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An Experimental Investigation on Concrete Recycled Coarse Aggregate, Fly Ash, and Waste Polyester Fibers

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ABSTRACT: The use of recycled coarse aggregate (RCA), fly ash, and waste polyester fibers in multi-blended mix concrete has received a lot of attention in recent years since it has the potential to reduce environmental impact and increase the sustainability of concrete construction. The purpose of this work is to describe current understanding about the characteristics and performance of concrete formed from RCA, fly ash, and waste polyester fibers. When RCA, fly ash, and leftover polyester fibers are combined in concrete, the resulting material's characteristics and performance might be affected in a complex way. According to studies, using RCA can reduce concrete's mechanical strength, however using fly ash can increase its durability and workability. The addition of waste polyester fibers can enhance the tensile strength and crack resistance. The use of RCA, fly ash, and waste polyester fibers in multi-blended mix concrete offers a promising approach to sustainable and durable construction materials. However, further research is needed to fully understand the complex interactions between these components and to optimize their combined use in concrete applications.M30 concrete by partial replacement of RCA with Coarse aggregate in proportions of 0%, 25%, 50%, 75% ,100% .For Binder material, OPC 43 grade of cement by partial replacement of Fly Ash with in proportions of 0%, 5%, 10%, 15%, and 20% .

To study the effect of RCA, fly ash, and waste polyester fibers on compressive strength, splitting tensile strength and flexural strength for M30 grade of concrete. The workability of Normal Concrete and WPFC Concrete Mix design WPFC C15-R25 slump value is WPFC C15-R50 is 78mm . The compressive strength of WPFC C15-R50 is 25.25 MPa and 42.35 MPa with 10.50 % and 9.43 % Increase in strength at 7 and 28- days curing of Cubes. the Splitting tensile strength is 4.15 MPa with 23.51% Increase in strength at 28 days the Splitting tensile strength is 4.350 MPa with 17.56 % Increase in strength at 28 days Cylinders of Cylinders. The flexural strength is 4.855 MPa with 17.75 % Increase in strength at 28 days curing of Beams.

KEYWORDS; Mix Design of M30 grade of concrete, OPC 43 grade of cement, Strength, recycled coarse aggregate (RCA), fly ash, and waste polyester fibers , compressive strength, flexural strength and splitting tensile strength.

I.INTRODUCTION

Recycled coarse aggregate is produced by crushing concrete debris from demolished structures. The incorporation of RCA into concrete mixes can lead to several effects: The use of RCA generally results in lower compressive strength compared to conventional aggregates due to its higher porosity and lower density. However, with proper mix design and treatment methods, such as soaking or using additives, the strength can be improved. Concrete made with RCA may exhibit reduced durability characteristics, particularly in terms of water absorption and resistance to freeze-thaw cycles. This is attributed to the inherent properties of recycled materials. The workability of concrete containing RCA can be affected negatively because RCA tends to absorb more water than natural aggregates. Adjustments in water-cement ratios or the use of superplasticizers may be necessary to maintain desired workability levels.

Fly ash is a byproduct from burning pulverized coal in electric power generating plants and is commonly used as a supplementary cementitious material (SCM) in concrete. Fly ash enhances the long-term strength of concrete through

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pozzolanic reactions that occur when it reacts with calcium hydroxide released during cement hydration. This leads to improved compressive strength over time. The spherical shape and fine particle size of fly ash improve the workability of concrete mixes, reducing segregation and bleeding while allowing for easier placement. Utilizing fly ash reduces the carbon footprint associated with cement production since it partially replaces Portland cement, which is energy-intensive to produce.

Waste polyester fibers are derived from post-consumer products such as plastic bottles and textiles.Tensile Strength Improvement: Incorporating polyester fibers into concrete enhances its tensile strength and ductility, which can help prevent cracking under stress. The addition of fibers improves impact resistance, making the concrete more durable against dynamic loads. Fibers help control shrinkage cracking by providing additional tensile support within the matrix, thus improving overall performance.

Combined Effects in Multi-Blended Mix Concrete

When combining RCA, fly ash, and waste polyester fibers into multi-blended mix concrete:

1. Synergistic Benefits: The combination can lead to a balance between sustainability and performance; while RCA may reduce mechanical properties initially, fly ash compensates for this by enhancing long-term strength and durability.
2. Optimized Mix Design: Careful consideration must be given to mix proportions to achieve optimal performance characteristics while ensuring adequate workability and durability.
3. Environmental Impact Reduction: Using these materials collectively contributes significantly toward reducing landfill waste and lowering greenhouse gas emissions associated with traditional concrete production processes.

II. RESEARCH GAP & OBJECTIVES OF VIEW

Research Gap:

1. How do different percentages of waste polyester fibers affect the workability, compressive strength, and tensile strength of M30 grade concrete incorporating RCA and activated fly ash.
2. What is the optimal dosage of waste polyester fibers to enhance the durability (e.g., water absorption, acid resistance, freeze-thaw resistance) of M30 grade RCA concrete with activated fly ash.
3. How does the microstructure (e.g., ITZ, crack bridging) of M30 grade concrete with RCA, activated fly ash, and waste polyester fibers compare to similar mixes with natural fibers or no fibers.
4. What are the environmental and economic benefits of using waste polyester fibers in M30 grade RCA concrete with activated fly ash, considering the entire life cycle.

Objectives of View

A review of previous studies on using Recycled Coarse Aggregate (RCA) in place of natural coarse aggregate (NCA), fly ash, Waste Polyester Fibers has the potential to produce durable concrete by improving the mechanical properties of concrete.

1. Increase the economy of the construction with using the cheaper material Fly ash as a replacement of the cement.
2. To compare the hardened properties of concrete with different amount of Recycled Coarse Aggregate (RCA) as 25%, 50%, 75% and 100%.
3. To compare the hardened properties of concrete with different amount of 0% 5% 10% 15% & 20% of fly ash as replacement of Cement to improve the quality of concrete.
4. In additional, 0.25% of Waste Polyester Fibers are added to concrete to create Waste Polyester Fibers concrete (WPRC).
5. To utilize IS 10262:2019 to create the mix design for M30 grade concrete and using the slump cone test to determine the workability.

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III. METHODOLOGY

Methodology of Recycled Coarse Aggregate, Fly Ash, and Waste Polyester Fibers in Multi-Blended Mix Concrete
Below is a detailed breakdown of this methodology:

1. Material Selection and Characterization
∟Recycled Coarse Aggregate (RCA): RCA is obtained from crushed concrete debris. The quality of RCA can vary significantly based on its source. It is essential to characterize the RCA by assessing its physical properties such as density, water absorption, porosity, and particle size distribution.
∟Fly Ash: This is a byproduct from coal combustion in power plants. Its pozzolanic properties make it an excellent supplementary cementitious material (SCM). The fly ash should be characterized for fineness, specific gravity, and chemical composition to ensure compatibility with other materials.
∟Waste Polyester Fibers: These fibers are derived from post-consumer or industrial polyester waste. They should be cleaned and processed to remove contaminants before use. The length and diameter of the fibers should also be measured to determine their impact on concrete performance.

Mix Design Development

- Proportioning: A multi-blended mix design should be developed considering the proportions of RCA, fly ash, and polyester fibers along with conventional aggregates and cement. The total binder content must account for both cement and fly ash.
- Water-Cement Ratio: The water-cement ratio must be optimized to achieve the desired workability while ensuring sufficient hydration for both cement and fly ash.
- Additives: Depending on the specific requirements of the project, chemical admixtures may be added to enhance workability or accelerate setting times.

Mixing Process
Dry Mixing: Initially, all dry ingredients including cement, fly ash, RCA, natural aggregates (if used), and any additives should be mixed thoroughly until a uniform blend is achieved.
Incorporating Water: Gradually add water while mixing to achieve the desired consistency. Care must be taken not to exceed the predetermined water-cement ratio.

Adding Polyester Fibers: Once a homogeneous mixture is formed, waste polyester fibers can be introduced into the mix. The fibers should be evenly distributed throughout the concrete matrix to enhance tensile strength and ductility.

Casting and Curing
∟Casting: The mixed concrete should be cast into molds immediately after mixing to prevent premature setting. Proper compaction techniques such as vibration may be employed to eliminate air voids.
∟Curing: After casting, curing methods such as wet curing or covering with curing compounds should be applied to maintain moisture levels during the hydration process for at least 7 days.

Table 1: Mix Proportion M30

Cement(Kg/m^3)	Fine aggregates (Kg/m^3)	Coarse aggregates (Kg/m^3)	Water content (Kg/m^3)
438	577	1189	197
1	1.32	2.71	0.45

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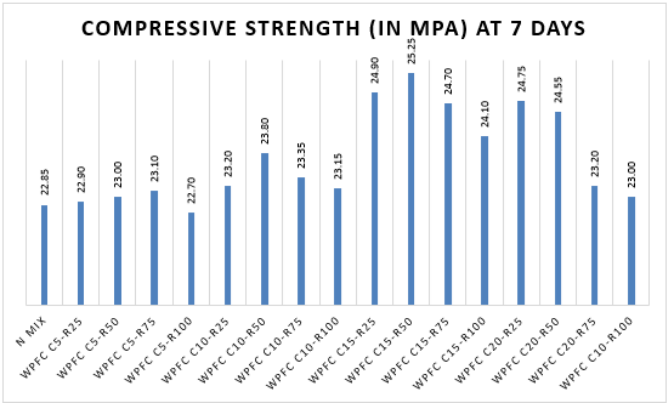
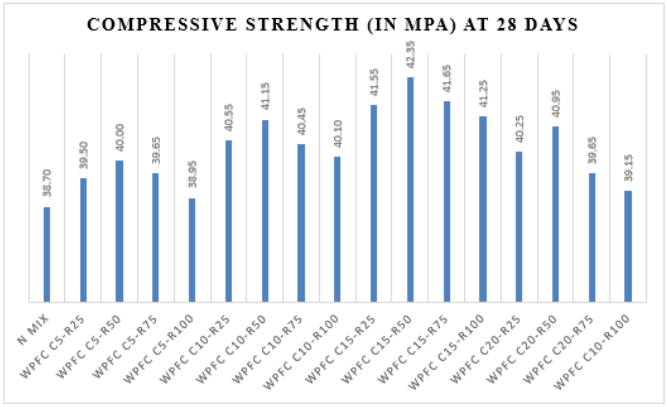
IV. RESULT DISCUSSION

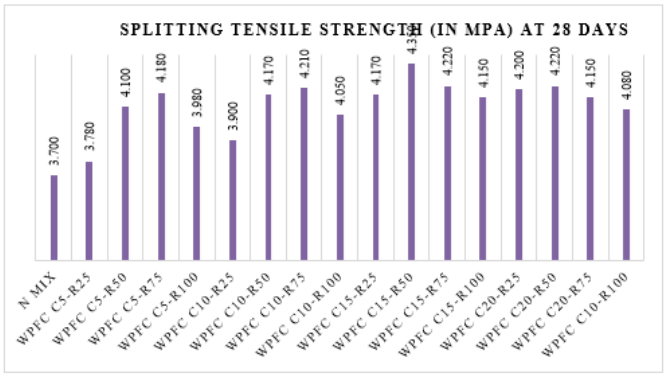
The concrete mix made of using Recycled Coarse Aggregate, Fly Ash, as partial replacement of coarse aggregate and OPC cement with Waste Polyester Fibers showed good workability and strength as compare to normal concrete mixes. The workability , compressive strength , Splitting tensile strength and flexural strength of Normal Concrete and WPFC Concrete.



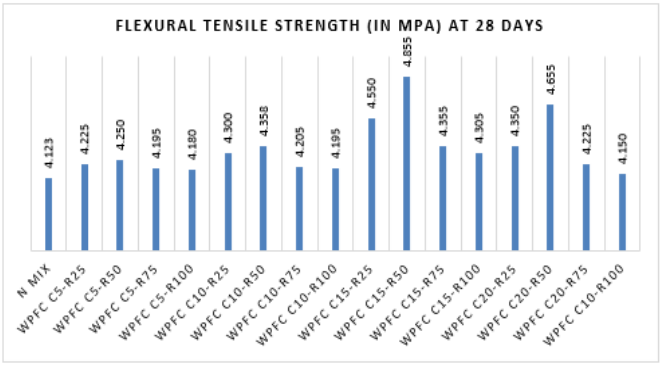
(a) compressive strength of Normal Concrete and WPFC Concrete at 7 days



(b) compressive strength of Normal Concrete and WPFC Concrete at 28 days



© Splitting tensile strength of Normal Concrete and WPFC Concrete at 28 days



(d) flexural strength of Normal Concrete and WPFC Concrete at 28 days

Figure 1 ; (a) , (b) , (c) and (d) shown resilts of Normal Concrete and WPFC Concrete

IV. CONCLUSION

The following conclusions are made from the study:

1. The concrete mix made of using Recycled Coarse Aggregate, Fly Ash, as partial replacement of coarse aggregate and OPC cement with Waste Polyester Fibers showed good workability and strength as compare to normal concrete mixes.
2. The workability of Normal Concrete and WPFC Concrete Mix design WPFC C15-R25 slump value is WPFC C15-R50 is 78mm .
3. The compressive strength of WPFC C15-R50 is 25.25 MPa and 42.35 MPa with 10.50 % and 9.43 % Increase in strength at 7 and 28- days curing of Cubes.
4. The Splitting tensile strength is 4.350 MPa with 17.56 % Increase in strength at 28 days Cylinders of Cylinders.
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