

PERFORMANCE EVALUATION OF ADHESION IN RECYCLED & REUSED CONSTRUCTION MATERIAL IN RCC

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ABSTRACT

This study investigates the use of recycled concrete aggregates (RCAs) as sustainable alternatives in construction to reduce costs and energy consumption associated with natural aggregates. The focus is on evaluating the characteristics of recycled concrete in fresh and hardened states, particularly compressive strength. Different ratios of recycled aggregate (0%, 25%, 50%, 75%, and 100%) are examined as substitutes for natural coarse aggregates. Results indicate that recycled concrete exhibits slightly lower compressive strength compared to original concrete, with up to 20% reductions in some cases. However, freeze/thaw resistance remains comparable, possibly due to cement paste sealing pores in porous recycled aggregates. The findings suggest that recycled concrete aggregates are a viable option, despite the slight reduction in strength. Appropriate design considerations and adjustments to mixture proportions can address this concern. By utilizing RCAs, the construction industry can contribute to sustainability by minimizing natural resource consumption and environmental impact. This study provides valuable insights into incorporating recycled concrete aggregates, highlighting their advantages and limitations.

Keywords: recycled concrete aggregates, sustainable construction, compressive strength, fresh state, hardened state, substitute, natural coarse aggregates, freeze/thaw resistance.

1. INTRODUCTION

Concrete has long been recognized as a fundamental building material, valued for its durability, versatility, and cost-effectiveness. It continues to play a crucial role in the construction industry due to its ability to meet a wide range of structural and aesthetic requirements. Concrete is typically produced on-site by combining cement, water, and inert aggregates such as crushed stone or gravel. It undergoes a series of processes, including transportation, placement, compaction, and curing, to achieve its desired properties. The components of concrete can be classified into two groups: active components, such as cement and water, and inert components, which encompass the fine and coarse aggregates. The inert aggregates are often referred to as the inert matrix of the concrete. While concrete exhibits high compressive strength, its tensile strength is relatively low. To enhance its ductility and structural performance, reinforcing bars or fibers are commonly incorporated, resulting in reinforced concrete (RCC) or fiber-reinforced concrete (FRC). The bond between the reinforcing bars and the hardened concrete, known as joint performance, is of paramount importance for ensuring the structural integrity of concrete elements. Joint performance is influenced by factors such as the adhesion of hardened concrete paste, friction between concrete and reinforcement, and the contraction of concrete due to reinforcement. Pull-out tests are typically conducted to evaluate joint performance, with the maximum load representing the achieved bond strength. However, the failure modes and load-displacement behaviors can vary for different types of reinforcement, emphasizing the need for a comprehensive understanding of joint behavior. In the construction industry, the demolition of existing structures is often inevitable due to various reasons, including aging, obsolescence, or damage caused by natural disasters or conflicts. As the rate of demolition increases, the disposal costs and scarcity of suitable landfill sites become significant concerns. Consequently, there is a growing need to explore efficient strategies for utilizing demolished concrete, reducing costs, and conserving non-renewable resources. Recycling offers a promising solution by transforming used materials into new products. Recycled concrete aggregate, obtained from crushed and graded demolition debris, presents a viable alternative to natural aggregates in concrete production. By incorporating recycled aggregates, the demand for virgin aggregates can be reduced, thus contributing to sustainability and resource conservation. Buildings, roads, bridges, and disaster-stricken areas serve as common sources of recycled aggregates. This study aims to investigate the utilization of crushed concrete as aggregate in concrete production, with a specific focus on the properties of fresh and hardened concrete. Various proportions of recycled aggregate (ranging from 0% to 100%) are considered as replacements for natural coarse aggregates. The compressive strength of concrete incorporating recycled aggregates is compared to that of concrete made with natural aggregates. Additionally, the economic feasibility of using recycled aggregates is discussed, taking into account material availability and cost. The research highlights the potential benefits of efficiently utilizing crushed concrete in construction, particularly in the context of India. Furthermore, the historical background, progress, and future prospects of recycling demolished concrete are presented, emphasizing the global

significance of this research field. Overall, this study seeks to contribute to the sustainable and cost-effective utilization of demolished concrete, aiming to reduce environmental impact and conserve valuable resources.

2. METHODOLOGY

2.1 Preparation of Ingredients from Demolished Concrete:

The demolished concrete obtained from the destruction of structures is likely to contain various contaminants such as coatings, cladding materials, earth, reinforcement equipment, timber, and plastics. These contaminants need to be removed to accurately assess the absence of unknown substances. In this study, the demolished concrete was processed using a jaw crusher set at a preliminary setting of 20 millimeters in the closed position. The crusher was used to pulverize a building element sourced from Ambala city. After crushing, the materials were sieved and combined for further evaluation.

2.2 Processing of Demolished Concrete Ingredients:

Large chunks of reinforced concrete (RCC) were crushed using a 200-tonne capacity compression testing machine. A 5 kg hammer was then employed to further break the concrete into smaller pieces. The crushed materials obtained were sieved and blended to achieve the desired grading according to IS 383-1970 specifications. The coarse aggregate from the demolished concrete was evaluated based on the guidelines of IS: 383-1970.

Table 1: Dimension of Moulds

| S. No. | Moulds | Dimension (mm x mm) | Specimen Casted |
|--------|--------|---------------------|-----------------------------|
| 1. | Cube | 150x150x150 | Potential under Compression |

2.3 Mixing and Compaction:

The component ingredients, including cement, fine aggregate, and coarse aggregate, were weighed using a weighing machine. Dry blending was performed to obtain a uniform mixture. Moisture was gradually added to achieve a homogeneous mix. The blending process lasted between 4-5 minutes for each mixture. The samples were cast in project iron molds following the requirements of IS 516-1959. To ensure proper compaction, the specimens were vibrated using a table vibrator for approximately 2 minutes. Excess materials were removed using a trowel, and a smooth finish was provided to the top surface using trowels and floats. After 24 hours, the specimens were demolded and placed in moisture tanks with ideal conditions for curing. The samples were then stored until testing at ages of 3, 7, 28, 56, and 90 days.



Figure 1: Compaction evaluating machine

3. RESULTS AND DISCUSSION

Once the mix proportions are determined, concrete specimens can be cast and tested to evaluate their fresh and hardened properties, including compressive strength, workability, and durability. The results obtained can be analyzed to assess the influence of the RCA substitution on the concrete's performance and to draw conclusions regarding its suitability and potential benefits in construction applications. The results regarding the effects of potential under compression and the effectiveness of different concrete blends are presented in Tables 2 to 3 and Figures 2 to 3. In the following sections, these outcomes are discussed in detail. Table 2 provides a comprehensive overview of the potential under compression for different concrete mixtures. The values obtained demonstrate the behavior of the concrete samples under various loading conditions. The data presented in this table allows for a comparative analysis of the compressive strengths of different concrete blends, including those incorporating recycled aggregates. Table 3 focuses on the effectiveness of different concrete blends by evaluating specific properties, such as durability, workability, and setting time. These properties play a crucial role in determining the suitability and performance of concrete in practical applications. The table provides a comprehensive comparison of the performance of various concrete mixtures, shedding light on the advantages and limitations of incorporating recycled aggregates. Table 3 presents additional relevant data on the mechanical properties of the concrete samples, such as tensile strength and flexural strength. These properties are important indicators of the structural performance and integrity of concrete elements. The table allows for a detailed assessment of the influence of different blend compositions on these mechanical properties.

Figures 2 to 3 visually represent the data and trends observed in the experimental results. These graphical representations provide a clearer understanding of the relationships between different variables and highlight any significant patterns or deviations. The figures assist in interpreting the effects of potential under compression and the performance of different concrete blends. The discussion of these results will provide insights into the implications and significance of the findings, addressing factors such as the influence of recycled aggregates on compressive strength, durability, workability, and mechanical properties of the concrete. Furthermore, the limitations and recommendations for future research will be discussed to enhance the understanding and applicability of using substantial blends in construction.

Table 1: Potential under Compression at diverse age (W/C=.48)

| S. No. | Mix | W/C | Age (Days) | Potential under Compression (MPa) | | | | |
|--------|-----------|-----|------------|-----------------------------------|-------|-------|-------|--------|
| | | | | %R=0 | %R=25 | %R=50 | %R=75 | %R=100 |
| A | 1:1.4:1.8 | .47 | 3 | 30.22 | 26.5 | 21.5. | 28.2 | 25.4 |
| B | 1:1.4:1.8 | .47 | 7 | 31.22 | 27.2 | 23.2 | 28.2 | 28.2 |
| C | 1:1.4:1.8 | .47 | 28 | 32.28 | 25.2 | 21.2 | 26.2 | 29.5 |
| D | 1:1.4:1.8 | .47 | 56 | 30.25 | 25.3 | 25.2 | 26.2 | 24.2 |
| E | 1:1.4:1.8 | .47 | 90 | 30.45 | 24.5 | 26.2 | 28.2 | 25.4 |

Table 2: Potential under Compression at different ages (W/C=0.48)

| S. No. | Mix | W/C | Age Days | Potential under Compression (MPa) | | | | |
|--------|-----------|-----|----------|-----------------------------------|-------|-------|-------|--------|
| | | | | %R=0 | %R=25 | %R=50 | %R=75 | %R=100 |
| 1. | 1:1.4:1.8 | .47 | 3 | 30.22 | 26.5 | 21.5. | 28.2 | 25.4 |
| 2. | 1:1.4:1.8 | .47 | 7 | 31.22 | 27.2 | 23.2 | 28.2 | 28.2 |
| 3. | 1:1.4:1.8 | .47 | 28 | 32.28 | 25.2 | 21.2 | 26.2 | 29.5 |
| 4. | 1:1.4:1.8 | .47 | 56 | 30.25 | 25.3 | 25.2 | 26.2 | 24.2 |
| 5. | 1:1.4:1.8 | .47 | 90 | 30.45 | 24.5 | 26.2 | 28.2 | 25.4 |

Table 3: Variation of Potential under Compression at different ages

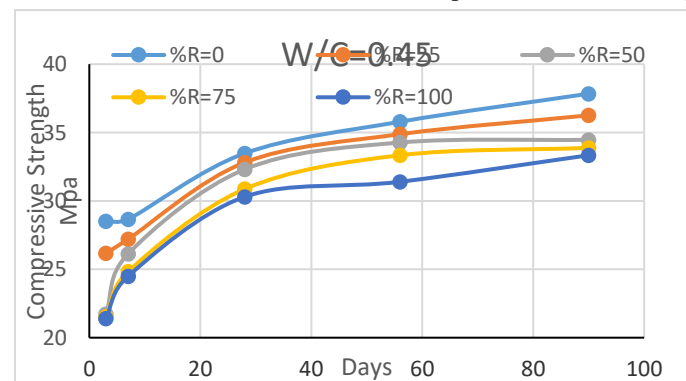


Figure 2: Potential under Compression vs. days graph at W/C=0.45

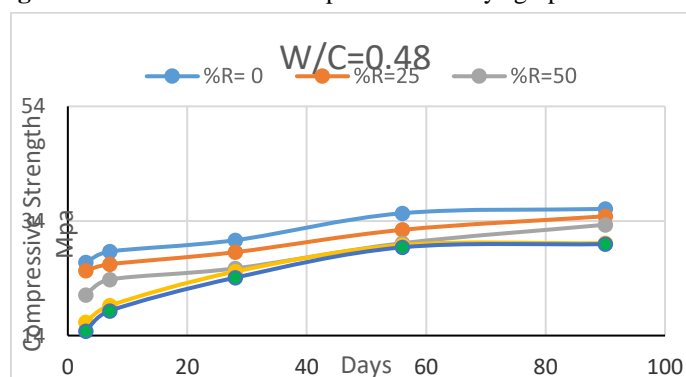


Figure 3: Potential under Compression vs. days graph at W/C= 0.48

4. CONCLUSION

The utilization of recycled concrete aggregates (RCAs) as sustainable alternatives in construction has been investigated in this study. The focus was on evaluating the characteristics of recycled concrete in both its fresh and hardened states, with specific emphasis on compressive strength. Different ratios of recycled aggregate (0%, 25%, 50%, 75%, and 100%) were considered as substitutes for natural coarse aggregates. The results obtained from this research indicate that recycled concrete exhibits a slightly lower compressive strength compared to original concrete, with reductions of up to 20% in certain cases. However, the freeze/thaw resistance of recycled concrete was found to be comparable to that of conventional concrete, possibly due to the cement paste sealing the pores in the porous recycled aggregates. This suggests that recycled concrete aggregates can be a viable option in construction, despite the slight reduction in strength. The findings of this study highlight the potential of utilizing demolished concrete as a valuable resource, reducing costs, and minimizing the demand for virgin aggregates. By incorporating recycled aggregates, the construction industry can contribute to sustainability and environmental conservation. Furthermore, the economic feasibility of using recycled aggregates was discussed, taking into account material availability and cost. The research emphasizes the need for appropriate design considerations and adjustments to mixture proportions to optimize the performance of recycled concrete. In conclusion, this study provides valuable insights into the use of recycled concrete aggregates as a sustainable alternative in construction. While the compressive strength of recycled concrete may be slightly lower, it exhibits comparable freeze/thaw resistance and offers potential cost and environmental benefits. Further research and innovation in the field of recycled concrete are recommended to optimize its properties and increase its acceptance in the construction industry.

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