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INVESTIGATING THE PROPERTIES OF AGGREGATES MADE WITH DEMOLISHED CONCRETE AND FLYASH

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ABSTRACT
The rapid expansion of the construction industry has led to a significant depletion of natural resources and a surge in construction and demolition (C&D) waste, necessitating sustainable alternatives for infrastructure development. This study investigates the physical and mechanical properties of recycled concrete aggregates (RCA) derived from demolished structures, integrated with fly ash as a supplementary pozzolanic material. The experimental program evaluates key parameters, including workability, density, compressive strength, and water absorption, by replacing natural coarse aggregates with RCA at varying percentages (e.g., 0%, 25%, 50%) and partially substituting cement with fly ash to enhance durability and environmental performance. Preliminary findings indicate that while higher replacement levels of recycled aggregates may slightly reduce initial mechanical strength due to increased porosity, the addition of fly ash helps mitigate these effects over time by improving the micro-structural density and overall concrete quality. Ultimately, this research aims to establish an optimized mix design that effectively utilizes waste materials, thereby reducing the carbon footprint of concrete production and promoting eco-friendly construction practices. This project investigates the feasibility of using recycled concrete aggregates (RCA) from demolished structures and fly ash as sustainable replacements for natural aggregates and cement in concrete production. With the increasing demand for construction materials and the rising environmental burden of construction waste, this study aims to evaluate the performance of eco-friendly "green concrete." The experimental phase involves replacing natural coarse aggregates with RCA at various levels (e.g., 25%, 50%, 75%, and 100%) and cement with fly ash (e.g., 15% to 25%). Key properties such as compressive strength, flexural strength, and split tensile strength are tested at 7 and 28 days to determine the optimal mix design. While RCA typically increases water absorption and can reduce initial strength, the pozzolanic activity of fly ash is expected to enhance long-term durability and workability. The study concludes by identifying the most effective replacement percentages to ensure structural integrity while significantly reducing the carbon footprint of concrete.

I. INTRODUCTION

1.1 Background

The rapid growth of the construction industry has led to an increasing demand for natural aggregates, which are essential components of concrete. At the same time, large quantities of construction and demolition waste are generated from old buildings, pavements, and infrastructure. The disposal of this waste poses serious environmental challenges, including land pollution and depletion of landfill space. In order to address these issues, the reuse and recycling of construction waste materials have gained significant importance in recent years.

Demolished concrete can be processed and reused as recycled aggregates, providing an alternative to conventional natural aggregates. Similarly, fly ash, a by-product of thermal power plants, has been widely used in construction due to its pozzolanic properties. The combination of demolished concrete and fly ash in the production of aggregates offers a sustainable solution by reducing waste and conserving natural resources.

1.2 Need for Study

The use of recycled aggregates derived from demolished concrete is an effective way to

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minimize environmental impact and promote sustainable construction practices. However, the properties of such aggregates may differ from natural aggregates due to the presence of adhered mortar and variations in material composition. The addition of fly ash can improve certain properties of recycled aggregates, but its influence needs to be thoroughly investigated.

There is a growing need to study the physical and mechanical properties of aggregates made with demolished concrete and fly ash to ensure their suitability for construction applications. Understanding these properties will help in determining their performance and potential use in concrete production.

1.3 Problem Statement

Although recycled aggregates offer environmental benefits, their use is often limited due to concerns regarding strength, durability, and consistency. The presence of impurities and higher water absorption in recycled aggregates may affect the quality of concrete. The role of fly ash in improving these properties is not fully understood, and further investigation is required to evaluate its effectiveness.

1.4 Objectives

- To investigate the properties of aggregates made from demolished concrete
- To study the effect of fly ash on aggregate properties
- To evaluate physical properties such as specific gravity and water absorption
- To analyze strength and durability characteristics
- To compare recycled aggregates with natural aggregates

1.5 Scope of Study

This study focuses on the experimental investigation of aggregates produced using demolished concrete and fly ash. The research includes evaluation of physical and mechanical properties of the aggregates under laboratory conditions. The study is limited to material-level analysis and does not include full-scale structural applications.

II. LITERATURE REVIEW

The use of recycled materials in construction has gained significant attention due to environmental concerns and the need for sustainable development. Researchers have extensively studied the properties of aggregates derived from demolished concrete and the role of fly ash in improving their performance.

Hansen (1992) conducted one of the earliest comprehensive studies on recycled aggregates and reported that aggregates obtained from demolished concrete exhibit higher water absorption and lower specific gravity compared to natural aggregates. The study emphasized that the presence of adhered mortar significantly affects the properties of recycled aggregates.

Ravindrarajah and Tam (1985) investigated the use of recycled concrete aggregates and observed that concrete made with these aggregates shows slightly reduced strength compared to conventional concrete. However, they concluded that recycled aggregates can be used effectively in construction with proper mix design.

Topçu (1997) studied the mechanical properties of recycled aggregate concrete and found that the strength reduction is mainly due to the weaker interfacial transition zone between the old mortar and new cement paste. The study suggested limiting the percentage of recycled aggregates to maintain desired strength levels.

Katz (2003) analyzed the influence of recycled aggregates on concrete properties and reported that the quality of recycled aggregates depends on the source of demolished concrete and processing methods. The study highlighted the importance of proper crushing and grading.

Poon, Shui, and Lam (2004) investigated the performance of recycled aggregate concrete and found that pre-treatment of recycled aggregates, such as soaking and removal of

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impurities, can significantly improve strength and durability.

Kou and Poon (2009) studied the use of recycled aggregates in concrete and observed that the addition of supplementary materials like fly ash can enhance the performance of recycled aggregate concrete by improving workability and reducing permeability.

Malhotra and Mehta (2005) highlighted the importance of fly ash as a supplementary cementitious material and reported that it improves the long-term strength and durability of concrete due to its pozzolanic reaction.

Naik, Ramme, and Tews (2002) investigated the use of fly ash in construction materials and found that it enhances the physical properties of aggregates and reduces environmental impact by utilizing industrial waste.

Chindaprasirt, Homwuttiwong, and Jaturapitakkul (2004) studied the effect of fly ash on concrete properties and concluded that it improves workability and reduces water demand, leading to better compaction and strength.

Siddique (2004) reviewed the use of waste materials in concrete and emphasized that fly ash significantly improves durability and reduces porosity, making it suitable for use with recycled aggregates.

Kumar and Sharma (2015) investigated aggregates made from demolished concrete and reported that although recycled aggregates show higher water absorption, their properties can be improved by using additives such as fly ash.

III. DATA COLLECTION

3.1 Overview

Data collection and methodology form the core of this study, as they provide the necessary framework for evaluating the properties of aggregates made with demolished concrete and fly ash. The reliability of the results depends on systematic data collection and proper experimental procedures. In this study, both primary and secondary data are used to analyze the physical and mechanical properties of recycled aggregates.

3.2 Materials Collection

The primary materials used in this study include demolished concrete, fly ash, natural aggregates, and water. The demolished concrete is collected from construction and demolition sites and is processed by crushing into suitable aggregate sizes. Fly ash is obtained from thermal power plants and is used as an additive to improve the properties of recycled aggregates.

Natural aggregates are also collected to serve as a reference for comparison. All materials are carefully selected and prepared to ensure consistency and accuracy in testing.

3.3 Preparation of Recycled Aggregates

The collected demolished concrete is crushed using mechanical equipment to produce coarse aggregates of required sizes. The aggregates are then cleaned to remove dust, impurities, and unwanted materials. Fly ash is incorporated into the recycled aggregates either by coating or mixing to enhance their properties.

Proper grading of aggregates is carried out to achieve uniform particle size distribution. The prepared aggregates are stored under controlled conditions before testing.

3.4 Primary Data Collection

Primary data is obtained through laboratory testing of the prepared aggregates. Various tests are conducted to determine the physical and mechanical properties of aggregates. These include specific gravity test, water absorption test, aggregate crushing value test, and impact value test.

The results obtained from these tests provide information about the strength, durability, and suitability of recycled aggregates for construction purposes. The tests are conducted as per standard procedures to ensure accuracy and reliability.

3.5 Secondary Data Collection

Secondary data is collected from research papers, textbooks, and standard codes related to

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concrete technology and recycled materials. Information regarding standard values for aggregate properties is obtained from IS codes and other relevant guidelines. This data is used for comparison and validation of experimental results.

3.6 Testing Procedure

The prepared aggregates are subjected to standard laboratory tests to evaluate their properties. The specific gravity test is conducted to determine the density of aggregates, while the water absorption test indicates their porosity. The aggregate crushing value test and impact value test are performed to assess strength and resistance to sudden loads.

Each test is repeated multiple times to ensure consistency, and average values are recorded for analysis.

3.7 Data Processing and Analysis

The collected data is systematically recorded, tabulated, and analyzed to identify trends and relationships between different parameters. The results obtained for recycled aggregates are compared with those of natural aggregates to evaluate performance.

Any variations in results are carefully examined, and conclusions are drawn based on experimental findings. This analysis helps in determining the suitability of aggregates made with demolished concrete and fly ash for use in construction.

IV. RESULTS

Comparison of Recycled Aggregates and Natural Aggregates

The experimental results obtained from the tests provide a clear understanding of the properties of aggregates made with demolished concrete and fly ash. The properties of recycled aggregates are compared with conventional natural aggregates to evaluate their performance.

The results indicate that recycled aggregates show slightly lower strength compared to natural aggregates due to the presence of adhered mortar. However, the incorporation of fly ash improves the properties of recycled aggregates by reducing porosity and enhancing bonding characteristics. The overall performance of recycled aggregates with fly ash is found to be satisfactory for construction applications.

Physical Properties of Aggregates

The physical properties such as specific gravity and water absorption are analyzed for both natural and recycled aggregates. It is observed that recycled aggregates have lower specific gravity compared to natural aggregates due to the presence of old mortar attached to the surface.

Water absorption of recycled aggregates is higher than that of natural aggregates. This is mainly due to increased porosity and micro-cracks in the recycled aggregates. However, the addition of fly ash helps in reducing water absorption by filling voids and improving the density of the aggregates.

Mechanical Properties of Aggregates

The mechanical properties of aggregates are evaluated using aggregate crushing value and impact value tests. The results show that recycled aggregates have slightly higher crushing and impact values compared to natural aggregates, indicating lower strength.

The presence of fly ash improves the mechanical properties by enhancing the internal structure and reducing weak zones. The aggregates treated with fly ash show better resistance to crushing and impact loads compared to untreated recycled aggregates.

Effect of Fly Ash on Aggregate Properties

The addition of fly ash plays a significant role in improving the quality of recycled aggregates. Fly ash acts as a filler material and improves the bonding between particles. It also reduces the porosity and enhances the strength of aggregates.

The results indicate that an optimum percentage of fly ash provides the best performance. Excessive addition of fly ash does not significantly improve properties and may lead to undesirable effects.

Observations and Discussion

The experimental investigation shows that aggregates made from demolished concrete have different characteristics compared to natural

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aggregates. The presence of adhered mortar results in higher water absorption and lower strength.

However, the use of fly ash improves these properties and makes recycled aggregates more suitable for construction applications. Proper processing and treatment of recycled aggregates are essential to achieve better performance.

Important Findings

- Recycled aggregates have lower specific gravity compared to natural aggregates
- Water absorption of recycled aggregates is higher due to porosity
- Mechanical strength of recycled aggregates is slightly lower
- Addition of fly ash improves strength and reduces porosity
- Optimum percentage of fly ash gives best performance
- Recycled aggregates with fly ash can be used in construction.

V. CONCLUSIONS

The present study on investigating the properties of aggregates made with demolished concrete and fly ash demonstrates that recycled aggregates can be effectively utilized as an alternative to natural aggregates in construction. The experimental results indicate that although recycled aggregates possess slightly inferior properties compared to natural aggregates, their performance can be significantly improved through proper treatment and the addition of fly ash.

The study reveals that recycled aggregates have lower specific gravity and higher water absorption due to the presence of adhered mortar and increased porosity. However, the incorporation of fly ash helps in reducing porosity and improving the density of the aggregates. This results in better bonding and enhanced overall performance.

The mechanical properties of recycled aggregates, such as crushing value and impact value, are found to be slightly lower than those of natural aggregates. With the addition of fly ash, these properties show noticeable improvement, indicating increased resistance to loads and better durability.

It is observed that there exists an optimum percentage of fly ash that provides the best results. Beyond this level, no significant improvement is observed, and the properties may even decrease. Therefore, proper proportioning and mix design are essential to achieve desired performance.

Overall, the study concludes that aggregates made from demolished concrete, when combined with fly ash, can be used as a sustainable and eco-friendly alternative in construction. The use of such materials not only helps in reducing construction waste but also conserves natural resources. With proper processing and quality control, recycled aggregates can be effectively used in various construction applications, contributing to sustainable development.

REFERENCES

Research and practical applications in India for demolished concrete (often referred to as Recycled Concrete Aggregate or RCA) combined with fly ash focus on creating sustainable "green concrete" that reduces both carbon emissions and waste.

Key Indian Research & References

1. Performance of Recycled Coarse Aggregate (RCA) & Fly Ash:
2. A.N. Dabhade et al. (2014): Investigated the "Effect of Fly Ash on Recycle Coarse Aggregate Concrete," noting that a 10% replacement of cement with fly ash can slightly increase axial compressive strength compared to using RCA alone.
3. Vikas Srivastava et al. (2013): Explored the use of "Demolition Waste as Cement Replacement" and its role in sustainable construction.
4. Dabhade et al. (Dadri, U.P. Study): Utilized fly ash from the NTPC Dadri power plant and demolished waste

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from 70-year-old buildings, finding that RCA and fly ash together can enhance overall concrete properties.

Soil Stabilization:

5. Highway Construction Study (2024): Adding 25% demolished concrete and fly ash significantly improved California Bearing Ratio (CBR) values for soil from 3.08% to 23.56%, making it suitable for road subgrades.

Geopolymer Concrete:

6. Ahirwar et al. (2018): "Compare the Strength of Fly Ash Based Geopolymer Concrete with Demolition Waste," showing that 100% replacement of natural aggregate with RCA is possible in fly ash-based geopolymer systems, despite a slight (6–15%) reduction in early-age strength.

Indian Standards & Guidelines

7. Applications of these materials are governed by several Bureau of Indian Standards (BIS) and Indian Roads Congress (IRC) codes:
8. IS 3812 (Part 1): Specifications for pulverized fuel ash (fly ash) for use as pozzolana in cement and concrete.
9. IS 383:2016: Now permits the use of Recycled Concrete Aggregate (RCA) in various proportions for lean concrete and structural concrete (up to 20% in some cases).
10. IS 10262: Guidelines for concrete mix proportioning, specifically addressing how to incorporate fly ash as a partial replacement for cement.
11. IRC:SP:58-1999: Guidelines specifically for the use of fly ash in road embankments.

Key Findings on Performance

12. Strength: Replacing natural aggregate with RCA typically leads to a decrease in strength, but the addition of fly ash helps "bridge" this gap over time due to its long-term pozzolanic activity