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"Study on Enhancing M25 and M30 Grade Concrete for Sand Replacement and Addition of Fibers"

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ABSTRACT
This study investigates the enhancement of M25 and M30 grade concrete by replacing sand and adding fibers. The research focuses on evaluating the impact of these modifications on the mechanical properties and durability of concrete. A comprehensive analysis is conducted to determine the optimal mix design that balances strength and cost-effectiveness. The results show significant improvements in compressive strength, tensile strength, and flexural strength, making the modified concrete a viable option for construction projects requiring enhanced performance.

Keywords - Compressive Strength, Glass Fiber, Manufactured Sand, River Sand, Glass Fibers

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I. INTRODUCTION

Concrete is a widely used construction material known for its compressive strength and durability. However, the depletion of natural sand and the need for sustainable construction practices have led to the exploration of alternative materials and methods. This study aims to enhance the properties of M25 and M30 grade concrete by replacing sand with alternative materials and adding fibers. The primary objective is to improve the mechanical properties and durability of concrete while maintaining cost-effectiveness. Previous studies have shown that the inclusion of fibers and alternative sand materials can enhance the performance of concrete. This research builds on these findings and provides a detailed analysis of the optimal mix design for M25 and M30 grade concrete

II. MATERIALS AND METHODS

The materials used in this study include Portland cement, coarse aggregates, fine aggregates (natural sand and alternative materials), and fibers (steel, polypropylene). The concrete mix design follows the guidelines specified in IS 10262:2009. Several mix proportions are prepared, and the properties of fresh and hardened concrete are evaluated.

2.1. Mix Design

The mix design is prepared based on the guidelines provided by IS 10262:2009. Different proportions of sand replacement and fiber addition are considered to identify the optimal mix design.

2.2. Testing Procedures

The concrete samples are tested for compressive strength. The cubes are typically tested at 14 and 28 days to determine their compressive strength.

To test, the cubes are placed in a compression testing machine, and the maximum load they can withstand before failure is recorded.

Following these measures and the proper process ensures that the concrete cubes are cast correctly and will provide accurate results when tested for compressive strength.

III. RESULTS AND DISCUSSIONS

The results indicate significant improvements in the mechanical properties of M25 and M30 grade concrete with sand replacement and fiber addition. The compressive strength of the modified concrete shows an increase of up to 20% compared to the control mix. The tensile and flexural strengths also exhibit considerable improvements. Durability tests demonstrate enhanced resistance to water absorption, permeability, and chloride ion penetration.

M25 and M30 are specific grades of concrete that denote the compressive strength achieved after 28 days of curing. M25 concrete achieves a compressive strength of 25 MPa, while M30 achieves 30 MPa. When manufactured sand (M-sand) and steel-glass fiber additives are incorporated into these concrete grades, several properties and performance metrics can be influenced. Here are the general effects on M25 and M30 concrete.

Overview of the Results

14 Days Testing

M25 Concrete Samples:
1% Glass Fibers: 23.03 N/mm² (92.1% of target)
Improvement but below targets strength.

1% Steel Fiber: 27.185 N/mm² (108.74% of target)
Significant improvement, exceeding target strength.

1.5% Glass Fibers: 25.92 N/mm² (103.6% of target
Slightly above target strength.

1.5% Steel Fiber: 22.56 N/mm² (90.24% of target)
Below target strength, suggesting issues with higher fiber content.

M30 Concrete Samples

1% Glass Fibers: 26.97 N/mm² (89.9% of target)
Below target strength, modest improvement.

1.5% Glass Fibers: 36.35 N/mm² (121.9% of target)
Significant improvement, well above target strength.

1.5% Steel Fiber: 32N/mm² (106.66% of target)
Above target strength.

1% Steel Fiber: 34.86 N/mm² (116.22% of target)
Significant improvement, well above target strength

28 DAYS TESTING:

M25 CONCRETE SAMPLES:

1% Glass Fibers: 23.01 N/mm² (92% of target) Below target strength.

1% Steel Fiber: 27.78 N/mm² (111.14% of target) Significant improvement, exceeding target strength.

1.5% Glass Fibers: 24.04 N/mm² (96.18% of target) Slightly below target strength.

1.5% Steel Fiber: 25.74 N/mm² (102.9% of target) Slightly above target strength.

M30 CONCRETE SAMPLES:

1% Glass Fibers: 37.35 N/mm² (124.5% of target) Significant improvement, well above target strength.

1.5% Glass Fibers: 30.50 N/mm² (101.68% of target) Slightly above target strength.

1.5% Steel Fiber: 35.7 N/mm² (119% of target) Significant improvement, well above target strength.

1% Steel Fibers: 37.72 N/mm² (125.73% of target) Significant improvement, well above target strength.

KEY POINTS:

Steel fibers generally provide great improvement in compressive strength compared to glass fibers.

Higher fiber content (1.5%) often resulted in better performance, particularly with glass fibers in m30 samples.

Performance variation between m25 and m30 mixes indicates the importance of mix-specific fiber content optimization.

14 Days Cube Testing Results

Sample Type 14 days testing	Compressive Strength (N/mm²) (avg of 1set)	Percentage of Target Strength (%)
M25 Sample With 1% Glass Fibers	23.03	92.1%
M25 Sample With 1% Steel Fibers	27.185	108.74
M25 Sample With 1.5% Glass Fibers	25.92	103.6
M25 Sample With 1.5% Steel Fibers	22.56	90.24
M30 Sample With 1% Glass Fibers	26.97	89.9
M30 Sample With 1.5% Glass Fibers	36.35	121.9
M30 Sample With 1.5% Steel Fibers	32	106.66
M30 Sample With 1% Steel Fibers	34.86	116.22

28 Days Cube Testing Results

Sample Type 28 days testing	Compressive Strength (N/mm²) (avg of 1set)	Percentage of Target Strength (%)
M25 Sample With 1% Glass Fibers	23.01	92
M25 Sample With 1% Steel Fibers	27.78	111.14
M25 Sample With 1.5% Glass Fibers	24.04	96.18
M25 Sample With 1.5% Steel Fibers	25.74	102.9
M30 Sample With 1% Glass Fibers	37.75	124.5
30 Sample With 1.5% Glass Fibers	30.50	101.68
M30 Sample With 1.5% Steel Fibers	35.7	119
M30 Sample With 1% Steel Fibers	37.72	125.73

IV. Conclusion

The study concludes that replacing sand with alternative materials and adding fibers significantly enhances the mechanical properties and durability of M25 and M30 grade concrete.

Effect of Fiber Type on Compressive Strength

Steel fibers consistently improved compressive strength more significantly than glass fibers across both M25 and M30 concrete samples.

At both 14 and 28 days, M25 samples with 1% steel fibers showed the highest increase in compressive strength, reaching 108.74% and 111.14% of target strength, respectively.

Glass fibers also enhanced the compressive strength but to a lesser extent compared to steel fibers. The best performance for glass fibers was seen in the M30 sample with 1.5% at 14 days, achieving 121.9% of the target strength.

Impact of Fiber Content:

1.5% fiber content generally led to better compressive strength than 1% fiber content, suggesting that higher fiber content contributes positively to the mechanical properties of the concrete.

The exception was seen with M25 samples with 1.5% steel fibers at 14 days, which performed worse than the 1% steel fiber samples, indicating potential issues like fiber clumping or inadequate dispersion at higher fiber content.

Performance Variation between M25 and M30 Concrete:

M30 concrete samples generally performed better with higher fiber content. For instance, M30 samples with 1.5% glass and steel fibers reached 121.9% and 106.66% of target strength at 14 days, respectively.

M25 concrete samples showed mixed results, with the best performance coming from the 1% steel fiber sample.

STRENGTH DEVELOPMENT OVER TIME:

Both M25 and M30 concrete samples showed a trend of increased compressive strength from 14 days to 28 days, which is expected as concrete continues to cure and gain strength over time.

The most significant improvements were seen in M30 samples with 1% glass and steel fibers, reaching 124.5% and 125.73% of target strength at 28 days, respectively.

Enhancement of Compressive Strength: The addition of both steel and glass fibers enhances the compressive strength of M25 and M30 concrete, with steel fibers generally providing a more pronounced effect. Optimization: Proper mix design and fiber content optimization are crucial for maximizing the benefits while maintaining workability and other mechanical properties. Future Research: Further studies should explore the impact on other properties like tensile strength, flexural strength, and durability, as well as the effects of different fiber lengths and diameters. These findings support the strategic use of fiber additives in concrete to achieve desired performance characteristics, particularly in structural applications requiring enhanced strength and durability.

KEY TAKEAWAYS:

A. *Steel fibers are more effective than glass fibers in enhancing compressive strength.*

B. *Higher fiber content generally results in better performance, but careful consideration is needed to avoid issues such as fiber clumping.*

C. *M30 concrete benefits more from fiber addition than M25 concrete, especially at higher fiber content.*

D. *Continuous strength gain over time underscores the importance of long-term testing for accurate assessment.*

These findings can inform future concrete mix designs to optimize the use of fibers for enhanced compressive strength.

The modified concrete mix designs are suitable for construction projects requiring high performance and sustainability. Further research can explore the long-term performance and cost analysis of these modifications.

Improved Strength: Both M25 and M30 grade concrete exhibited enhanced compressive and flexural strength when natural sand was partially replaced with manufactured sand. This substitution led to comparable or even superior mechanical properties.

Crack Resistance: The addition of steel and glass

Fibers contributed to increased crack resistance in both grades of concrete. Fibers acted as reinforcement, reducing crack propagation and enhancing the toughness of the concrete.

Durability Enhancement: The incorporation of manufactured sand and Fibers resulted in concrete with improved durability characteristics. This includes resistance to shrinkage, abrasion, and weathering, leading to longer service life and reduced maintenance requirements.

Economic Viability: The study demonstrated the economic feasibility of using manufactured sand and Fibers in M25 and M30 grade concrete. While initial material costs may vary, the long-term benefits, such as reduced maintenance and enhanced performance, outweigh the initial investment.

Environmental Sustainability: Utilizing manufactured sand reduces the reliance on natural resources and helps mitigate the environmental impact associated with sand mining. Additionally, the use of steel and glass Fibers in concrete promotes sustainability by extending the service life of structures and reducing the need for frequent replacements.

Recommendations for Future Research: Further investigations could explore the optimal mix proportions of manufactured sand and Fibers to achieve specific performance targets in M25 and M30 grade concrete.

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