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TRANSFORMING TRASH TO STRENGTH: PLASTIC WASTE IN FINE AGGREGATE REPLACEMENT

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ABSTRACT

Plastic waste accumulation poses a significant environmental challenge due to its resistance to degradation and improper disposal practices. Addressing this issue requires innovative strategies that not only reduce waste but also promote sustainable development. This study, "Transforming Trash to Strength," explores the feasibility of utilizing waste plastics as a partial replacement of fine aggregate in concrete. Experimental investigations were carried out with varying proportions of plastic waste to assess workability, compressive strength, and durability characteristics. The findings reveal that limited substitution of fine aggregates with plastic waste can produce eco-friendly concrete with acceptable performance, thereby reducing the reliance on natural resources and mitigating environmental hazards. This research demonstrates how plastic waste can be transformed into a valuable construction material, contributing to sustainable infrastructure development.

Keywords

Plastic Waste, Fine Aggregate Replacement, Sustainable Concrete, Eco-Friendly Construction, Compressive Strength, Waste Utilization, Green Building Materials, Environmental Sustainability

I. INTRODUCTION

T The rapid growth of urbanization and industrialization has led to a massive increase in plastic production and consumption worldwide. Plastics, while highly versatile and durable, pose a significant environmental threat due to their non-biodegradable nature and inefficient disposal systems [1], [2]. Globally, millions of tons of plastic waste are generated annually, and improper management has resulted in severe ecological challenges, including land pollution, ocean contamination, and adverse effects on human health [3]. In this context, recycling and reusing plastic waste in construction materials have emerged as sustainable alternatives to address both environmental and infrastructural demands [4], [5].

Concrete is the most widely used construction material, composed primarily of cement, sand, aggregates, and water. However, the extraction of natural aggregates, especially river sand, has resulted in ecological imbalances, depletion of resources, and environmental degradation [6]. This has prompted researchers to explore alternative fine aggregates from industrial and municipal waste sources. Plastic waste, due to its lightweight, durability, and availability in large volumes, has attracted significant attention as a partial replacement for fine aggregates in concrete [7], [8].

The incorporation of plastic waste into concrete, often referred to as plastic sand replacement, not only reduces the dependency on natural sand but also contributes to sustainable solid waste management [9]. Studies have demonstrated that replacing fine aggregates with shredded or granulated plastic can enhance specific concrete properties such as toughness, impact resistance, and ductility [10], [11]. However, it may also reduce compressive strength when used in higher proportions, necessitating optimized replacement levels for structural applications [12].

Experimental investigations conducted by various researchers highlight that partial replacement of fine aggregates with plastic waste in the range of 5–20% provides a balance between

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mechanical strength and environmental benefits [13]. Moreover, plastic-modified concrete exhibits improved resistance to shrinkage cracking and enhanced durability performance, particularly against moisture ingress and chemical attacks [14]. These findings suggest that plastic waste can be effectively valorized in construction, offering dual benefits of environmental protection and infrastructure development [15].

This study aims to experimentally evaluate the feasibility of using plastic waste as a partial replacement of fine aggregates in concrete. By analyzing mechanical properties such as compressive strength, flexural strength, and durability, the research seeks to establish optimized replacement proportions and validate plastic waste as a sustainable construction material..

1.1 CONCRETE

Second only to water, concrete is the most widely used man-made construction material in the world. It is formed by mixing concrete ingredients, and sometimes admixtures, in the right amounts. The mixture solidifies into concrete, a rock-like mass, when it is put into moulds and allowed to cure. Concrete may alternatively be thought of as an artificial stone in which cement fills the crevices between fine aggregates since the hardening is created by a prolonged interaction between cement and water. The cementing ingredient and water are combined in a concrete mix to create a paste called cement water-paste, which fills the spaces in the fine aggregates and, when it dries, covers the surfaces of the fine aggregates and binds them together, cementing the fine aggregate particles into a compact mass.

1.2 Plastics

Nowadays, plastics are used extensively in our daily life. Almost all industrial processes include the usage of plastics. Thousands of tonnes of plastic products are produced daily, and the garbage keeps piling up. Developed nations contribute the most to the enormous amount of plastic waste that continues to build worldwide since the majority of plastics are not biodegradable. More specifically, the majority of plastic waste comes from containers and packaging. Concern about the amount of land required for landfills is spreading over the world. An estimated 6.3 billion tonnes of plastic were produced worldwide between 1950 and 2018, of which 9% was recycled and the other 12% was burnt. Only about 25% of the more than 5 million tonnes of plastic that India uses annually is recycled; the remainder ends up in landfills. This enormous amount of plastic waste will ultimately find its way into the environment; according to study, 90% of seabirds may include plastic garbage in their bodies.

Plastic type	Name	Properties	Density Range	Common Uses
[illegible]	Polyethylene terephthalate	[illegible]	[illegible]	[illegible]
[illegible]	High Density Polyethylene	[illegible]	[illegible]	[illegible]
[illegible]	Polyvinyl Chloride	[illegible]	[illegible]	[illegible]
[illegible]	Low Density Polyethylene	[illegible]	[illegible]	[illegible]
[illegible]	Polypropylene	[illegible]	[illegible]	[illegible]
[illegible]	Polystyrene	[illegible]	[illegible]	[illegible]

1.3 NEED OF PROJECT:

These days, there is a scarcity of river sand due to environmental issues such as river erosion and the need for fine aggregate. In order to prevent excessive river erosion, there is a rising need to find innovative alternative materials to replace river sand due to the depletion of natural sand resources and the need to lower the cost of producing concrete. Over the last 20 years, researchers have looked at replacing natural sand entirely or in part with alternative materials such plastics, iron slag, polyethylene terephthalate, quarry dust, and others in order to maintain ecological balance. One experimental investigation of the strength characteristics of PET (polyethylene terephthalate) in lieu of natural sand is presented in this research.

1.4 SCOPE

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The study contributes to and helps develop more environmentally friendly concrete binders. In this study, the effects of PET (polyethylene terephthalate) on the durability and strength of concrete properties were thoroughly examined.

In concrete and OPC paste, pulverised PET (polyethylene terephthalate) is used in varying proportions (0% to 30%) to substitute fine aggregate. In contrast to the usual fine aggregates used in the manufacturing of concrete, the granulated PET-Polyethylene Terephthalate was assessed for its physical characteristics, including aggregate grading, water absorption, and relative density, before being ground into powder.

1.5 LITERATURE SURVEY

The use of plastic waste as a replacement for natural fine aggregates in concrete has been widely investigated in recent years, driven by both sustainability goals and the shortage of river sand. Researchers have consistently reported that low-level substitution of sand with plastic aggregates can improve certain mechanical and durability properties of concrete [16]. For instance, experimental studies showed that partial replacement up to 10–15% could enhance ductility and impact resistance while maintaining acceptable compressive strength levels [17].

Several investigations have also explored the microstructural behavior of plastic-modified concrete. It was found that the hydrophobic nature of plastic particles reduces water absorption and permeability, thereby enhancing resistance against chemical attack and freeze–thaw cycles [18]. Such improvements make plastic waste a promising material for non-structural and semi-structural applications, particularly in pavement blocks, lightweight panels, and low-cost housing. However, high replacement percentages often lead to decreased compressive strength due to poor bonding between plastic and cement paste, indicating the need for optimized mix designs [19].

Beyond mechanical properties, sustainability and life-cycle performance of plastic waste concrete have also been studied. Life-cycle assessment (LCA) analyses revealed that the integration of plastic aggregates not only diverts waste from landfills but also reduces the carbon footprint of concrete production [20]. These findings strongly support the incorporation of plastic waste into construction materials as part of a circular economy model, contributing to both environmental protection and resource conservation.

Overall, the literature underscores the feasibility of plastic waste as a sustainable fine aggregate replacement in concrete. Nonetheless, further research is required to standardize testing protocols, optimize replacement ratios, and evaluate long-term durability under real-world environmental conditions.

II. MATERIALS

The following materials are used for the present work Cement

1. Fine aggregate
2. Coarse aggregate
3. Water
4. Plastic (poly Ethylene terephthalate)

2.1.Cement

Cement may be used to join different construction materials and compacted assemblies because of its cohesive and adhesive properties. Depending on how it reacts with the carbon dioxide in the air, cement, a material that sets and hardens as it dries, may bond other materials together. The most often utilised basic constituents in the manufacturing of cement are lime, silica, alumina, and iron oxide. These oxides combine in the kiln to form more complex combinations. Cement's varied properties, including cooling rate and grinding fitness, are influenced by the relative amounts of different oxide compositions. 53 Grade was used in this project.

Table 2.1: Approximate Oxide Composition Limits Of Ordinary Portland Cement

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Chemical Compound	Percentage
Lime, (CaO)	60-66
Silica, (SiO_2) Alumina , (Al_2O_3)	17-25 3-8
Iron Oxide, (Fe_2O_3)	0.5-6
Magnesia , (MgO)	0.5-4
Sulphur Trioxide, (SO_3)	1-2
Alkalis	0.5-1.3

2.1.1. Fine Aggregate:

Fine aggregates are defined as those that flow past a screen that is smaller than 4.75 mm. The coarse and fine aggregate separation limit is 4.75 mm. Coarse aggregates have a diameter more than 4.75 mm, while fine aggregates have a diameter less than 4.75 mm. The fine aggregate should consist of combinations of strong, sturdy, long-lasting particles or natural sand or, with permission, another input material with similar properties. It is forbidden to mix or store fine aggregates from different sources in the same pile, or to use them in the same construction class or mix in any particular sequence. There should be no hazardous organic or inorganic pollutants present in the fine aggregate. Filling up the gaps left by coarse aggregates is the aim of fine aggregates. Silica makes up the majority of fine aggregate. Sand that is smaller than 4.75 mm in size and passes through an IS filter is selected for use as a fine aggregate in this study's concrete manufacturing.

2.1.2. Coarse Aggregate:

It should come as no surprise that aggregate quality is crucial since it accounts for at least three-quarters of the volume of concrete. The longevity and structural performance of the concrete are significantly influenced by the aggregate qualities. Particles greater than 4.75 mm in diameter are referred to as coarse aggregate. Coarse aggregates occupy more area than cement and fine aggregates since they are the main load-bearing ingredients in concrete. The quantity and quality of these are crucial in the best concrete production method. The coarse aggregates utilised in this project are a mixture of 20 mm and 12 mm in size. 40 percent of 12 mm and 60 percent of 20 mm were chosen for this project.

2.1.3 Drinking Water:

Due to its involvement in the chemical process known as hydration, water is a necessary component of concrete. This hydration provides the cement particles their cohesive quality in joining the coarse and fine aggregates by releasing the hydration products known as tri-calcium silicates and di-calcium silicates. The quantity and quality of water are essential for efficient concrete practice. If there is more concrete than is necessary, it is considered a criminal. It may drastically reduce the strength of concrete by causing capillary pores in the material. Quality is often measured using the criterion that "the water that is utilised for drinking water may be a suitable match for concrete production." Potable water is used in this project. The W/C ratio for this study was 0.50.

2.2 TESTING ON MATERIALS

2.2.1 Test on cement

The following tests are done on the cement

- **a.** Fineness test
- **b.** Specific gravity test.

a. Fineness of cement:

Weigh 100 grammes of cement accurately after placing it on a standard 90 micron IS sieve. Any lumps of air-set cement should be broken apart with your fingers. Continuously sift the material in a vertical and circular motion for 15 minutes. It is also possible to use mechanical sieving equipment. The residue that has gathered on the sieve should be weighed.

The residue's weight as a percentage of the whole sample is provided as,

%Weight of residue

$$= \frac{\text{Weight of sample retained on sieve}}{\text{Total Weight of sample}}$$

No more than 10% of the sample should have residue.

Table 2.2: Observations of Fineness of Cement Test

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Trail No.	1	2
Weight of cement in grams	100	100
Weight of residue on sieve in grams	4	4
Amount retained	4	4

Fineness of cement = 4%.Hence it is within the permissible limits.

b. Specific Gravity Test:

Before weighing a specific gravity bottle, make sure it is clean and dry (W1). Weigh the water weight using the bottle (W2) after halfway filling the specific gravity bottle with water. The specific gravity container should be filled to the brim with kerosene after the water has been drained and dried (W3). Pour cement into the specific gravity bottle, then weigh the container to get the cement's weight (W5). Pour kerosene into the specific gravity bottle, then use the following formula to get the weight of the bottle containing cement and kerosene: (W4).

In line with IS: 456-2000

Limits: Specific Gravity of cement <3.15gm/cc

TABLE 2.3: OBSERVATIONS OF SPECIFIC GRAVITY OF CEMENT TEST

S.NO	Description	Trial(gm)
1	Mass of empty bottle(W_1)gm	50.0
2	Mass of bottle + water (W_2)gm	182.0
3	Mass of bottle + kerosene (W_3)gm	155.0
4	Mass of bottle + cement + kerosene (W_4)gm	192.2
5	Mass of cement (W_5)gm	50.0

Specific gravity of cement (G)

$$= \frac{W5(W3-W1)}{(W5+W3-W4)(W2-W1)}$$

$$= \frac{50(155-50)}{(50+155-192.2)(182-50)}$$

= 3.11 gm/cc

The specific gravity of cement obtained is 3.11 gm/cc.

Hence it is within the permissible limit.

Table 2.4. Test results of cement

S.NO	Properties		Results	Suggested values as per IS Specification
1	Fineness of cement		4% retained	<10%
2	Specific Gravity		3.11	<3.15

2.3.Tests on Fine Aggregate (sand):

The tests below are carried out to determine the characteristics of fine aggregates:

a. Grading of sand

b. Specific gravity and water absorption Test

a. Grading of Sand –Sieve Analysis: One kilogramme of sample may be obtained by quartering a fifty kilogramme sample using a riffle box. With the sieve size increasing as you approach the top, stack the corresponding sieves one on top of the other. Put the pan on the pot's bottom. Place the sieve in the upper sieve after covering it. For 20 to 30 minutes, shake the sieves in a sieve shaker. Weigh both the pan and the material retained in each filter. Using its grading parameters, get its fineness modulus.

4.75 mm, 2.36 mm, 1.18 mm, 600µ, 300µ, 150µ, and a pan are the sieve sizes that are used.

TABLE 2.5: OBSERVATIONS OF SIEVE ANALYSIS TEST:

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S.NO	Sieve size	Weight retained	% Weight retained	Cumulative % of weight retained	% weight passing	Cumulative % weight passing
1	4.75mm	9	0.9	0.9	99.1	99.1
2	2.36mm	11.6	1.16	2.06	97.94	197.04
3	1.18mm	188.5	18.85	20.91	79.01	276.05
4	600µ	300	30.0	50.91	49.09	374.15
5	300µ	380	38.0	88.91	11.01	385.16
6	150µ	102.5	10.25	99.16	0.84	386
7	Pan	6	0.6	99.76	0.24	386.24

From the table the fineness modules of the sand = $\frac{\sum F}{100} = \frac{386.24}{100} = 3.86$

Hence it is within the permissible limits.

b. Specific Gravity of fine Aggregate (sand):

Weigh the dry and clean density bottle as W1. Weigh the oven-dried dirt that has gone through a 4.75mm sieve as W2 and fill a density bottle halfway. Take 200 grammes if the soil has medium to coarse grains. Using the glass rod, thoroughly mix the distilled water halfway into the density bottle. Fill the density bottle with water from the outside, weighing it as W3, and replace the sieve top. Empty the density bottle, rinse it, and then fill it with distilled water until the hole in the conical top is filled. Weigh it as W4.

Table 2.6. Observations of Specific Gravity of Fine Aggregate Test:

S.NO	Description	Trail(gm)
1	Weight of density bottle (W_1)gm	181
2	Weight of density bottle + Dry soil (W_2)gm	381
3	Weight of density bottle + Dry soil + Water (W_3)gm	879
4	Weight of density bottle + Water (W_4)gm	752

Specific gravity of sand= $\frac{W2-W1}{(W4-W1)-(W3-W2)}$ $= \frac{(375-181)}{(752-181)-(879-381)}$ = 2.65

Table 2.7: Test Results of Fine Aggregate

S.NO	Properties	Results
1	Grading of sand	3.86
2	Specific gravity	2.65

Therefore, these values fall within the acceptable ranges..

TABLE: RESULTS OF AGGREGATE IMPACT TEST:

S.NO	DETAILS	TRAILS

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1	Total weight of aggregate sample filling in the cylindrical measure=(a)gm	1282
2	Weight of aggregate passing 2.36mm sieve after the test = (b)gm	923
3	Weight of aggregate retained on 2.36mm sieve after the test= (c)gm	53.5
4	Difference in the weight = a-(b+c) gm	359
5	Aggregate impact value= $\frac{B}{A} * 100$	14.902%

According to IS: 456-2000, the effect value of a particular aggregate is 14.902 percent; it should be less than 45 percent, therefore it is likewise within acceptable limits.

TABLE: TEST RESULTS OF COARSE AGGREGATES:

S.NO	PROPERTIES	RESULTS	SUGGESTED VALUES AS PER IS: 456-2000 SPECIFICATIONS
1	Specific Gravity	2.82	2.3 to 3.0
2	Water Absorption	0.35%	0.1% to 2.0%
3	Crushing Value	16.5%	30%
4	Impact Value	14.902%	45%

III.Plastic (poly Ethylene terephthalate):

One of the thermoplastics that is recycled the most is PET, which has the recycling symbol "1."

Recycled PET may be turned into sheets, fibres, and textiles for use in packaging and vehicle parts. Chemically, polybutylene terephthalate and polyethylene terephthalate are quite similar.

In its natural state, PET is a semi-crystalline resin that is very flexible and colourless. Depending on how it is handled, it may be either semi-stiff or rigid. It resists alcohols and solvents, is impact resistant, moisture resistant, and has outstanding dimensional stability.

Fine powder is made from plastics that are no longer degradable. High-density polyethylene (HDPE) makes up the bulk of these polymers.

3.1 Uses OF Plastic

Due to its numerous benefits, such as being lighter than similar materials and using less fuel for transportation, plastic is becoming more and more popular.

- Durability and longevity
- Resistance to chemicals, water, and impacts
- Outstanding electrical and thermal insulation properties.
- Reduced production costs relative to.

IV.METHODOLOGY

This is how the study "partial replacement of natural sand with Polyethylene terephthalate" is conducted.

Polyethylene terephthalate is used to partially replace the sand in the M20 concrete mix up to 30% at 10% intervals, i.e., 0%, 10%, 20%, and 30%. A brief summary of the project is given in the following table.

THEME: Polyethylene terephthalate may replace up to 80% of sand, with a 10% gap between replacements.

CEMENT USED: OPC M20 Concrete Mix ratios of 1:1.5:3 are used, and the curing times are 7 and 28 days.

1:1.5%:3; 10 kg: 15 kg: 30 kilogramme

In order to assess compressive strength, six cubes were cast for every percentage replacement, with

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three cubes assigned for every seven and twenty-eight days of curing.

Table 4.1: Details of Cement, FA, CA and PET Composition in Concrete

% of Poly ethylene terephthalate	Materials used to cast cubes			
	Cement(kg)	F.A + Poly ethylene terephthalate	C.A	W/C Ratio
0%	10	15+0	30	0.54
10%	10	13.5+1.5	30	0.54
20%	10	12+3	30	0.54
30%	10	10.5+4.5	30	0.54

The following procedural stages are followed in order to achieve the work's goal.

1. Batching
2. Mixing
3. Casting of cubes
4. Compaction
5. Curing
6. Testing

4.1. BATCHING:

It involves weighing and adding the various components of the concrete mix, either by mass or by volume, to the mixture. Although most standards require batching by mass rather than volume, batching has always been done by volume.

coarse aggregate

Fine aggregate

Cement

Poly ethylene terephthalate

4.2 MIXING

A non-porous surface is ideal for mixing. Distribute the designated quantities of coarse and fine aggregate in alternating layers. Cover it with cement and use a shovel to mix it dry, stirring often until the colour is uniform. The layer of this uniform mixture is 20 cm thick. At the same time,

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the mixture is turned over and sprayed with water. Until a good, homogeneous concrete is produced, this procedure is repeated. The fact that the water is sprinkled rather than poured should also be noted. A little quantity of water should be added towards the end of the mixing operation to get the required consistency. At that moment, even a little quantity would do.

(i) Concrete mix workability testing:

For concrete to reach its maximum strength, 100% compaction is necessary. The presence of air gaps due to a lack of compaction will affect strength and durability just as much as or more than capillary cavities. Concrete that satisfies the following requirements is considered workable. Although "consistency" and "workability" are sometimes used interchangeably, "workability" or "workable concrete" has a far deeper and wider meaning. The degree of fluidity or movement is referred to as consistency, which is a general term. The word "workability" means the "property of concrete that affects the amount of beneficial internal work required to achieve complete compaction." One further definition that is more inclusive is "Ease with which concrete may be compacted 100 percent regardless of method of compaction and location of deposition."

4.2.1 SLUMP CONE EXPERIMENT:

It is the most often used method for figuring out concrete's consistency, and it may be used both on the work site and in the lab. It's not a suitable method for concrete that is very wet or very dry, it doesn't take into consideration all the factors that impact workability, and it's not always a reliable indicator of how well concrete will place. It does, however, show the uniformity of concrete from batch to batch and is helpful as a control test. Repeated batches of the same mix supplied to the same slum will have the same water content and water content ratio if the weights of the aggregate cement and additive are constant and the aggregate grading is within reachable bounds. Additional information about the concrete's workability and quantity may be obtained by observing how the concrete slumps. Another way to assess the quality of concrete is to use a tamping rod to blast or tamp the base plate. The metal sheet used to create the mould must be at least 1.6 mm thick. Sometimes the mould comes with appropriate lifting guides. Concrete is tamped with a steel tamping rod with a bullet end that is 0.6 meters long and 16 mm in diameter. The internal surface of the mould is thoroughly cleaned to remove any excess moisture and old set concrete adhesion before the test begins. The mould is placed on a firm, level, smooth, and non-absorbent surface. Next, four layers of filling are made, each filling the mould approximately one-fourth of the way up. Each layer is tamped 25 times with the tamping rod, being careful to evenly distribute the strokes over the cross section. After the top layer has been rodded, the concrete is levelled using a trowel and tamping rod. The mould is carefully and gently lifted vertically to remove it from the concrete right away. Because of this, the concrete will have the opportunity to settle. The name for this kind of sinking is concrete SLUMP. The height difference between the mould and the highest point of the concrete that is sinking is measured.

TABLE 4.2: TEST RESULTS OF SLUMP WITH DIFFERENT %REPLACEMENT OF SAND WITH POLY ETHYLENE TEREPHTHALATE

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% of polyethylene terephthalate	SLUMP VALUE(mm)
0%	90
10%	80
20%	70
30%	50

4.3. CASTING OF CUBES:

The purpose of the concrete cubes was to test the compressive strength of the material. The cubes were formed in steel or cast iron metal moulds. These moulds should have sufficient thickness to prevent distortion. The purpose of these moulds is to facilitate the simple removal of the moulded object without causing any harm. Each mould comes with a base plate that has a flat surface. The base plate, which is fastened to the mould, should be big enough to support the mould while it is being filled without leaking. The interior surface of the mould is gently oiled to stop concrete from sticking.

These procedures include thoroughly mixing the concrete's constituent parts—cement, fine and coarse aggregates, plastic (polyethylene terephthalate), and water—under dry circumstances until a consistent colour is achieved. After that, the water is added in the appropriate proportions and well mixed once again. After that, the concrete is poured into the mould.

As part of the test program, the 150 x 150 x 150 mm concrete cubes were cast and put through testing. The compressive strength of M20 concrete was assessed using six specimens, and two specimens were used for each percentage of PET replacement (0, 10, 20, and 30%). The components of regular Portland cement 53 Grade, natural river sand, and crushed stone no larger than 20 mm are used in the casting and testing of partially plastic waste replaced (10%, 20%, and 30% of replacement with fine aggregate in concrete cubes) (150mm x 150mm x 150mm in size).

4.4 COMPACTION

Use a tamping rod to ensure that the concrete is adequately compressed. The concrete may become harsh due to poor workability caused by inadequate compaction. Inadequate compaction may result in voids, which let water seep through the concrete and reduce its longevity. Hand compaction and mechanical compaction are the best methods for achieving proper compaction. For mechanical compaction, a table vibrator may be used. When the compaction process is finished, use a trowel to remove any excess concrete. Put a reference mark on the cubes of concrete. Don't let these cubes dry out over the course of a day. To cure these cubes, immerse them in water.

The following amounts of concrete ingredients and a polyethylene terephthalate substitute are used to create the cubes.

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4.5 Curing of Cubes

Concrete gets its strength from the cement particles hydrating. Cement hydration is not a masonry operation; rather, it is a prolonged process. Naturally, hydration occurs quickly at initially but gradually slows down. The degree of hydration determines the quantity of hydration product generated and, therefore, the amount of gel formed. The cement must have a W/C ratio of 0.15 in order to fill the gaps in the gel pores. In other words, in order to fill the gel pores and hydrate all of the cement particles, a water/cement ratio of around 0.38 would be required. In theory, a concrete manufactured and stored in a sealed container with a W/C concentration of 0.38 might satisfy the need for water for hydration without creating any capillary cavities.

Nonetheless, it is evident that in order to maintain the appropriate relative humidity level for complete hydration in a sealed container, a water content of 0.5 is required.

4.6 Concrete Testing CUBES-Compressive Strength Test:

Compressive strength testing is the most common test performed on hardened concrete, in part due to its ease of use and in part because the majority of the desirable properties of concrete are qualitatively related to its compressive strength.

The specimen used to determine the compressive strength is either cylindrical or cubical. Although prism is not often used in our country, it is sometimes used as well. Concrete's compressive strength may sometimes be assessed using flexure tests on specific beam components. Because the beam usually has a cross section, the end sections of the beam remain intact after a flexure failure and may be used to calculate the compressive strength. The cubes are 15 cm by 15 cm by 15 cm. 10cm size cubes may be used in place of aggregate if its maximum nominal size is less than 20mm. Test specimens that are cylindrical are twice as long as they are broad. They are 30 cm long and 15 cm in diameter. Although smaller test specimens may be used, they must have a diameter that is at least three times the aggregate's maximum size.

V. RESULTS

The next section presents the experimental research's results.

The following illustrates the workability of different percentages of polyethylene terephthalate as a partial fine aggregate substitution in terms of slump values.

Table 5.1: Result of Slump Values

% OF POLY ETHYLENE TEREPHTHALATE	SLUMP VALUE(mm)

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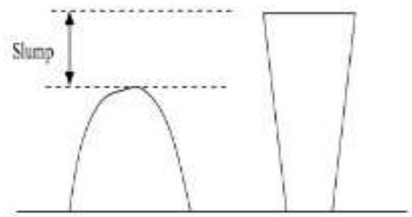
0%	90
5%	80
10%	70
15%	50



Compressive Strength of Concrete

$$\text{Compressive strength} = \frac{\text{Ultimate load}}{\text{Area of Specimen}}$$

Table 5.2 values for 0% replacement of fine aggregate with polyethylene terephthalate

Cube No.	Days of curing	Load in kN	Area in cm^2	Compressive strength in N/mm^2
1	7	658	225	29.24
2	28	897	225	39.86

Table 5.3: values for 10% replacement of fine aggregate with polyethylene terephthalate

Cube No.	Days of curing	Load in kN	Area in cm^2	Compressive strength in N/mm^2
1	7	624	225	27.73
2	28	864	225	38.4

Table 5.4: values for 20% replacement of fine aggregate with polyethylene terephthalate

Cube No.	Days of curing	Load in kN	Area in cm^2	Compressive strength in N/mm^2
1	7	614	225	27.2
2	28	719	225	31.95

Table 5.5 values for 30% replacement of fine aggregate with polyethylene terephthalate

Cube No.	Days of curing	Load in kN	Area in cm^2	Compressive strength in N/mm^2
1	7	368	225	16.35
2	28	486	225	21.6

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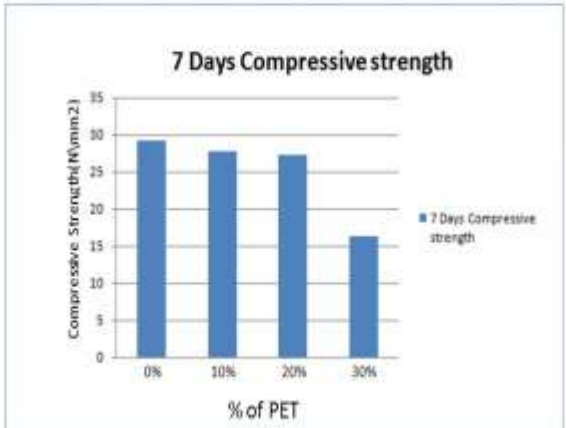
Graph: 7 days compressive strength



Graph: 28 days compressive strength

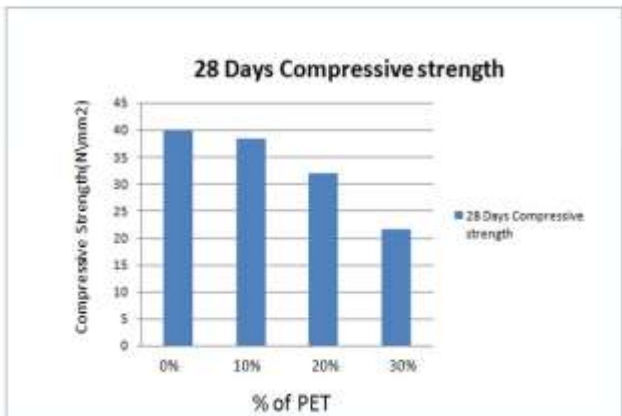


Table 5.6: Test results of Replacement of Fine Aggregate with PET

Type of aggregate	**No. of days cures**	**Average compressive strength at different % replacement of fine aggregate with polyethylene terephthalate (N/mm^2)**			
		0%	**10%**	**20%**	**30%**
Fine Aggregate	**7**	**29.24**	**27.73**	**27.2**	**16.25**
	28	**39.86**	**38.4**	**31.95**	**21.6**

Graph: Total Result

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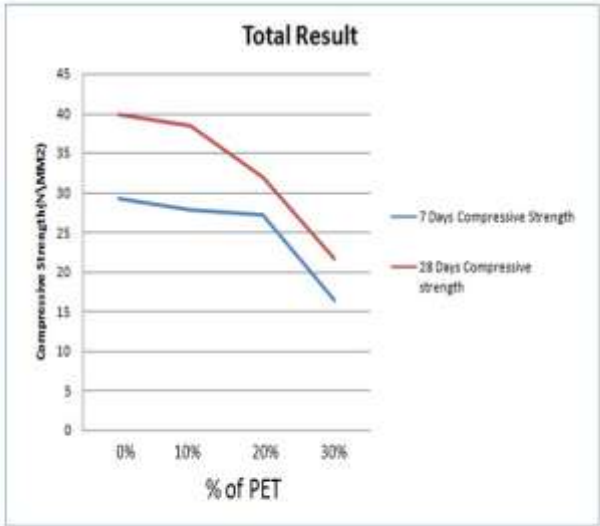
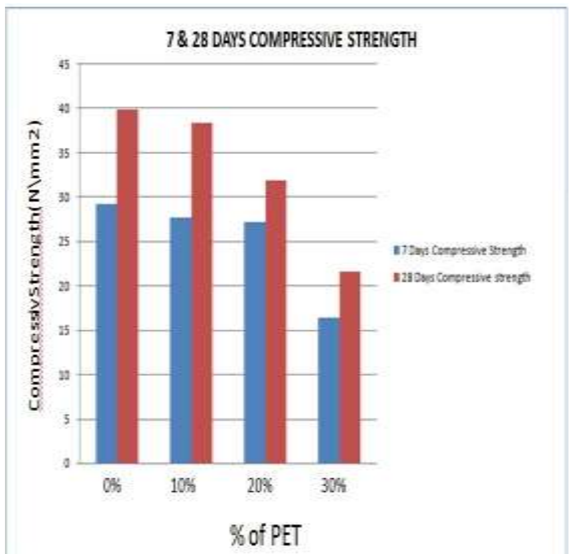


Graph: Comparison of 7 & 28 days Compressive Strength



VI.CONCLUSIONS

The experimental investigation on the utilization of waste plastics as a partial replacement of fine aggregates in concrete demonstrates both environmental and engineering significance. The findings indicate that incorporating plastic waste in controlled proportions can produce concrete with acceptable strength and workability for certain structural and non-structural applications. While higher replacement levels may reduce compressive strength, moderate substitution offers a balance between performance and sustainability. This approach not only reduces the consumption of natural sand but also provides a practical solution for managing plastic waste, which is a major environmental concern. By transforming non-biodegradable waste into a useful construction material, this study supports the vision of eco-friendly and resource-efficient infrastructure development. Future research should focus on optimizing mix proportions, exploring the long-term durability of plastic-modified concrete, and assessing its potential in large-scale construction projects.

10.48047/jocaaa.2024.32.01.49

REFERENCES

[1] R. Geyer, J. R. Jambeck, and K. L. Law, "Production, use, and fate of all plastics ever made," Science Advances, vol. 3, no. 7, pp. e1700782, Jul. 2017.

[2] J. R. Jambeck, R. Geyer, C. Wilcox, et al., "Plastic waste inputs from land into the ocean," Science, vol. 347, no. 6223, pp. 768–771, Feb. 2015.

[3] K. Andrady and M. A. Neal, "Applications and societal benefits of plastics," Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 364, no. 1526, pp. 1977–1984, Jul. 2009.

[4] A. M. Alhozaimy, "Waste plastic in concrete: A review," Construction and Building Materials, vol. 73, pp. 195–207, Dec. 2014.

[5] K. B. Najim and M. R. Hall, "A review of the fresh/hardened properties and applications for plain-(PRC) and self-compacting rubberised concrete (SCRC)," Construction and Building Materials, vol. 24, no. 11, pp. 2043–2051, Nov. 2010.

[6] M. Mehta and P. J. M. Monteiro, Concrete: Microstructure, Properties, and Materials, 4th ed. New York, NY, USA: McGraw-Hill, 2014.

[7] R. Siddique, J. Khatib, and I. Kaur, "Use of recycled plastic in concrete: A review," Waste Management, vol. 28, no. 10, pp. 1835–1852, 2008.

[8] A. Saikia and S. K. Brito, "Use of plastic waste as aggregate in cement mortar and concrete preparation: A review," Construction and Building Materials, vol. 34, pp. 385–401, Sep. 2012.

[9] A. M. Al-Manaseer and T. R. Dalal, "Concrete containing plastic aggregates," Concrete International, vol. 19, no. 8, pp. 47–52, 1997.

[10] P. S. Song, S. Hwang, and B. C. Sheu, "Strength properties of nylon- and polypropylene-fiber-reinforced concretes," Cement and Concrete Research, vol. 35, no. 8, pp. 1546–1550, Aug. 2005.

[11] V. S. Barbhuiya, "Strength and durability properties of concrete with plastic aggregate," Journal of Materials in Civil Engineering, vol. 25, no. 10, pp. 1474–1480, Oct. 2013.

[12] K. Hannawi, S. Kamali-Bernard, and W. Prince, "Physical and mechanical properties of mortars containing PET and PC waste aggregates," Waste Management, vol. 30, no. 11, pp. 2312–2320, 2010.

[13] A. Ismail and A. Al-Hashmi, "Use of waste plastic in concrete mixture as aggregate replacement," Waste Management, vol. 28, no. 11, pp. 2041–2047, Nov. 2008.

[14] A. Marzouk, R. Dheilly, and J. Queneudec, "Valorization of post-consumer waste plastic in cementitious materials," Waste Management, vol. 27, no. 2, pp. 310–318, 2007.

[15] S. Choi, Y. Moon, and H. Kim, "Mechanical properties of concrete containing recycled PET bottle fibers," Construction and Building Materials, vol. 23, no. 8, pp. 2829–2835, Aug. 2009.

[16] C. Albano, N. Camacho, J. Hernández, A. Matheus, and A. Gutiérrez, "Influence of content and particle size of waste pet bottles on concrete behavior at different w/c ratios," Waste Management, vol. 29, no. 10, pp. 2707–2716, 2009.

[17] A. Rahmani, M. Dehestani, M. H. Beygi, I. M. Allahyari, and H. Nikbin, "On the mechanical properties of concrete containing waste PET particles," Construction and Building Materials, vol. 47, pp. 1302–1308, 2013.

[18] F. Frigione, "Recycling of PET bottles as fine aggregate in concrete," Waste Management, vol. 30, no. 6, pp. 1101–1106, 2010.

[19] R. Medina, M. Frías, and M. I. Sánchez de Rojas, "Microstructure and properties of recycled PET lightweight concrete," Construction and Building Materials, vol. 25, no. 8, pp. 3548–3556, 2011.

[20] A. Horvath, "Life-cycle environmental and economic assessment of using recycled plastics in

10.48047/jocaaa.2024.32.01.49

concrete," Resources, Conservation and Recycling, vol. 54, no. 11, pp. 802–809, 2010.