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Performance of Lightweight Concrete With Plastic Aggregate

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ABSTRACT

This study explores the use of recycled high-density polyethylene (HDPE) plastic and robo sand to fabricate lightweight plastic coarse aggregates (PCA) for concrete. These PCAs were produced by melting HDPE plastic and mixing it with robo sand in a 1:3 ratio, forming aggregates sized 2.36 mm to 20 mm. The main aim was to replace conventional coarse aggregates entirely and assess structural and sustainability benefits.

Three concrete cubes were cast using 100% HDPE-based aggregates, and tests were conducted to evaluate workability, compressive strength, and physical properties like specific gravity and impact value. The results showed a notable reduction in concrete density and a 28-day compressive strength averaging around 29 MPa, indicating promising potential for lightweight structural applications. The project highlights the environmental benefits of plastic reuse in concrete and supports eco-friendly alternatives in construction.

INTRODUCTION

Floods The growing demand for concrete in civil construction has led to the overuse of natural aggregates, causing environmental concerns like resource depletion. To address this, researchers are exploring sustainable alternatives that maintain concrete's structural integrity.

Plastic waste, especially high-density polyethylene (HDPE), is a major pollutant due to its non-biodegradable nature. Recycling this plastic into construction materials offers an eco-friendly solution. This study focuses on producing lightweight plastic aggregates by melting shredded HDPE and mixing it with sand or robo sand to form coarse aggregates.

These plastic coarse aggregates (PCA) are used as a partial or full replacement for natural aggregates in concrete. The research evaluates the workability and compressive strength of HDPE-based concrete, aiming to develop sustainable, lightweight concrete suitable for civil infrastructure applications.

LITERATURE REVIEW

Literature Survey on Performance Of Lightweight Aggregate Using HDPE Plastic:

Concrete is the most widely used construction material, but its reliance on natural aggregates and the growing issue of plastic waste have encouraged researchers to find sustainable alternatives. Incorporating high-density polyethylene (HDPE) plastic and manufactured sand (robo sand) into concrete has emerged as a promising solution.

Use of Plastic Waste in Concrete:

Ismail and Al-Hashmi (2008) found that partial replacement of coarse aggregates with plastic waste reduced density while maintaining acceptable strength. Saikia and de Brito (2012) observed that plastic aggregates offer moderate strength and low water absorption. Batayneh et al. (2007) confirmed improvements in sustainability and reduction in concrete weight using plastic aggregates.

HDPE as Aggregate:

Mochane et al. (2021) and Rahmani et al. (2013) highlighted HDPE's chemical stability and strength. These studies concluded that HDPE aggregates can reduce concrete weight and offer acceptable mechanical performance, especially for non-load-bearing applications.

Use of Robo Sand (M-Sand):

Ilangovana et al. (2008) and Elavenil & Vijaya (2013) supported robo sand as a reliable replacement for river sand due to its consistent grading and improved strength characteristics.

Artificial Aggregates and Sustainable Construction: Kumar and Dutta (2020) reported that artificial aggregates made from plastic waste offer satisfactory strength and significant environmental benefits. Choi et al. (2009) demonstrated enhanced thermal insulation, while Verma and Chandak (2014) showed up to 50% plastic replacement still retained over 80% of compressive strength.

Summary of Observations:

Workability: Improved due to smooth plastic surface Strength: Acceptable up to 25–30% plastic replacement.

Weight: Reduced significantly, producing lightweight concrete

Durability: Enhanced chemical resistance and crack control Identified Research Gaps:

Limited long-term durability studies

Need for better understanding of HDPE bonding in cement matrices Structural viability of 100% replacement cases These findings collectively support the feasibility of using HDPE and robo sand as sustainable concrete aggregates, aligning with environmental and performance goals in modern construction.

MATERIALS USED

The following materials were used in the preparation of lightweight concrete with plastic aggregates:

1. Recycled Plastic (HDPE):

High-Density Polyethylene plastic waste was collected from a local plastic shredder. The plastic pieces, ranging from 1 mm to 6 mm in size, were washed, shredded, and melted at temperatures between 294°C and 339°C to form plastic aggregates.

2. Robo Sand:

Manufactured sand (robo sand) was used as a fine aggregate. It provided compatibility with the plastic mix and contributed to the strength and texture of the concrete.

3. Natural Sand:

Clean and graded natural river sand was used for comparison and blending purposes.

4. Cement:

Ordinary Portland Cement (OPC) of 43/53 grade was used as the binding material in the concrete mix.

5. Water:

Clean potable water was used for mixing and curing, complying with IS 456:2000 standards.

6. Plastic Coarse Aggregates (PCA):

These were prepared by mixing molten HDPE plastic with sand or robo sand in a 1:3 ratio, producing aggregate sizes between 2.36 mm and 20 mm. Both single-sized and well-graded aggregates were tested.

IMPLEMENTATION

The This study aimed to produce lightweight concrete by replacing traditional coarse aggregates with plastic coarse aggregates (PCA) made from HDPE plastic and robo sand. The methodology involved the following steps:

1. Collection and Preparation of Materials

HDPE Plastic Waste was collected from local sources (e.g., bottles, containers), cleaned, dried, and shredded into small pieces (1–6 mm).

Robo Sand, a by-product of stone crushing, was sieved to ensure consistent grading and kept dry before use.

Other Materials used include Ordinary Portland Cement (OPC 53 grade), natural river sand as fine aggregate, and clean potable water for mixing.

2. Fabrication of Plastic Coarse Aggregates (PCA)

The shredded HDPE plastic was melted in a pan at temperatures ranging from 294°C to 339°C.

Robo sand was added gradually to the molten plastic in a 1:3 ratio (HDPE: robo sand).

The hot mixture was stirred until a uniform sticky mass formed.

While still hot and pliable, the mix was manually broken into pieces ranging from 2.36 mm to 20 mm to resemble natural aggregates.

These were cooled, sieved, and stored for use in concrete mixes.

3. Testing of Aggregates

The fabricated PCA underwent the following tests to evaluate their physical and mechanical properties:

Specific Gravity

Water Absorption

Aggregate Impact Value (AIV)

Aggregate Crushing Value (ACV)

Los Angeles Abrasion Test

Sieve Analysis (Grading)

Bulk Density

Shape and Texture Analysis

4. Mix Design and Casting

Mix design was prepared according to ACI 211.2-98 guidelines for structural lightweight concrete.

100% replacement of natural coarse aggregates with PCA was adopted.

Concrete cubes of 150 mm × 150 mm × 150 mm were cast using the designed mix.

The mix proportions included cement, fine aggregate, water, and PCA as per the calculated ratios.

5. Curing and Testing

Cast cubes were cured in clean water for 7, 14, and 28 days.

After curing, tests were conducted to evaluate: Workability using the slump cone test (IS 1199:1959) Compressive strength using the compression testing machine (CTM) (IS 516:1959) Density/Unit weight to confirm lightweight characteristics. This methodology enabled the systematic evaluation of recycled HDPE plastic as a coarse aggregate in concrete, assessing both physical properties and structural performance

CALCULATIONS

Table 3.2.22

ACI-211-2-550

1. AGGREGATES: Normal maximum aggregate Size = 9. 5mm = 12.5mm = 19mm [slump range: 125-150] ACI table 3.2 2.3
2. .Water cement ratio: Compressive strength N/mm2 Take as 35 N/mm2 (from table) Non air entrained concrete = 0.48 Air entrained concrete = 0.40
3. cement content Y1/Y2 OR W/C = 187/0.40 = 467.5 kg/m3 of cement ACI table 2. 2.24
4. Coarse Aggregate Size of aggregate = 19mm 0.72 x density of HDP aggregate 0.72x930 = 669.6kg/m³ of coarse aggregate.
5. Fine Aggregate 1- (cement – water – C.A – sp-air%) 1- (467.5 – 187 – 669.6 – 0.02 – 0.02) 390.14 x density of sand 390.14 x 1600 kg/m3 = 624.224 kg/m3 of fine aggregate. V=L X D X W 150mm x 150mm x 150mm= 3375000mm3 Cement = 467.5 kg/m3
6. Coarse aggregate = 669.6 kg/m3
7. Fine aggregate = 624.224 kg/m3
8. Water = 0.187 l.
9. 1m3 = 1000000000mm3 3375000/1000000000 = 3.375x10-3 Or =0.00375m3
10. Water = 187 x 0.003375= 0.632l ~ 632ML
11. Fine aggregate = 624.224x 0.003375 2.106756 = 2.107kg
12. Coarse aggregate = 669.6 x 0.003375 2.2599= 2.360kg 150mm3
13. Water = 632ml
14. Fine aggregate = 2.107kg
15. Coarse aggregate = 2.360kg
16. Cement = 1.580k

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RESULTS

This section presents the results obtained from physical testing of the plastic coarse aggregates (PCA) and the performance of concrete made using 100% replacement of natural aggregates with PCA. The tests were conducted to evaluate workability, density, and compressive strength at different curing intervalThe experimental phase involved testing both the physical properties of the plastic coarse aggregates (PCA) made from HDPE and robo sand, as well as evaluating the performance of concrete prepared with 100% replacement of natural coarse aggregates using PCA. The PCA showed a specific gravity between 1.25 and 1.35, confirming its lightweight nature compared to natural aggregates. Water absorption was low (0.7–0.9%), and mechanical tests such as Aggregate Impact Value (22–24%), Crushing Value (28–30%), and Abrasion Resistance (35–38%) were within acceptable limits for lightweight applications. The aggregates were well-graded between 2.36 mm and 20 mm, had a bulk density of approximately 980–1080 kg/m³, and showed good angular shape and rough texture, promoting better bonding in concrete. The concrete mix exhibited a slump value of 55 mm, indicating medium workability suitable for casting. The density of the hardened concrete was measured at 1920 kg/m³, classifying it as lightweight concrete. Compressive strength was tested at 7, 14, and 28 days, with average values of 18.73 MPa, 25.62 MPa, and 28.83 MPa respectively. These results demonstrate that concrete with HDPE-based PCA achieves adequate structural strength while significantly reducing weight, making it suitable for non-structural and moderately loaded structural applications.

CONCLUSION

This project successfully demonstrated the feasibility of using recycled HDPE plastic and robo sand to fabricate plastic coarse aggregates (PCA) as a complete replacement for natural coarse aggregates in lightweight concrete. The PCA was produced by melting HDPE plastic and blending it with robo sand in a 1:3 ratio, followed by manual shaping into aggregate-sized particles. Physical tests conducted on the PCA showed acceptable values for specific gravity, water absorption, impact resistance, and abrasion—confirming their suitability for structural applications with moderate load requirements.

Concrete mixes were prepared using 100% PCA, and tests were carried out for workability, density, and compressive strength. The slump value indicated medium workability, while the density was significantly lower than that of conventional concrete, confirming the lightweight nature of the material. The 28-day compressive strength averaged around 28.83 MPa, which is well within the range for structural lightweight concrete.

Overall, the use of HDPE-robo sand-based PCA in concrete presents a sustainable and effective alternative to traditional materials. It not only reduces environmental pollution caused by plastic waste but also helps conserve natural aggregate resources. This eco-friendly approach supports green construction practices and offers promising potential for use in non-load-bearing structures, precast elements, and lightweight components in civil engineering.

REFERENCES

[1] 1. Ismail, Z. Z., & Al-Hashmi, E. A. (2008). Use of waste plastic in concrete mixture as aggregate replacement. Waste Management, 28(11), 2041–2047.

2. Saikia, N., & de Brito, J. (2012). Use of plastic waste as aggregate in cement mortar and concrete preparation: A review. Construction and Building Materials, 34, 385–401.

3. Batayneh, M., Marie, I., & Asi, I. (2007). Use of selected waste materials in concrete mixes. Waste Management, 27(12), 1870–1876.

4. Rahmani, E., Dehestani, M., Beygi, M. H. A., Allahyari, H., & Nikbin, I. M. (2013). On the mechanical properties of concrete containing waste plastic as aggregate. Construction and Building Materials, 48, 584–589.

5. Ilangovana, R., Mahendran, N., & Nagamani, K. (2008). Strength and durability properties of concrete containing quarry rock dust as fine aggregate. ARPN Journal of Engineering and Applied Sciences, 3(5), 20–26.

6. Elavenil, S., & Vijaya, B. (2013). Manufactured Sand, A Solution and an Alternative to River Sand and in Concrete Manufacturing. Journal of Engineering, Computers & Applied Sciences, 2(2), 20–24.

7. Kumar, A., & Dutta, D. (2020). Sustainable concrete using recycled plastic as aggregate: A review. Materials Today: Proceedings, 33, 569–573.

8. IS 383:2016 – Coarse and Fine Aggregate for Concrete – Specification, Bureau of Indian Standards.

9. IS 516:1959 – Methods of Tests for Strength of Concrete, Bureau of Indian Standards.

10. IS 2386 (Part I to IV):1963 – Methods of Test for Aggregates for Concrete, Bureau of Indian Standards.

11. Standard practice for setting proportions for structural lightweight concrete (ACI 211.2-98)

12. IS 10262 (200) For Mix Proportion