International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 09 September 2024
Page No: 2270 - 2275
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0309

Influence of Non-Biodegradable Polyethylene Terephthalate on Fresh and Hardened Properties of High-Strength Concrete

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Abstract
The influence of non-biodegradable Polyethylene Terephthalate (PET) on the mechanical characteristics and workability of the produced specimens was examined in this research work. However, in cement mixtures with a consistent cement content and water to cement ratio, river sand was substituted for four different PET weight fractions of 10, 20, 30, and 40%. Increasing the amount of PET replacement improves the combinations' workability. However, as PET inclusion increases, the dry density, compressive and flexural strengths decreased, with the exception of the mix that contained 10% PET, which increased the compressive and flexural strengths. It was concluded that the combination containing 30% PET is regarded as a lightweight mortar and appropriate for structural uses based on the dry density and compressive strength data.
Keywords: *compressive strength; flexural strength; OPC; PET; river sand; workability;*

1. Introduction
Since plastics have been around for more than a century, both positive and bad uses for them can be found everywhere. Plastics are a substance that is both useful and friendly to the average person, but after usage, they can harm the environment. Plastic pollution is the build-up of plastic items in the environment that negatively impacts aquatic life, humans, wildlife habitat, and lands, rivers, and oceans. Plastic disposal is a threat that won't go away unless real actions are taken at the local level. The performance of the concrete mixtures used in the construction can be enhanced. Research on the application of recycled plastic—primarily polyethylene—in the production of blended plastics revealed decreased rutting and low-temperature cracking of the building's surface over time. The outdoor tests survived the strain and demonstrated that the addition of plastic wastes that have been properly processed would extend the life of the building and address environmental issues. Plastic is an incredibly useful substance. Because of the industrial revolution and its widespread use, plastic appeared to be a more efficient and cost-effective raw material. The use of plastics has almost changed every important area of the economy today, including building construction, communication, electronics, packaging, automotive, and agricultural. Since plastic is not biodegradable, scientists have discovered that it can endure 4500 years on Earth without degrading. The health risks associated with improperly disposing of plastic garbage have been demonstrated by numerous research. Genital deformities and issues with human and animal reproduction are among the health hazards. Municipal solid trash is either dumped on land or burned. The waste should not be disposed of using either technique since it pollutes the air and the soil. Currently, the Indian concrete industry uses 400 million tons of concrete annually; in less than ten years, it's predicted that this number might exceed a billion tonnes. Plastic is a relatively new engineering material that has entered the global market. It is estimated that the building industry uses about 25% of the world's total plastic production. While the per capita usage of plastics in wealthy countries is between 500 and 1000N, it is only approximately 2N in our country. But awareness of the usage of plastic as a practical building material has not increased in our nation. This research aims to investigate the use of recycled plastic components of non-biodegradable polyethene terephthalate (PET) in

construction applications. This is an alternative solution to administer the growing quantity of the non-biodegradable polyethene terephthalate. The properties of concretes containing PET particle were investigated in this study. The strength properties of specimens were observed with the use of PET in various percentages (0%, 10%, 20%, 30%, and 40%).

2. Literature Review

Amula R.G et al [1] This study examines the behaviour of concrete composed of recycled plastic materials and examines some of the physical attributes that are associated with it. In concrete mix, plastic has been substituted for fine aggregate in the following ranges: 0%, 10%, 15%, 20%, and 25%. The compressive strength of each replacement level is provided. They came to the conclusion that, at all curing ages, the compressive strength values of all waste plastic concrete mixtures tended to go below the values for the reference plastic ratio. Mastan Vali N et al [2] This research aims to determine the optimal quality and effects of using recycled PET as a partial replacement of the fine total in a typical Portland bond. This investigation uses Concrete at 0% and 5%.PET container waste percentages of 10%, 15%, and 20% were delivered for the fine total and compared to blend, no substitution, and 0% substitution. 45 instances of each of the 3D square and shaft forms were thrown, cured, and tested for 7 and 28 days of quality, respectively. Pressure and flexural quality measurements were made, and the outcomes were compared with a control sample. Based on the analysis, a relationship was found for the prediction of the flexural and compressive qualities of cement that contains waste PET as a fine total replacement. Zainab Z. Ismail et al[3] It looked into the industrial operations in Iraq that are linked to large volumes of solid waste that is not biodegradable, with waste plastic being one of the most notable examples. In order to ascertain how effective it is to recycle waste plastic in the creation of concrete, this study included 254 tests and 86 trials. Thirty kilograms of waste plastic in fibriform forms were mixed with 800 kg of concrete mixtures to replace sand to varying degrees (0, 10%, 15%, and 20%). At room temperature, each concrete composition was tested. Slump, fresh density, dry density, compressive strength, flexural strength, and toughness indices are among the tests that are conducted. For testing of compressive strength and dry density, seventy cubes were molded, and tests of flexural strength and toughness indices were conducted on fifty prisms. Fahad et al [4] Examined Plastic garbage contributes significantly to environmental contamination due to its low rate of recycling. Therefore, it is imperative that waste plastic be used in many purposes, like as aggregates in concrete. This report presents a study on the replacement of volcanic lightweight aggregate and Lytag aggregate in concrete with manufactured plastic aggregate. It was looked into how replacement level affected the fresh, hardened, and microstructure characteristics of concrete. The slump, splitting tensile strength, flexural strength, compressive strength, and elastic modulus all reduced as the replacement level rose. Replacement level had no discernible impact on either the fresh density or the hardened density. Rafat Siddique et al [5] It was discovered that this publication provides a thorough analysis of waste and recycled plastics, strategies for managing waste, and published studies on the impact of recycled plastic on the properties of concrete, both fresh and hardened. This research examines the effects of waste and recycled plastic on a variety of properties, including bulk density, air content, workability, compressive strength, splitting tensile strength, modulus of elasticity, impact resistance, permeability, and abrasion resistance. Concrete is more affordable and less problematic to dispose of because it contains waste materials. Reusing large wastes is thought to be the most environmentally friendly way to address the disposal issue. Plastic is one such waste that has several potential uses. Islam et al., [6] used waste pet as a substitute in both fresh and hardened concrete; a rise in waste pet caused the concrete's compressive strength to decrease. At a low water-to-cement ratio, PET aggregate concrete may have excellent workability. Choi et al., [7] found that, when the percentage replacement was increased, the waste PET lightweight aggregate concrete's compressive strength and structural efficiency declined; nevertheless, when the replacement percentage was increased to 75%, the workability of the material surpassed 120% when compared to the natural aggregate. This suggests that the strength of

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PET concrete may not increase with uniformity. Thiruppathi, [8] examined a few parameters, including aggregate size, shape, and curing time, that affect rubber tire concrete's performance. Rubber aggregate concrete showed promise as a long-term solution for rubber waste management, despite its weak development. Ganjian et al., [9] There was no discernible increase in concrete strength when rubber tire waste was used in place of coarse aggregate in concrete up to a 5% replacement ratio; however, noticeable changes were seen at higher replacement ratios. Srivastava et al., [10] concluded that waste glass could be used up to 50% in place of coarse aggregate without significantly affecting compressive strength.

3. Objectives

- to determine that PET waste is suitable for disposal through the use as building materials.
- to use PET waste as fine aggregate instead of PET trash.
- to figure out how strong the concrete is when it has PET aggregate in it.
- to lessen the structure's total weight.

4. Materials And Methodology

Using non-biodegradable polyethene terephthalate materials to produce concrete is the primary goal of this article. Plastic garbage has a negative effect on the environment since it is difficult to dispose of. The greatest practical use of PET waste is thought to be in the concrete industry. It lowers the cost of materials and lessens environmental pollution.

- Cement: Ordinary Portland cement (OPC) obtained from local cement shop in kadapa used in the present research. Chemical and physical characteristics of cement are given in Table 1.
- Sand: River sand which passed sieve 4.75 mm was used as fine aggregate, The fineness modulus and specific gravity of sand are 2.18 and 2.83; respectively.
- Polyethylene Terephthalate (PET): Plastic waste used in this investigation was polyethylene terephthalate (PET) waste. Water absorption capacity and specific gravity are 0.1% and 1.37; respectively, plastic waste size is 4.75 mm and less.

Table 1 **Chemical and Physical Characteristics of Cement**

Chemical properties	Weight percentage %
CaO	62.20
SiO_2	21.31
Al_2O_3	5.89
MgO	3.62
Fe_2O_3	2.67
SO_3	2.60
L.O.I %	1.59
In. SUL.R	0.55
Free Lime	0.92
L.S.F %	95.31
C3S	33.37
C2S	35.92
C3A	11.09
C4AF	8.12

5. Mix Proportion and Testing Procedures

In this study, the cement concrete mixtures were designed and consist of one reference mixtures. The reference mixture (R1) which consist of cement, river sand and water to cement ratio of 523, 1523 kg/m3 and 0.48, respectively. However, all mixtures contained 10% of SBR with various ratios (0, 10, 20, 30 and 40%) of PET as a partial replacement of river sand.

Compressive strength test: The compressive strength was tested according to ASTM C109. 150*150*150 mm cubes were tested using a standard compression machine, the average of three cubes were adopted. Test was conducted at ages of 3 and 28 days.

Flow test: After mixing, flowability of mortar was measures performed in accordance with ASTM C230 with the purpose of determining the flow ability as well as the consistency of the fresh concrete.

Flexural strength test: Specimens were prepared for flexural strength of hardened concrete was determined in accordance with ASTM C348. Average of three prisms were adopted. Test conducted at age 28 days.

Dry density test: Specimens of 150*150*150 mm were prepared for dry density test. Average of three cubes were adopted after putting the specimens in the oven at 110±5 °C for 24 h. Test was conducted at age of 28 days.

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6. Results and Discussion

6.1. Flow Ability

By adding more PET to the concrete mixtures, the workability of the concrete is improved. Figure 1 shows the flow ability versus PET at various percentages. cement might be connected to the plastic particles, which have lower absorption capacities and smoother outer surfaces than sand. as a result, when the PET content increased, concrete's flowability increased.

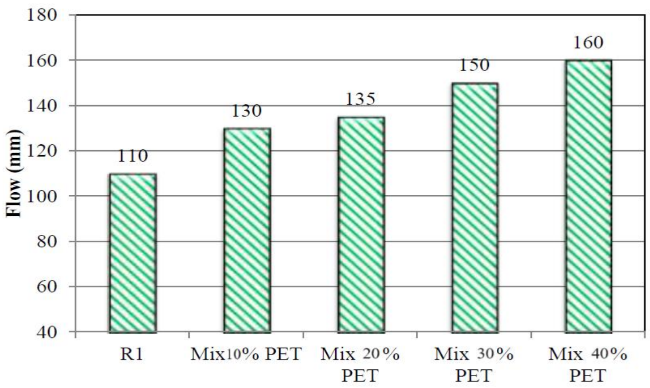

Figure 1 Flow Vs Mixes Types of Modified Concrete

6.2. Dry Density

The results of dry density for all the concrete mixes were presented in Figure 2. The addition of 10% SBR led to increase the dry density of concrete mix in a small amount. While the dry density of the other mixes began to decrease gradually with an increase in the percentage of PET. This may be because of the specific weight of PET waste was less than the specific weight of the used sand.

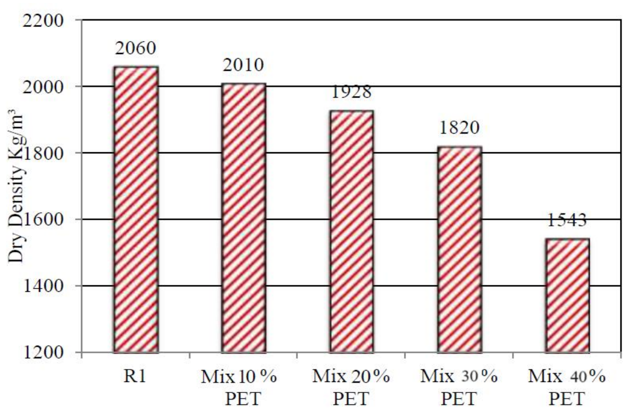

Figure 2 Dry Density of Modified Concrete

On the other hand, the dry density affected by the specific gravity of concrete constituents. Therefore, the specific gravity of PET is lower than sand. Consequently, it is expected that the dry density of the concrete will be reduced by increasing the replacement ratio of PET.

6.3. Compressive Strength

As the amount of PET replacement in the mixtures grew, the concrete's compressive strength characteristic progressively reduced as seen graphically in Figure 3. there was an unavoidable rise in compressive strength, with the exception of the 10% PET addition. In contrast, increasing the PET fractions resulted in losses in compressive strength. Conversely, inadequate adhesion between PET and cementitious materials, PET's lower strength than natural sand, increased air content in mixtures, and limited cement hydration reactions at the PET surface are the causes of strength reduction.

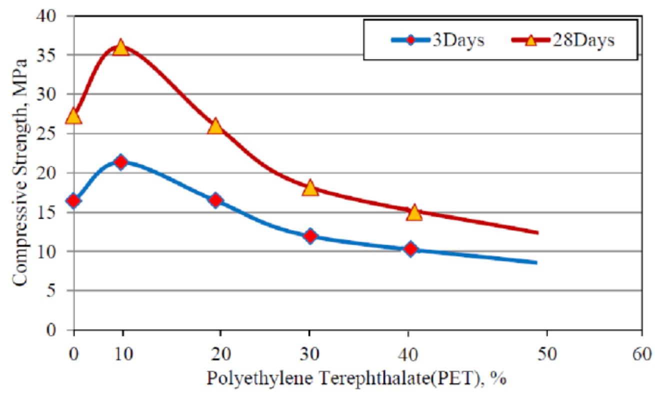

Figure 3 Compressive Strength at Various Ages with Increasing % Of PET

6.4. Flexural strength

There was behavior similar to the behavior of compressive strength since flexural strength is a function of the concrete's compressive strength attribute. With the exception of the combination containing 10% of PET, which rose as shown in Figure 4, the flexural strength of the mixes tested at 28 days of curing age showed that the results declined as PET concentrations in the mix increased. The leaking water surrounding the PET aggregate particles and the fact that plastic waste is a hydrophobic substance that lowers the water requirements for cement hydration are the primary

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causes of the weak interfacial interaction between plastic trash and cement paste.

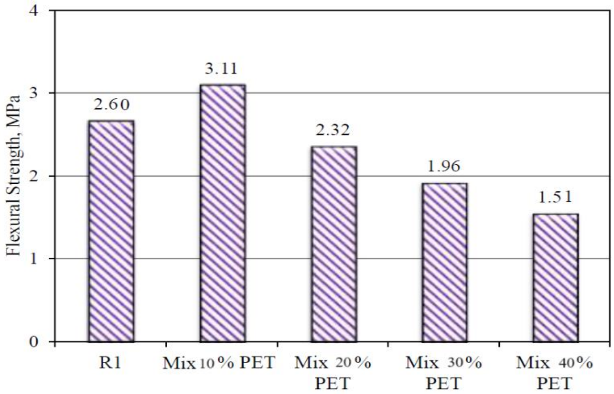

Figure 4 Flexural Strength at Various Increasing % Of PET

Conclusion

This study explores the feasibility of partially substituting sand in cement mortar modification with non-biodegradable Polyethylene Terephthalate (PET). Dependent on the outcomes, the main conclusions can be summarized as below:

- A partial replacement of fine aggregate with PET up to 10% could boost the compressive strength. The compressive strength of the mixtures was then reduced by the specimens with 20, 30, and 40% partial replacement of PET.
- The compressive strength of the specimens was enhanced with increasing curing ages from 3 to 28 days by 66% and 58% for the mix contained 0 and 20% PET, respectively.
- When PET was utilized as 10% fine aggregate, the flexural strength increased by almost 16%. Next, with 20, 30, and 40% of PET replacement, the flexural strength dropped.
- Increasing the percentage of PET as a partial replacement of fine aggregate greatly improves flowability.
- It is evident that lightweight cement mortar that is appropriate for structural applications may be made by utilizing PET, as the dry density decreased with increasing PET inclusion in the combinations.
- The compressive and flexural strengths showed a good correlation with one other.
- It has been effectively shown that large volumes of PET materials can be recycled and used to make concrete structures.

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