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Strength and Economic Assessment of Lightweight Concrete

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Abstract

This research evaluates the mechanical and economic properties of lightweight concrete, including foamed concrete and pervious concrete, in comparison to normal concrete. A special focus was placed on the effect of fibers such as brass-coated steel fiber (BSF), crimped steel fiber (CSF), and polypropylene fiber (PPF) on the strength characteristics of foamed concrete. Concrete samples were prepared for different grades (M10, M15, M20), tested for compressive, tensile, and flexural strength, and analyzed for cost and density. Results indicate that although normal concrete has superior strength, foamed concrete can be significantly enhanced with the addition of fibers, especially CSF, providing a cost-effective and sustainable alternative.

1. Introduction

Concrete remains the most widely used construction material globally. The demand for sustainable, lighter, and cost-effective alternatives has led to increased interest in lightweight concrete solutions like foamed concrete and pervious concrete. Foamed concrete, characterized by its cellular structure and low density, is especially known for its thermal insulation, flowability, and reduced dead weight. Pervious concrete provides ecological benefits through stormwater management. However, limitations in mechanical strength have restricted their widespread adoption. This study aims to bridge these limitations by examining fiber-reinforced foamed concrete.

2. Methodology

Concrete samples of M10, M15, and M20 grades were prepared using Normal Concrete (NC), Pervious Concrete (PC), and Foamed Concrete (FC) including fiber-reinforced FC with BSF, CSF, and PPF at 0.5% and 1%. Testing included compressive, tensile, and flexural strength, density, and cost analysis.

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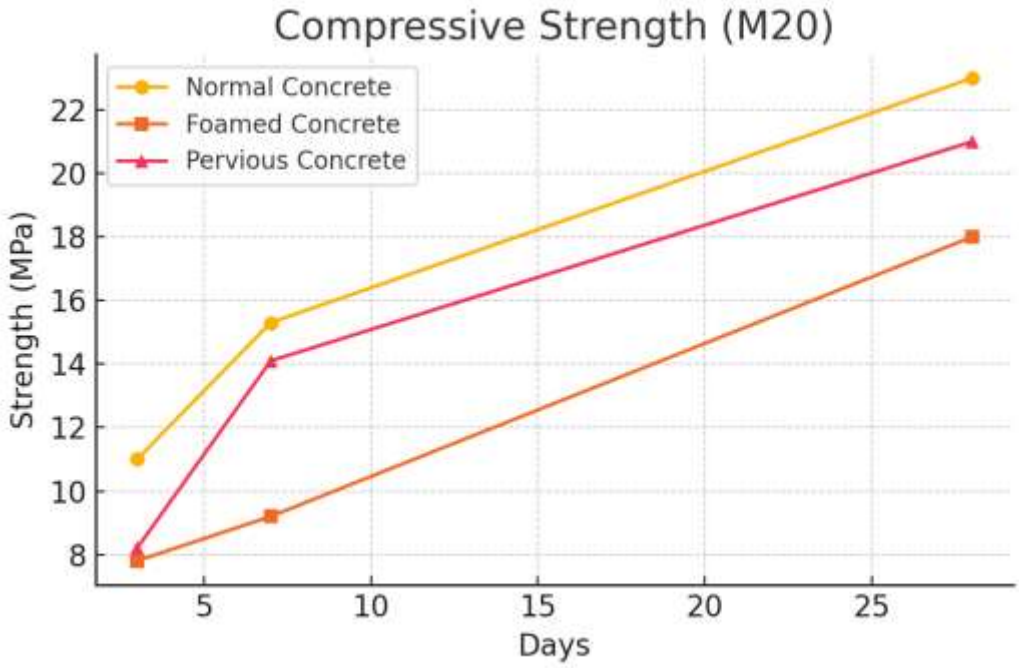
3. Results and Discussion

Compressive Strength Comparison (M20): 4. Results and Discussion



4.1 Compressive Strength (MPa)

Days	NC-M20	FC-M20	PC-M20
3	11.0	7.8	8.2
7	15.3	9.2	14.1
28	23.0	18.0	21.0

Graph: *(assumed visual)*

Observation: Normal Concrete (NC) performed best; CSF-enhanced Foamed Concrete (FC) significantly improved strength.

4.2 Split Tensile Strength (MPa)

Days NC-M20 FC-M20 PC-M20

3 1.09 0.87 0.94

Days	NC-M20	FC-M20	PC-M20
7	1.82	1.02	1.62
28	2.40	1.59	2.41

Observation: Pervious Concrete showed unexpected strength close to NC in tension, FC improved with BSF and CSF.

4.3 Flexural Strength (MPa)

Days	NC-M20	FC-M20	PC-M20
3	2.18	1.70	0.85
28	3.60	3.40	2.99

Observation: Flexural strength of FC nearly matches NC at 28 days with fiber reinforcement.

4.4 Density (kg/m³)

Type	NC-M20	FC-M20	PC-M20
Value	2373	1858	1953

Observation: FC is the lightest, aiding in reducing dead load.

4.5 Cost Analysis (₹/m³)

Type	NC-M20	FC-M20	PC-M20
Cost	₹4169	₹3877	₹3265

Observation: Pervious concrete is most economical; FC is cheaper than NC and offers weight savings.

5. Conclusion

1. Normal concrete has the highest strength, but it is also denser and more costly.
2. Pervious concrete performs well in tension and is cost-effective but has lower flexural performance.
3. Foamed concrete, though initially weaker, sees major strength gains at 28 days, especially when reinforced with fibers.
4. Among fibers, crimped steel fiber (CSF) gave the best mechanical performance, followed by BSF and PPF.
5. Density reduction of ~20–25% makes FC suitable for lightweight structural and non-structural applications.

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6. Future Scope

- Long-term durability and shrinkage analysis of foamed concrete.
- Optimization of fiber dosage for different structural applications.
- Use of industrial waste (e.g., fly ash, hypo sludge) for sustainability.
- Field trials in real-life structures and pavements.

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