Utilization Of Recycled Polyethylene Terepthalate In Concrete As A Construction Material

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Abstract - this study looks at how recycled plastic waste, especially pet (from plastic bottles), can be used instead of some of the sand in concrete. different tests were done to check how strong and durable the concrete becomes when mixed with plastic at different amounts. the results showed that adding 10% plastic improved the concrete's strength and resistance to cracks and impacts. special concrete that flows on its own (self-compacting concrete) also worked well with plastic waste. microscopic tests confirmed that the plastic mixes held together properly. overall, using waste plastic in concrete is a smart and eco-friendly way to reduce plastic pollution while making strong and useful building materials

I. INTRODUCTION

using pet in concrete by replacing 10% fine aggregate

plastic is a big part of our daily lives because it is lightweight, strong, and affordable. one of the most common plastics is polyethylene terephthalate (pet), which is mainly used in bottles and packaging. however, pet waste is a major environmental problem because it does not decompose easily and often ends up polluting land and oceans.

to help reduce plastic waste, researchers have found a way to use recycled pet in concrete by replacing 10% of the fine aggregate (sand) with pet waste.

this not only helps manage waste but also reduces the need for natural sand, which is becoming scarce due to heavy usage in construction.

using recycled pet in concrete can improve certain properties like durability and thermal insulation. however, it can also create challenges, such as weaker bonding between plastic and cement. despite this, adding pet to concrete is a promising step toward sustainable construction by reducing waste, saving natural resources, and making eco-friendly buildings.

this study looks at how pet affects concrete's strength and durability and explores its potential to make construction more sustainable.

II. POLYETHYLENE TEREPHTHALATE

polyethylene terephthalate, or pet, is a type of plastic used in many everyday items like water bottles, food containers, and clothing fibers. it is strong, lightweight, and resistant to water and chemicals, making it very useful.

one of the best things about pet is that it can be recycled and turned into new products, helping to reduce plastic waste. because of this, researchers are finding new ways to use recycled pet, including mixing it with concrete to make construction more eco-friendly.

III . MATERIAL AND METHOD -

Cement
In PET concrete, where PET waste replaces cement or aggregates, 53 Grade Cement (OPC 53) helps maintain strength due to its high early strength (53 MPa at 28 days) and superior bonding. Its high fineness improves PET dispersion, while low heat of hydration minimizes cracks. This ensures better strength, workability, and durability in sustainable construction.

Fine aggregates
in concrete are materials that pass through a 4.75 mm IS sieve and help fill voids between coarse aggregates, improving workability, strength, and durability. They ensure a dense mix, enhance bonding with cement, and reduce segregation and bleeding. Commonly used fine aggregates include natural sand, manufactured sand (M-sand), and stone dust. Their grading, fineness modulus, shape, and water absorption significantly impact the concrete mix design. Proper selection and proportioning of fine aggregates improve compressive strength, finishing quality, and overall durability of concrete structures

Coarse aggregates
in concrete are crushed stone or gravel with a size range of 10 mm to 20 mm. They provide strength, durability, and stability, forming the bulk of the concrete mix. Proper grading, shape, and texture ensure good bonding with cement, reducing voids and improving workability and load-bearing capacity. Their selection impacts compressive strength, shrinkage, and overall performance of concrete structures

PET
PET granules in concrete are typically used as a partial replacement for fine aggregates to enhance sustainability and reduce environmental waste. These granules are processed from recycled polyethylene terephthalate (PET) plastic and are usually sized to pass through a 4.75 mm sieve, similar to sand. Their use affects workability, density, and mechanical properties of concrete. While small PET replacements (up to 10%) show minimal impact on compressive and flexural strength, higher percentages may reduce bonding due to PET's smooth surface and lower density. However, PET granules improve lightweight properties, impact resistance, and thermal insulation, making them useful in non-structural and lightweight concrete applications. Proper mix adjustments are necessary to maintain the balance between strength, durability, and environmental benefits

Mould

The 150 × 150 × 150 mm mould is widely used for casting concrete specimens for compressive strength testing. These moulds are typically made of steel or cast iron, ensuring durability and reusability. They adhere to standard testing guidelines such as IS 516:1959, ASTM C39/C39M, and IS 10086:1982, ensuring consistency in results. To prevent adhesion and facilitate easy demolding, the inner surfaces of the moulds must be smooth, non-absorbent, and properly oiled or wetted before use. Additionally, they should be leak-proof to prevent cement slurry from escaping during casting. After pouring and compacting the concrete, the cubes are left to set for 24 hours before being demolded and transferred to curing tanks for strength development over 7, 14, or 28 days. Properly designed and maintained moulds are essential for achieving accurate and reliable compressive strength test results.

IV. MIX DESIGN –

The material quantities for a single concrete cube (150mm × 150mm × 150mm = 0.003375 m^3) were calculated as follows:

Cement Content

{Cement} = {Volume of Concrete} × {Cement Content}

= (0.15 × 0.15 × 0.15) m^3 × 320 kg/m^3]

= 1.08 kg

2.2.2 Fine Aggregate (Sand) Content

{Fine Aggregate} = {Volume of Concrete} × {Density of Fine Aggregate}}{1000}

= \frac{0.003375 × 650}{1000}]

= 2.16 kg

2.2.3 PET Granules as Partial Replacement (10%)

{PET Granules} = 10\% { of Fine Aggregate}

= 0.10 × 2.16]

= 0.216 kg

2.2.4 Coarse Aggregate Content

{Coarse Aggregate} = {Volume of Concrete} × {Density of Coarse Aggregate}}{1000}

= {0.003375 × 1260}{1000}]

= 4.25 kg

2.2.5 Water Content

{Water} = {W/C ratio} × {Cement Content}

= 0.55 × 1.08]

= 0.59 kg (liters)

Hence,
For grade m20 of proportion (1:1.5:3)

Cement content : 1.08kg
Fine aggregate : 2.16kg
Pet granuals : 0.216 kg
Coarse aggregate : 4.25 kg
Water content : 0.59 litre

Fig. curing of PET Concrete cube

Fig testing of cube

V. RESULTS :

P.E.T Results :

Sr no	Name of specimen	Compressive strength N/mm^2	Period of curing
1	PET 1	10.57 N/mm^2	7 days
2	PET 2	11.57 N/mm^2	14 days
3	PET 3	25.57 N/mm^2	28 days

PCC Results :

Sr no	Name of specimen	Compressive strength N/mm^2	Period of curing
1	PCC 1	8.64 N/mm^2	7 days
2	PCC 2	15 N/mm^2	14 days
3	PCC 3	16.18 N/mm^2	28 days

Conclusion:
While compressive tests might occasionally show a PET-modified concrete block withstanding a higher load than a plain cement concrete (PCC) block, it's essential to interpret such results with caution. The introduction of PET often leads to a reduction in traditional compressive strength due to weaker bonding between the plastic and cement matrix. However, PET fibers significantly enhance ductility and toughness, allowing the concrete to absorb more energy and deform further before failure. Therefore, "strength" in this context extends beyond peak load resistance to include improved crack resistance, energy dissipation, and overall structural resilience. Any observed increase in load-bearing capacity in a PET block is likely influenced by specific factors like optimized mix design, PET fiber type and distribution, and testing variations, rather than a universal trend. Thus, while individual tests may yield seemingly contradictory results, the general understanding remains that PET modifies concrete strength characteristics, prioritizing ductility and toughness over pure compressive strength, and that the general trend is that PET additions to concrete can reduce the compressive strength.

The incorporation of polyethylene terephthalate (PET) into concrete, while primarily driven by sustainability goals to mitigate plastic waste, presents a nuanced picture regarding its impact on concrete strength. Research indicates that substituting traditional aggregates with PET can, under specific conditions, enhance certain mechanical properties of concrete. While a direct increase in compressive strength isn't consistently observed, particularly with higher PET replacement percentages due to weak interfacial bonding, PET fibers can significantly improve ductility, crack resistance, and energy absorption capacity. This enhancement translates to improved load-resisting capacity, stiffness, and displacement ductility, indicating that PET-modified concrete can withstand greater deformations and absorb more energy before failure. Therefore, while traditional strength metrics might not always show a boost, the overall performance and durability of concrete can be enhanced with PET inclusion, particularly in applications where resistance to cracking and impact is crucial. The success of this approach hinges on careful mix design, optimized PET particle size and type, and appropriate surface treatments to improve bonding, ultimately balancing environmental benefits with maintained or improved concrete performance.

References :

1] Use Of Irradiated Pet Waste For Cement Replacement :
Authors: K. Grigoriadis, J. Banuls-Ciscar, A. Caverzan, Et Al.

2] Utilization Of Recycled Pet In Engineering Materials :
Authors: M. Sulyman, J. Haponiuk, K. Formela

3]. Strength Behavior Of Reinforced Concrete Beams Using Recycled Pet Fibers
Authors: Hamsa M. Adnan, Abbas O. Dawood

4] Fresh Properties Of Self-Compacting Concrete With Plastic Waste As Partial Replacement Of Sand :
Author : Sheelan M. Hama, Nahla N. Hilal

5]Mechanical Properties Of Concrete Contining Waste Pet Particles
Authors: E Rahmani, M. Dehestani

6]Effects Of Waste Pet Bottles Aggregate On The Properties Of Concrete
Authors- Yw Choi, Js Chung, Sk Cho

7]Recycling Of Pet Bottles As Fine Aggregate In Concrete
Authors: Mj Islam, Ms Meherier, Akmr Islam

8]Assesmentof Mechanical And Durability Properties Of Concrete Containing Pet Waste
Authors : R. Saksena, T Gupta, Rk Sharma

9]Experimental Study Of Thermo Mechanical Properties Of Recycled Pet Fiber Reinforced Concrete
Author :F Fraternali, V Ciancia, R Chechile, Grizzano

10evaluation Of Eco Friendly Concrete Having Waste Pet As Fine Aggregates
Author: Go Bamigboye, K Tarvedi, A Umoren, Be

11] A Review On Use Of Polyethylene Terephthalate As Concrete
Author-Tanvir U. Chowdhury, Mahmud A. Mahi, Kazi A. Haque, Md. M. Rahman

12]Effects Of Waste Pet As Coarse Aggregate On The Fresh And Harden Properties Of Concrete
Author-Md. J. Islam, Md. S. Meherier, A.K.M. R. Islam

13]Mix Proportion Design And Mechanical Properties Of Recycled Pet Concrete*
Authors: Zhanyong Yao, Xiaomeng Zhang, Zhi Ge, Et Al

14]Improving Impact And Mechanical Properties Of Gap-Graded Concrete By Addingwaste Plastic Fibers
Author-Abdulkader Ismail Al?Hadith

15]Use Of Irradiated Pet Plastic Waste For Partially Replacing Cement In Concrete
Author-K. Grigoriadis , J. Banuls Ciscar , A Caverzan