JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ENHANCING CONCRETE PROPERTIES USING RECYCLABLE MATERIALS (GLASS FIBER, GLASS POWDER, AND HUMAN HAIR)

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Abstract :

This study investigates the use of recyclable waste materials such as glass powder (GP), glass fiber (GF), and human hair (HH) to enhance the mechanical performance and sustainability of M-30 grade concrete. Concrete mixes were prepared by partially replacing of fine aggregate with glass powder and incorporating glass fibers and human hair at prearranged dosages. Workability and compressive strength were tested at 7, 14 and 28 days. Results indicate that all mixes achieved more than 60% of their 28-day strength at 7 days, with the experimental mixes demonstrating modest improvements in early and ultimate compressive strength. The optimal mix achieved a 28-day compressive strength of 32.21 N/mm². The findings suggest that these recyclable materials can be employed to improve performance while promoting environmental sustainability.

Index Terms – M-30 concrete, glass powder, glass fiber, human hair, compressive strength, sustainable materials

I. INTRODUCTION

Concrete is the most widely used construction material that consumes significant natural resources and generates substantial waste. In response, studies have concentrated on using waste-derived and recyclable additives to enhance mechanical performance and lessen environmental effect. Glass powder has pozzolanic potential and can partially replace fine aggregate to refine the microstructure of concrete. Glass fibers improve crack resistance and post-cracking ductility, however, human hair, a plentiful waste fiber, can help fill up microcracks and stop them from spreading. The combined effects of glass fiber, glass powder, and human hair on the development of M30 concrete's compressive strength are examined in this study

II. MATERIALS AND METHODS

OPC 53 grade cement, natural river sand as fine aggregate, and 20 mm crushed stone as coarse aggregate were the materials employed in this investigation. Fine aggregate was partially substituted with glass powder (GP) at weight percentages of 2.5%, 5%, and 7.5%. At 0.5%, 1.0%, and 1.5% of the cement weight, glass fiber (GF) was added. Human hair (HH) fibers were added in amounts ranging from 0.5% to 1.5% of the cement's weight. When needed, a superplasticizer was added at a rate of 1% of the cement weight to preserve workability. Standard M30 mix design processes were followed for mix proportions. For every mix, 150 mm cubes were cast and let to cure in water. Compressive strength tests were conducted at 7, 14 and 28 days in accordance with IS 516 (or equivalent).

III. EXPERIMENTAL MIXES AND TESTING

For this investigation, four concrete mixes were created: three experimental mixes (S1, S2, and S3) with varying amounts of glass powder, glass fiber, and human hair, and one control mix (N). Three cube specimens, each measuring 150 x 150 x 150 mm, were created from each mix. The average value for each age was noted after the concrete's compressive strength was assessed at 7, 14, and 28 days. Since no slump test or superplasticizer was utilized in this investigation, the workability of the mixtures was visually assessed during mixing and placement.

Figure 1. Fresh concrete filled into 150×150×150 mm cube molds during casting and marking

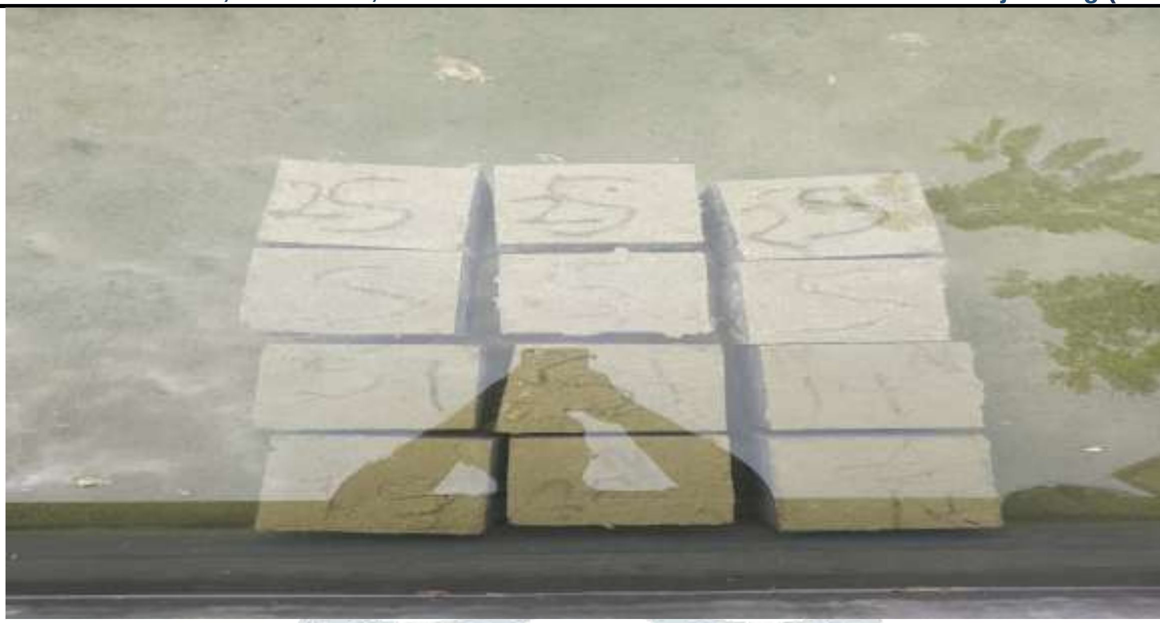

Figure 2. Curing of concrete cube specimens in a water tank

IV. COMPRESSIVE STRENGTH RESULTS

Mix Type	7-Day Strength (N/mm^2)	14-Day Strength (N/mm^2)	28-Day Strength (N/mm^2)	7-Day % of 28-Day	14-Day % of 28-Day
Natural (N)	19.89	26.11	30.28	65.7%	86.2%
Experimental 1 (S1)	22.50	27.89	31.84	70.7%	87.6%
Experimental 2 (S2)	19.48	28.80	32.21	60.5%	89.4%
Experimental 3 (S3)	18.94	27.53	30.89	61.3%	89.1%

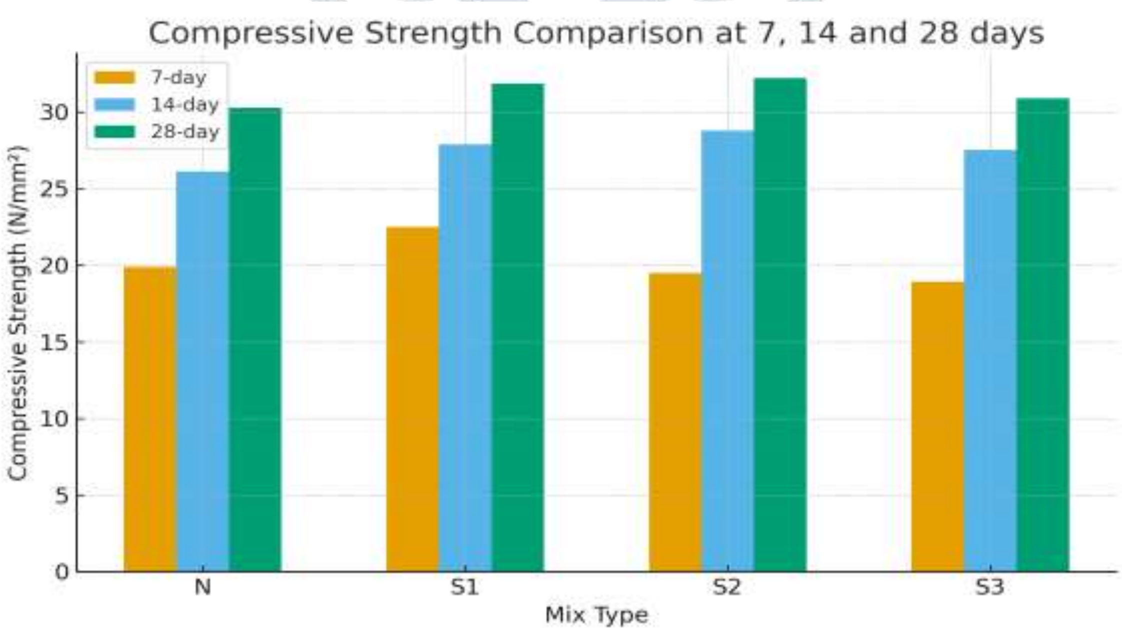

Figure 3. Compressive strength comparison of M30 concrete mixes at 7, 14, and 28 days.

V. RESULTS AND DISCUSSION

The experimental data showed that all mixes achieved more than 60% of their 28-day strength by 7 days, which is consistent with the therapeutic action of M30. The increased early strength (7-day) of the experimental mix S1 in comparison to the control suggests that the combination of glass powder and glass fiber may accelerate early hydration or improve microstructure. Mix S2's highest 28-day strength of 32.21 N/mm² indicates that its unique mix of additives generated the best long-term densification. The 14-day strengths, which ranged from about 85 to 90% of the 28-day values, generally displayed a normal strength increase trend. Fibers likely improved post-cracking energy absorption and inhibited microcrack propagation, while glass powder helped with pozzolanic reactions that densify the cement matrix.

VI. FUTURE SCOPE

Additional mechanical and durability properties, including as flexural strength, split tensile strength, water absorption, and resistance to chemical exposure, might be examined in future research to broaden this work. Long-term experiments involving carbonation depth, freeze-thaw cycles, sulfate assault, and chloride ion penetration would shed more light on how GP, GF, and HH function under challenging environmental circumstances.

To determine the best mix proportions, future research may also examine various fiber lengths, different fiber combinations, and different glass powder fineness levels. The appropriateness of these sustainable materials for actual construction applications might be evaluated by combining cost and environmental assessments with microstructural evaluation methods like SEM, XRD, and EDX.

VII. LIMITATIONS

This study was restricted to short-term curing times of 7, 14, and 28 days and solely examined compressive strength. Because no slump tests or admixtures were utilized, which could have affected consistency between mixes containing fibers, workability was assessed visually. Large-scale field performance was not assessed, and the trials were conducted on a modest laboratory scale with fewer specimens.

Furthermore, the physical characteristics of waste elements like glass powder and human hair might differ greatly, which could affect the consistency of concrete behavior. The long-term durability performance of these mixes is yet unknown, and the distribution of fibers within the concrete matrix was not observed.

VIII. CONCLUSION

This study demonstrates how recyclable components including glass powder, glass fiber, and human hair can enhance the mechanical properties of M30 concrete. All experimental mixes met or exceeded expected strength values, with Mix S2 having the maximum 28-day compressive strength. Together, fiber reinforcement and pozzolanic glass powder offer a practical way to create concrete with improved mechanical qualities and environmental friendliness. Further work is recommended to optimize proportions and evaluate flexural behavior and long-term durability.

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