AN EXPERIMENTAL STUDY ON COMPRESSIVE STRENGTH OF FIBER REINFORCED HIGH STRENGTH CONCRETE USING RECYCLED COARSE AGGREGATE

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ABSTRACT

The increasing demand for natural aggregate has led to a scarcity of natural resources, making the recycling of destroyed concrete a viable solution for sustainable development. Recycled concrete aggregate (RCA) has been produced by crushing demolished concrete, and it is an eco-friendly alternative that reduces the burden on landfills and consumes less energy. However, the usage of RCA in structural concrete requires careful consideration of its strength characteristics. Coarse aggregate plays a crucial role in the compressive strength of concrete, and natural coarse aggregate is often used to replace crumbling concrete. Concrete is the most widely used building material in civil engineering, but the current disposal of concrete waste in landfills poses a threat to the environment. The use of RCA in new concrete production is considered an efficient solution to address this problem, but more detailed information on its characteristics is needed. This study aims to develop high-strength grade concrete using RCA and silica fume as a mineral admixture material. The experiment involved creating 18 sets of concrete, each with five cubes. A control mix was also included in the study. In the fresh state, the mixes were subjected to a slump test, and in the hardened state, a 28-day compression test was performed. The results showed that using RCA and silica fume as a mineral admixture material resulted in high-strength grade concrete with improved mechanical properties. In conclusion, the use of RCA in new concrete production is an efficient way to utilize concrete waste while preserving natural resources and reducing environmental pollution. The results of this study provide important information on the strength characteristics of concrete using RCA and silica fume as a mineral admixture material. Further research is needed to fully explore the potential of using RCA in structural concrete and to optimize its performance.

Keywords : Recycled concrete aggregate, compressive strength, mineral admixture

1.0 Introduction

High-Strength Concrete (HSC) and Fiber Reinforced Concrete (FRC), as well as Recycled Aggregate. HSC is defined as concrete with a compressive strength greater than 41 MPa, and the addition of fiber reinforcement to concrete can significantly improve its static and dynamic properties. Different types of fibers can be used in FRC, such as glass, steel, natural, and carbon fibers, and they can enhance properties such as ductility, seismic resistance, impact and abrasion resistance, and strength. Recycled aggregate is made of crushed, graded inorganic particles from construction and demolition waste, and it can be used as an alternative material to natural aggregate. Recycled aggregate has several benefits, such as preserving natural aggregate, lessening the load on landfills, using less energy, and reducing costs. Recycled aggregate can be used in various applications, such as concrete kerbs, paving blocks, building blocks, and backfill materials. Prof. Jayesh kumar Pitroda and Chetna M. Vyas (2013) studied the durability of recycled coarse aggregate and fly ash in concrete. They used Fly Ash instead of cement and found good results compared to traditional concrete.Dr. Salahaldein Alsadey's (2012) research looked at the impact of superplasticizer on concrete strength. Concrete mixes of grade M30 were made with SP dosages of 0.6%, 0.8%, 1.0%, and 1.2%. A dosage of 1.0% of SP increased the compressive strength by 55N/mm2.P. Muthupriya et al. (2011) examined the behavior of short columns made of High-Performance Concrete (HPC) grade M60 with varying replacement levels of silica fume and fly ash and a superplasticizer dosage of 1.5% by weight of cement. The study found that a 7.5% silica fume replacement level was ideal.Neela Deshpande et al. (2011) researched the effectiveness of using coarse recycled concrete aggregate in concrete. The study found that using recycled concrete aggregate in fresh concrete was appropriate.Y. V. Akbari et al. (2011) studied the impact of recycled aggregate on the characteristics of concrete. The study found that increasing the percentage of aggregate replacement caused a drop in compressive strength, flexural strength, split tensile strength, and workability.Kenai and Debieb (2010) investigated the possibility of using crushed clay bricks as coarse and fine aggregate for new concrete and found that the concrete produced had comparable properties to those of concrete made with natural aggregates.K. Jagannadha Rao and T. Ahmed Khan (2009) investigated the applicability of glass fibers in High Strength Recycled Aggregate Concrete. The study found that the presence of fibers improved ductility and increased compressive, split tensile, and flexural strengths.Madan Mohan Reddy.K et al., (2000) studied the use of crushed building and demolition trash as recycled concrete aggregate in the creation of new concrete.Limbachiya et al. (2000) found no difference in the strength of recycled aggregate concrete compared to conventional aggregate concrete, but the recycled aggregate concrete had a lower relative density and a higher water absorption rate.

2.0 Experimentation

An experimental inquiry that aims to investigate the use of recycled material and silica fume as admixtures in concrete production. The experiment involves casting and testing 18 sets of cubes, with each set consisting of five cubes used to calculate compressive strength. One set serves as the control mix, while the remaining 17 sets contain varying amounts of recycled material and silica fume. The first phase of the experiment involves casting and testing cubes that contain 20% recycled coarse material. The goal of the second phase is to achieve the ideal recycled coarse aggregate content. The cube specimens have dimensions of 15x15x15 cm and are lubricated before pouring concrete into the molds. After casting, the molds are removed the next day, and the cubes are carefully transferred to a curing tank.

The study uses several materials with specific characteristics, including Ordinary Portland Cement 53 grade with a specific gravity of 3.15, locally available river sand with a bulk density of 1710 kg/m3 and a specific gravity of 2.67, and coarse aggregate with a bulk density of 1685 kg/m3 and a specific gravity of 2.81. Silica fume, with a specific gravity of 2.20, is used as an admixture in the experiment. The water used in the study conforms to the requirements of water for concreting and curing as per IS ; 456 – 2000. Additionally, the study employs a superplasticizer, Conplast SP 430, and glass fibers in the concrete mix.

2.1 Mix Design

In the experiment, the mix design for each set with different combinations was carried out using the ACI: 211.4R-93 (Reapproved 1998) approach. The mix ratio for the typical M50 grade concrete was 1:1.11:2.10, and the water-cement ratio was 0.3. The mix design process involved selecting the target strength, maximum aggregate size, and minimum cement content based on the specified compressive strength, workability, and durability requirements. The ACI mix design method utilizes the absolute volume method to determine the proportions of the constituent materials in the mix. The first step in the mix design process is to calculate the absolute volume of concrete based on the unit weight of the concrete mix. The second step is to determine the proportions of the cement, water, fine aggregate, and coarse aggregate based on the desired mix ratio and the absolute volume of concrete. The third step involves adjusting the mix proportions to account for variations in the properties of the constituent materials, such as moisture content and specific gravity. The mix design process ensures that the concrete mix meets the specified strength, workability, and durability requirements while minimizing material costs.

3.0 Test Results & Discussion

Table 1: Test Results of compressive strength of High Strength Concrete using Recycled Coarse Aggregate and Glass Fiber

S.No	Mix Designation	% of Recycled Coarse Aggregate	Compressive Strength (MPa) 7 days	Compressive Strength (MPa) 28 days
1.	M50 CM	0	34.66	58.22
2.	M50 5%S.F+5% RCA	5	35.55	55.11
3.	M50 (5%+10%)	10	35.11	53.77
4.	M50 (5%+15%)	15	34.66	53.33
5.	M50 (5%+20%)	20	33.77	52.44
6.	M50 (7.5%+5%)	5	37.77	54.22

7.	M50 (7.5%+10%)	10	36.44	54.66
8.	M50 (7.5%+15%)	15	36.88	53.77
9.	M50 (7.5%+20%)	20	37.33	56.88
10.	M50 (10%+5%)	5	36.44	48.94
11.	M50 (10%+10%)	10	35.55	47.11
12.	M50 (10%+15%)	15	34.66	45.77
13.	M50 (10%+20%)	20	31.11	42.66

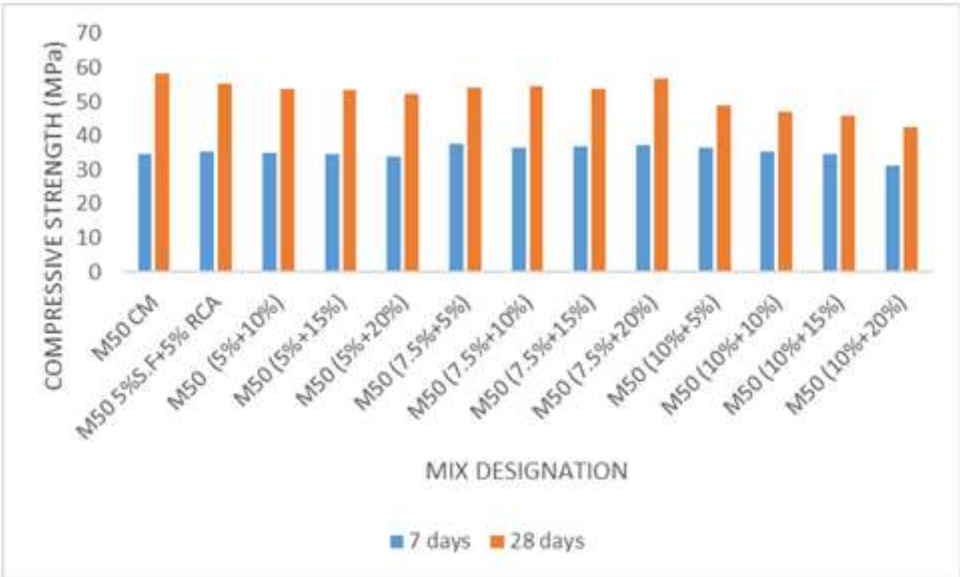

Fig.1 Test Results

The experimental findings suggest that the partial replacement of silica fume with 5% recycled coarse aggregate can lead to a significant increase in the compressive strength of concrete at 7 days, with a percentage increase of 10.80% compared to the control mix. However, it should be noted that the compressive strengths at 28 days show a decline as the content of mineral admixtures and recycled aggregate increases. Therefore, it is important to carefully balance the use of these materials to ensure optimal strength and durability while also considering the environmental impact of concrete production. Overall, the study provides valuable insights into the use of recycled materials and mineral admixtures in concrete production, and highlights the potential for improving both the performance and sustainability of concrete structures through careful material selection and mix design.

Table 2: Test Results of compressive strength of High Strength Concrete using Recycled Coarse Aggregate and Glass Fiber

S.No	Mix Designation	% of Recycled Coarse Aggregate	Compressive Strength (7 days) MPa	Compressive Strength (28days) MPa
1.	M50 7.5%S.F+1.5%SP 30% RCA	30	36.88	55.11
2.	M50 7.5%S.F+1.5%SP 40% RCA	40	36.00	54.22
3.	M50 7.5%S.F+1.5%SP 50% RCA	50	34.66	52.00
4.	M50 7.5%S.F+1.5%SP 75% RCA	75	33.33	48.94
5.	M50 7.5%S.F+1.5%SP 100% RCA	100	31.55	41.22

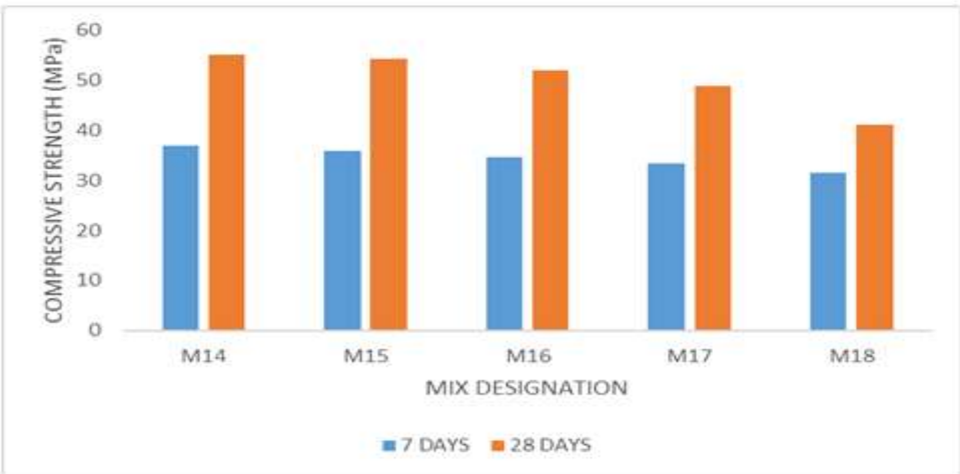

Fig.2 Test Results

The experimental investigation revealed that the compressive strength of the cubes decreased with the increase in the percentage of recycled coarse aggregate. Specifically, when the recycled coarse aggregate content was replaced with natural coarse aggregate at 30%, 40%, 50%, 75%, and 100%, the compressive strength of the cubes decreased by approximately 9.4%, 9.31%, 8.93%, 8.41%, and 7.0% coMPared to the control mix. However, when silica fume was partially replaced with 5% recycled coarse aggregate, the maximum strength of 7 days was achieved, with a percentage increase of 10.80% coMPared to the control mix. The trail mix percentage M50 (7.5% SF + 30% RCA) had the highest cube compressive strength, indicating that using 50% recycled coarse aggregate in high strength concretes is ideal. These findings suggest that incorporating recycled materials in concrete production can be an effective approach to reducing environmental pollution while still achieving high strength and economical outcomes.

Table :3 Test Results of compressive strength of High Strength Concrete using Recycled Coarse Aggregate and Glass Fiber

S.No	Mix Designation	% of glass fibers	Compressive Strength (7 days) MPa	Compressive Strength (28days) MPa
1.	M50 7.5%S.F+1.5%SP 50% RCA	0	34.66	52.00
2.	M50 7.5%S.F+1.5%SP 50% RCA	0.5%	36.88	56.00
3.	M50 7.5%S.F+1.5%SP 50% RCA	1.0%	39.55	58.66
4.	M50 7.5%S.F+1.5%SP 50% RCA	1.5%	41.33	60.88
5.	M50 7.5%S.F+1.5%SP 50% RCA	2.0%	40.44	60.00

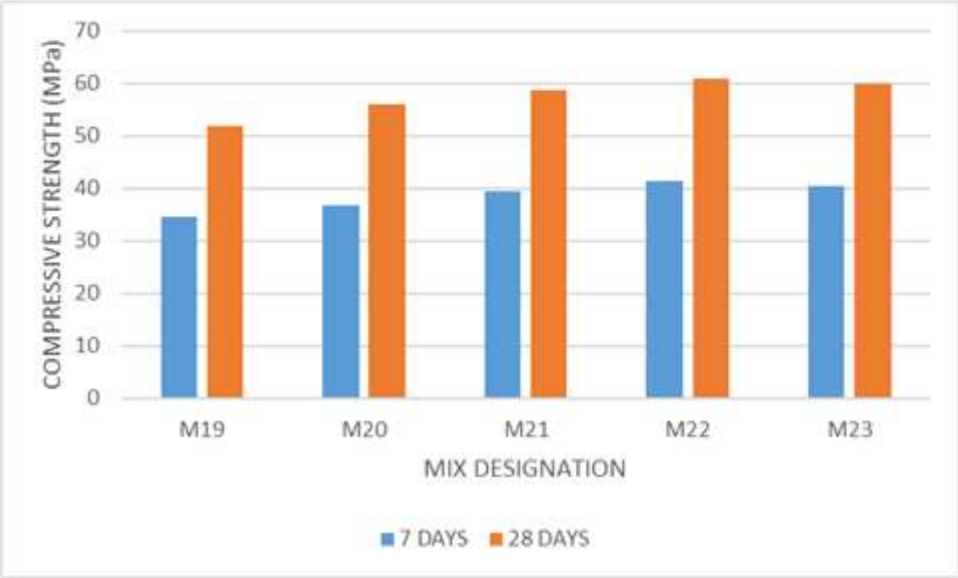

Fig.3 Test Results

4.0 Conclusions

The present study investigated the use of recycled coarse aggregate (RCA) and glass fibres in high strength concrete mix design. The results showed that the compressive strength of the concrete decreased with an increase in the amount of RCA. However, trial mix M50 (7.5% SF) with a replacement of 20% RCA demonstrated better outcomes and was used as a guide for the following stage of work. Combining this trial mix with 50% RCA resulted in a compressive strength of over 50 MPa. Moreover, using 50% RCA in high strength concrete resulted in better economy without using glass fibres and minimising environmental pollution. The addition of glass fibres was found to increase the compressive strength of the concrete. The mix with the highest increase in compressive strength was M50(7.5% SF) and 1.5% glass fibre, which showed a 11.7% increase when compared to the mix without glass fibre, i.e., M50(7.5% SF) (50% RCA). These findings suggest that a combination of RCA and glass fibres in high strength concrete mix design can lead to more sustainable and cost-effective construction practices. Further research is needed to explore the potential of these materials in other types of concrete and structural applications.

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