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Pre-Coting is a Treatment for Recycled Concrete Aggregate

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Abstract - *By minimizing waste and lowering dependency on natural aggregates, recycled concrete aggregate (RCA) promotes sustainable building practices. However, because of the residual mortar that is affixed to the aggregate particles, RCA usually has disadvantages such as increased porosity, increased water absorption, and decreased compressive strength. These characteristics have a detrimental effect on the strength and durability of RCA-based concrete. In order to overcome these drawbacks and improve the structural properties of RCA concrete, this study investigates a pre-coating treatment technique. The suggested technique involves precoating RCA with substances like polymer-based solutions, cement slurry, or silica fume. These coatings work to improve interfacial transition zones in concrete by filling surface pores and fortifying the bond between RCA and the new cement matrix. This effectively lowers water absorption. By using this method, the treated RCA shows improved physical characteristics, which raises the concrete mix's compressive strength. According to experimental analysis, pre-coated RCA concrete outperforms untreated RCA concrete in terms of compressive strength. According to the results, pre-coating recycled aggregate concrete (RCA) improves its overall performance and lessens its inherent flaws, making it a good substitute for structural applications. By encouraging the efficient use of recycled materials without sacrificing quality, this technique advances sustainable building practices.*

***Key Words*: Recycled Concrete Aggregate, Pre-coating Treatment, Compressive Strength, Water Absorption, Sustainable Concrete.**

1. INTRODUCTION

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works, including infra-structure, low and high-rise buildings, defence installations, environment protection and local/domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixtures. Among these aggregates and, inert granular materials such as sand, crushed stone or gravel form the major part. Traditionally aggregates have been readily available at economic prices and of qualities to suit all purposes. However, in recent years the wisdom of the continued wholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection. In light of this, the availability of natural resources to future generations has also been realize. Cement-based coating: Apply a thin layer of cement paste to the RCA surface. Polymer -based coating: Spray or brush a polymer emulsion onto the RCA surface. Pozzolanic material-based coating: Mix pozzolanic materials (e.g., silica fume, fly ash) with water to create a paste, then apply to the RCA surface. Enhancing the bond between RCA and fresh concrete. Reducing the water absorption of RCA. Filling pores and micro-cracks on the RCA surface. Demolition aggregate is a valuable material obtained from the demolition of buildings, roads, and other structures. It consists of fragments of concrete, bricks, stones, and other construction materials that can be reused in various applications. The use of demolition aggregate conserves natural resources, reduces the amount of waste sent to landfills, and can be more cost-effective than using virgin materials. The processing of demolition aggregate involves crushing, screening, and sorting to produce specific products, such as crushed concrete aggregate, recycled concrete aggregate, brick aggregate, and stone aggregate. These products meet ASTM and AASHTO standards and can be used in a range of applications, including fill material, base material for roads and highways, aggregate in concrete production, drainage material, and landscaping material. By reusing demolition aggregate, the environmental impact of construction and demolition activities can be significantly reduced.

1.1 Purpose

- Enhance bonding between RCA and cement paste
- Reduce water absorption and porosity
- Improve compressive strength and durability
- Increase use of RCA in concrete applications

1.2 Types of pre-coating materials

- Cement-based
- Polymer-based (e.g., epoxy, polyurethane)
- Pozzolanic material-based (e.g., silica fume, fly ash)
- Silane-based

1.3 Pre-coating methods

- Brushing
- Spraying
- Dipping
- Mixing with cement paste

2. MATERIALS AND METHODS

2.1. CEMENT (OPC)

Cement is a ligature substance used in construction that adheres to other materials to create a bond and hardens over time. Inorganic cements, like those based on calcium or slimes liquid, are commonly used in buildings and can be categorized as hydraulic or non-hydraulic depending on how well they scenery features a water fountain. In the current work, OPC-53 grade accordance with IS 12269:1979 is utilized as shown in Figure 2.1.

Figure 2.1.

2.2. SILICA FUME

Silica fume, a byproduct of the ferrosilicon industry as shown in Figure 2.2 is used for this study. The highly pozzolanic material reacts with calcium hydroxide (CH) during cement hydration process. It can be added to concrete either by itself or in combination with Portland cement; over 90% of the material is silicon dioxide. The growth of dense structures and strength is supported by silica fume in concrete.

Figure 2.2 Silica sand

2.3. GGBS

As shown in Figure 2.3, GGBS is a product of the iron manufacturing industry. It's a cementitious compound that increases strength. High-quality, enhanced slag cement is made in place of GGBS, and when mixed with ordinary Portland cement or pozzolanic materials, it enhances the relationship between a construction's strength and dehydration.

Figure 2.3 Ground granulated furnace slag.

2.4. COARSE AGGREGATE

These aggregates are commonly used in concrete, road base, and foundation construction to provide structural strength and stability. The size of coarse aggregate typically ranges from 4.75 mm to 37.5 mm or larger, depending on the project's requirements.Proper selection and grading of coarse aggregate is crucial for ensuring the quality and performance of concrete and other construction applications

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Figure 2.4 Coarse Aggregate.

3. RESULTS

Precoating recycled aggregate can significantly enhance the compressive strength of concrete. By applying treatments such as cement slurry, fly ash, or silica fume coatings to recycled aggregate, the surface is improved, reducing water absorption and enhancing bonding with fresh cement paste. This leads to better interfacial transition zones and overall concrete performance.

3.1 SEIVE ANALYSIS COARSE AGGREGATE

Table 3.1 SEIVE ANALYSIS

Sieve analys (mm)	Mass retain (g)	Cumulative mass retained(g)	Cumulative retained %	Pass %
40.0	0	0	0	100
25.0	25	25	5	95
20.0	100	125	25	75
12.5	150	275	55	45
10.0	50	325	65	35
4.75	75	400	80	20
PAN	100	500	100	0

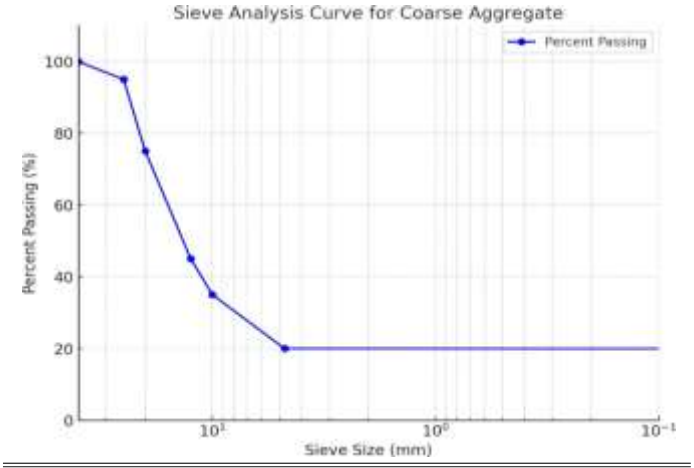

Figure 3.1

3.2 TEST ON COMPRESSIVE STRENGTH

- Improved Water Absorption and Permeability: Precoated RA has lower water absorption, which is crucial for preventing degradation in the concrete matrix. This reduces the permeability and enhances the durability of the concrete.
- Reduction of Micro-Cracks: The precoating process fills surface voids and cracks in RA, preventing further crack propagation. This can directly enhance the compressive strength of concrete.
- Interfacial Transition Zone (ITZ) Improvement: SEM (Scanning Electron Microscope) images often show a more homogeneous and well-bonded.

Figure 3.2 RCA COMPRESSIVE STRENGTH-640

Strength Improvements: Research indicates that concrete with pre-coated recycled aggregates can achieve compressive strength improvements of up to 17% compared to uncoated aggregates. This is due to the enhanced interfacial transition zone (ITZ) between the aggregate and the cement paste. Durability: Pre-coating also contributes to better durability properties, such as reduced permeability and increased resistance to chloride ion penetration and carbonation .

Optimal Replacement Levels: The optimal replacement level of natural aggregates with pre-coated recycled aggregates varies, but studies suggest that a 25% replacement can yield significant improvements in compressive, flexural, and tensile strengths.

3.3 Flakiness

Table 3.2 Flakiness

Passing through IS sieve in (mm)	Retained in is sieve in (mm)	Size slot in gauge in (mm)	Weight of retained in (kg)
31.5	25.0	16.95	0.04
25.0	20.0	13.50	0.04
20.0	16.0	10.80	0.06
16.0	12.5	8.55	0.00
12.5	10.0	6.75	0.00
10.0	6.3	4.89	0.00

Flakiness=A/B*100
total =0.14
0.14/1.46*100=9.58

3.4 Elongation`

Passing through is sieve in (mm)	Retained in is sieve in (mm)	Size slot in gauge in (mm)	Weight of retained in (kg)
31.5	25.0	58.50	0
25.0	20.0	40.50	0.04
20.0	16.0	82.40	0.18
16.0	12.5	25.60	0.10
12.5	10.0	20.20	0.14

Elongation=A/B*100 total=31.506
0.46/1.46*100=31.506

Compressive strength results f or m25 grade:

Normal aggregate = 25.66

RCA+ NA = 25.89

Recycled concrete aggregate= 28.89

Precoated RCA with cement slurry=26.65

Precoated RCA with GGBS=24.58

4.1. CONCLUSION

- **Improved Bond Strength:** Precoating materials, such as cement slurry, fly ash, silica fume, or polymer coatings, reduce the porosity of RCA and provide a smoother surface that improves the bond between the RCA and the new cement paste. This leads to better internal strength and durability of the concrete.
- **Reduction in Water Absorption:** RCA has higher water absorption compared to natural aggregates due to the porous nature of the old mortar. Precoating reduces the porosity and limits the absorption of water during mixing, ensuring that the water intended for hydration remains available for cement, thus improving concrete strength.
- **Enhanced Compressive Strength:** Studies have shown that precoated RCA can achieve compressive strength that is comparable or even superior to concrete made with natural aggregates. The use of cement-based or polymer-based coatings effectively mitigates the weaknesses of RCA and enables higher compressive strength, potentially increasing by 10-20% depending on the type of precoating material used.
- **Sustainability and Cost Efficiency:** Utilizing RCA with precoating treatments aligns with sustainable construction practices by promoting the recycling of construction waste, reducing the demand for natural aggregates, and minimizing landfill waste. Although precoating may increase the initial processing cost, the overall economic and environmental benefits make it a feasible solution in large-scale projects.

4.2 SUGGESTION FOR FUTURE WORK

Exploration of Different Precoating Materials

- Further research should investigate a variety of precoating materials, such as nano-silica, geopolymer coatings, or advanced chemical admixtures, to optimize the bond strength and durability of RCA.

- Natural or bio-based coatings could be explored to make the process even more eco-friendly.

Optimization of Precoating Processes

- The method and duration of precoating application (spraying, immersion, or mixing) and its impact on the microstructure of RCA need to be optimized. Each precoating method may influence how well RCA bonds with cement paste.

Long-Term Durability Testing

- Long-term tests of precoated RCA concrete under different environmental conditions (freeze-thaw cycles, sulphate attack, and chloride penetration) should be conducted to assess durability.
- Shrinkage and creep behaviour of precoated RCA concrete should also be studied to prevent cracking in large concrete structures.

Application in High-Strength Concrete

The use of precoated RCA in high-performance or ultra-high-performance concrete (UHPC) could be a viable option. Exploring how precoating influences the mechanical properties of RCA in high-strength concrete mixtures may broaden its applicability.

Standardization and Guidelines

- The development of standardized guidelines for the use of precoated RCA in structural concrete applications is necessary. Currently, many specifications for RCA focus on natural aggregates, and tailored standards for precoating treatments would ensure consistency and quality in practice.

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