is the subject of multiple laboratory tests . The experiments consist of the water content test, the sieve analysis study, and the specific gravity experiment. The findings of the studies are listed below.

Table 3 Properties of coarse aggregate

S.No	Characteristics	Values	Standard values
1	Type	Crushed	-
2	Maximum size	20mm	-
3	Specific gravity	2.7	2.6 -29
4	Total water absorption	0.3%	0.1% to 2%
5	Fineness Modulus	7.32	6.5 to 8
6	Impact value	22%	-

7	Crushing value	17%	-

The durability and workability of the concrete in both its fresh and hardened states can be significantly impacted by the size of the aggregate. Both fine and coarse aggregate are comparable in this regard. In RCC structures, the maximum size of cementitious material that may be used shouldn't be greater than 5mm less than the minimum clear spacing between reinforcing, or 1/4th of the nominal thickness of the structural element.Utilizing particles of the largest possible size reduces the amount of cement used as the binding agent, lowers the amount of water needed, and lessens shrinking and creeping caused by the drying of freshly-poured concrete.

3.3 Properties of Fine aggregate

The grade of fine aggregate is assessed using a variety of laboratory studies, including those on moisture content, specific gravity, and fineness modulus. The outcomes of the laboratory water experiments are as follows: It can be shown from the test results in Table 3 that the mean fine aggregate water content is 3.023%. More moisture will be present in the aggregate, the larger the differential between the initial weight of the aggregate and the value of the aggregate before heating.

S.No	Characteristics	Results	Standard values
1	Grading Zone	Zone II	-
2	Specific Gravity	2.47	2.3 to2.7
3	Water absorption	0.5%	Not greater than 3%
4	Fineness Modulus	2.69	2.2 to 2.8
5	Moisture Content	Nil	-

Table 4 Properties of fine aggregate

3.4 Mix Design

The stage of concrete design known as mix design planning is crucial. The proportion of concrete, moisture, fine and coarse aggregates, and coarse aggregate can be determined based on the mix design planning. Design mix preparation in this research is done in accordance with (IS 10262:2019). For each change, 3 samples are made using data from the cement content material. Table 5 and 6 show that mix design and preparation of waste plastic.

Table 5 Mix design Of Waste Plastic

Determining the optimum ratios of cement, sand, and aggregates for concrete to provide the desired strength in constructions is known as mix design. Concrete Mix = Cement: Sand: Aggregates can be used to describe the design of a concrete mix. To determine the proper mix proportions, the concrete mix design process requires numerous procedures, mathematics, and lab testing.The proper amounts of components are provided by concrete mix design, enabling concrete construction cost-effective in delivering the needed strength of structural parts.

Cement (Kg/m^3)	**Fine aggregate**	**Coarse aggregate**	**water**	**Super plasticizer**	**Waste plastic** (%)
504	683	1108	146	31	0 to 20

Table 6 Mix propositions of waste plastic

Mix id	Cement	Fine aggregate	Coarse aggregate	Water	Super plasticizer	Waste plastic
	(Kg/m^3)					(%)
M1	504	683	1108	146	31	0
M2	504	683	1108	146	31	5
M3	504	683	1108	146	31	10
M4	504	683	1108	146	31	15
M5	504	683	1108	146	31	20

3.5 Testing the concrete specimens

(a) Mechanical properties

The presence of plastic waste may alter the failure mode of cylinders, but the plastic waste will be minor on the improvement of compressive strength values (M1 to M5 %).The presence of plastic waste may alter the failure mode of concrete, but the plastic waste effect will be minor on the improvement of compressive strength values (M1 to M5 %) marginally.

As the load increases, the deflection also increases. However the area under the load–deflection curve also increases substantially depending on the type and amount of plastic waste added. Figure 2 show the Snapshot for testing the concrete specimens and Figure 3,4,5 shows that mechanical properties of concrete.

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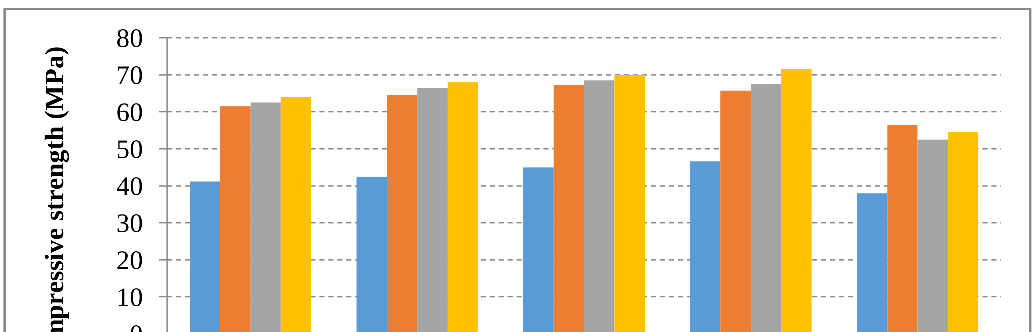
Figure 2 : (a) Cube size 150 X 150 X 150 mm (b) Compressive testing machine (c) Image for beam moulds casted (100 x 100 x 500 mm) (d) Third point loading arrangement



	M1	M2	M3	M4	M5
14 days	41.2	42.5	45	46.6	38
28 days	61.5	64.5	67.3	65.7	56.5
56 days	62.5	66.5	68.5	67.5	52.5
90 days	64	68	70	71.5	54.5

Figure 3 Compressive strength of concrete at different curing days

For flexural strength test beam specimens of dimension 100x100x500 mm were cast. The specimens were demoded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 28 days. These flexural strength specimens were tested fewer than two point and four point loading as per I.S. 516-1959, over an effective span of 400 mm on Flexural testing machine. Load and corresponding deflections were noted up to failure. In each category three beams were tested and their average value is reported.

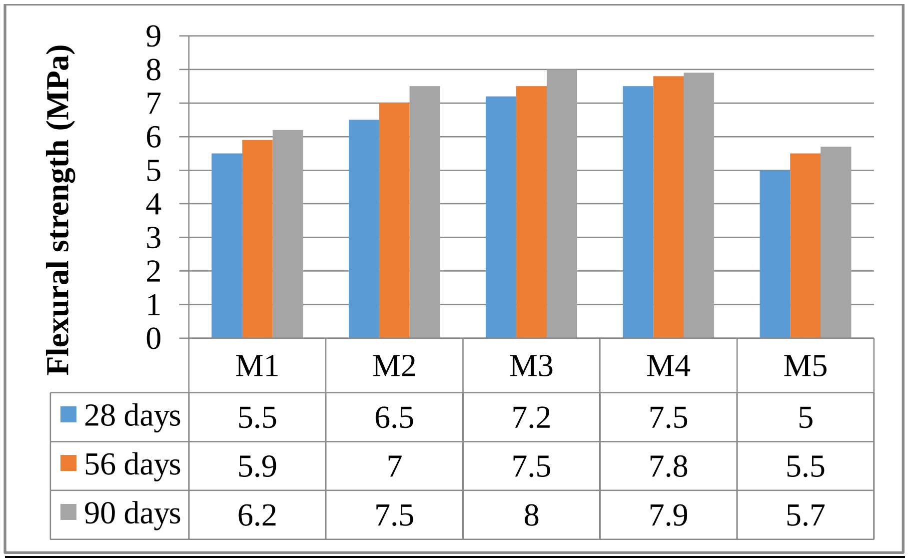


Figure 4 Flexural strength of concrete at different curing days

One of the fundamental and significant qualities that significantly influences the size and degree of cracking in structures is the split tensile strength of concrete. Since cement has a low tensile strength and is fragile by design, it is not often anticipated to withstand the reason for increased.The formula used to calculate the splitting tensile stress of concrete that complies with ASTM C496/C496M-11 is f spt MPa = 2 F / D L, where F is the force applied (N), D is a specimen's diameter (mm), and L is a specimen's length (mm).

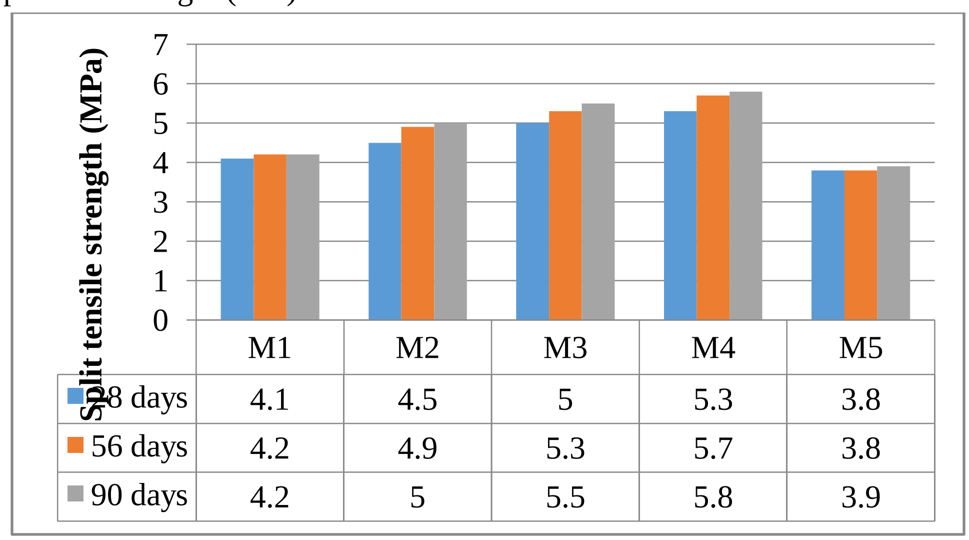


Figure 5 Split tensile strength of concrete at different curing days

4. Conclusions

The Indian standard size of cubical steel mould was cast for different curing days for various mixes. It shows an increasing trend in compressive strength values with the partial replacement of fine aggregate with waste plastic.

- The plastic waste an increase of 13.11%, 6.83%, 8.00% and 11.72% for 7, 28, 56 and 90 days in compressive strength is observed respectively when compared to control mixes.
- The split tensile strength test was carried out varying mix proportions in M60 grade of concrete. The plastic waste was replaced in fine aggregate from 0%, 5%, 15% & 20 % for different curing periods. It's showing the better strength gain attainment while replacing up to 15% waste plastic in fine aggregate shows up to 29.27%, 35.71%, and 38.10% respectively for 28 days, 56 days and 90 days.
- The development of indirect tensile strength (flexural strength) for M60 grade concrete with 15% of waste plastic was 36.36%, 32.20% and 27.42% for 28 days, 56 days and 90 days respectively.
- The results from the study clearly outline the utilization of waste plastic up to 15% replaced in control concrete as the fine aggregate will reduce the problem due to scarcity of natural river sand. It will also reduce the global warming and cost of building construction.
- The recycled waste plastic, PET bottles can be used in the concrete production at certain replacement rates. This approach reduces the self-weight of concrete in structures and helps conserve natural resources such as river or manufactured sand.
- The most vulnerable effective outcome measures to minimize the E-waste due to large quantity utilization and reduce the carbon di oxide and reduce the global effects.

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