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COMPARATIVE ANALYSIS OF NORMAL CONCRETE AND FIRE RESILIENT CONCRETE

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ABSTRACT:
This project, presented under the theme Building Material, focuses on two critical innovations in the field of construction the replacement of aggregates in concrete and the development of fire-resilient building materials. Both areas are pivotal in addressing the challenges of sustainability, safety, and resource efficiency in the construction industry. The study emphasizes the importance of balancing environmental impact, economic feasibility, and material performance while ensuring compliance with safety regulations. The focus area addresses the need for fire-resilient building materials. With increasing urbanization and climate-related risks, fire safety is paramount in construction. This aspect of the study explores innovative materials and technologies that enhance fire resilient while adhering to regulatory standard The project's objectives include improving occupant safety minimizing fire damage, and contributing to the development of safer infrastructure. Experimental procedures involve subjecting materials to fire tests to evaluate their resilience and performance under extreme conditions. Key challenges addressed in the study include the scarcity of natural resources, economic constraints, pollution, and fire safety risks. Through a systematic and comparative analysis, the project demonstrates the viability of alternative materials and fire-resilient technologies in modern construction practices.

KEYWORDS:

INTRODUCTION:

To solve issues related to safety, the economy, and the environment, the construction sector is always changing. Two significant innovations are covered in the presentation under analysis here:

Concrete Aggregate Replacement: Investigating environmentally friendly and high-performing substitutes for conventional aggregates.

Creation of Fire-Resilient Building Materials: Developing new fire-resistant materials and technologies to protect buildings and their occupants.

These programs are in line with worldwide building trends that favor safer, more effective, and environmentally friendly construction methods.

The shortage of natural resources, risks brought on by climate change, and rising urbanization present the construction sector with more and more difficulties. Traditional building methods that use regular concrete are currently being reexamined in favor of long-lasting, fire-resistant, and sustainable substitutes.

Even though concrete is a durable and adaptable material, it does not have the best fire resistance unless it is modified. This study focuses on creating fire-resilient concrete by incorporating additives like lime, glass, and clay, as fire incidents in urban infrastructure increase. By evaluating these alternative mixtures, the study seeks to close the gap between structural safety and environmental responsibility.
Both innovations' approaches adhere to methodical processes:
Problem Identification: Understanding the drawbacks of traditional materials, such as their lack of resources, pollution, expense, and susceptibility to fire.
Material Selection: Using materials like clay, glass, and lime in place of conventional aggregates.
Manufacturing: Making M25 grade concrete with a mix ratio of 1:1:2 while adding substitute components.
Testing: Assessing weight fluctuations, fire resistance, and compressive strength.

OBJECTIVES OF CONCRETE:
The main objectives of the study are:
1.Evaluation of Mechanical Properties:
Compare density, elasticity, tensile strength, and compressive strength.
2. Conduct at High Temperatures:
Assess cracking, spalling, heat tolerance, and structural deformations.
3. Testing for Durability:
Assess resilience to load, moisture, and heat fluctuations.
4. Financial Viability:
Examine trade-offs between costs and benefits.
5. Compliance with Safety:
Check for compliance with fire safety regulations.
6. Adequacy for Real-World Use:
Determine the relevant environments and make design recommendations.
The goal is to look into substitute materials for concrete aggregates in order to lessen the impact on the environment, cut expenses, and preserve or improve structural performance.
to create and evaluate building materials that are resistant to fire in order to increase fire safety, lessen property loss, and save lives
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Methodology:
In order to perform a thorough comparison of regular concrete with fire-resilient concrete, a methodical experimental technique was used in this work.
In order to guarantee consistency, dependability, and reproducibility of results throughout all experimental phases, the approach was created. The consecutive steps listed below were taken:

1. Selection of Materials
Two different kinds of concrete compositions were made:

Normal Concrete:
Using common ingredients like cement, sand, and gravel, M25 grade concrete was made with a mix ratio of 1:1:2 (Cement: Fine Aggregate: Coarse Aggregate).
Fire-Resilient Concrete:

Using specific fire-resistant additives including lime, glass, and clay to partially substitute traditional aggregates, the same M 25 mix ratio was kept.
These materials were picked because they are readily available locally and have demonstrated thermal resistance.

2. Casting and Mixing

Standardized techniques were used to mix the two types of concrete in order to obtain consistent workability and consistency:

1. A complete dry mixing was done with cement, fine and coarse aggregates, and any relevant fire-resistant additives.
2. To create a workable mixture, water was added gradually.
3. Standardized molds with predetermined measurements were filled with freshly mixed concrete:

Cubes measuring 150 mm by 150 mm by 150 mm are used to measure compressive strength.
Slabs or cylinders for deformation study and fire resistance assessment.
To guarantee homogeneity and remove air voids, every specimen was compressed.

3. Curing Process

In order to fully hydrate and acquire the required compressive strength, the cast specimens were cured in water for 28 days under controlled conditions.

4. Methods of Testing

The following tests were carried out when the curing period was over:
Compressive Strength Test: To ascertain the specimens' ability to support loads, a Universal Testing Machine (UTM) was used. Compressive strength was computed and the highest load at failure was noted.
Test for Fire Resistance: In a controlled furnace environment, specimens were heated to high temperatures.
Both during and after fire exposure, visual observations and structural evaluations were carried out to measure alterations like: surface fissures, Spalling, Color change, Deformations of structures
Weight and Deformation Analysis: To measure weight loss, specimens were weighed both before and after being exposed to fire.
To find any expansion, shrinkage, or deformation brought on by temperature impacts, dimensional measurements were made.

5. Data Collection and Analysis

Compressive strength, weight fluctuations, and physical observations were all carefully documented in the experimental data. The purpose of the statistical analysis was to:
Examine the differences in performance indicators between regular and fire-resistant concrete.
Examine averages, trends, and variances.
Consider the trade-offs between thermal performance and mechanical strength.

Conclusive recommendations regarding the applicability of fire-resilient concrete for different construction applications resulted from the findings' methodical organization for comparative interpretation

Problem Statement:
The research tackles a number of industry issues, including Natural aggregate availability is declining.
1. Rising prices for materials.
2. Pollution of the environment is growing.
3. Standard materials don't have enough fire resistance.
4. Eco-friendly and financially feasible substitutes are required.

Concrete Description:
Usually made out of cement, water, and aggregates, concrete is a fundamental component of building. With a 1:1:2 cement, fine aggregate, coarse aggregate ratio, the M25 grade concrete used here has a 28-day target compressive strength of 25 MPa.

Manufacturing and Innovation:
The core innovation in this study involved the integration of lime, glass, and clay as partial or full replacements for conventional coarse and fine aggregates in M25 grade concrete. These alternative materials were selected for their proven fire-resistant properties and potential to enhance the thermal performance of concrete without compromising essential mechanical strength.
Innovation in Materials
Lime: renowned for its capacity to increase fire resistance by creating a protective layer in the presence o f high temperatures and for its thermal insulation qualities.
Glass: In addition to providing heat resistance and lowering environmental waste, crushed discarded glas s promotes sustainability. In the event of a fire.
Clay: inhibits spalling and offers heat insulation.
The goal of the study was to create fire-resilient concrete that could be used in industrial facilities, fire-prone locations, and infrastructure that needed higher safety standards by incorporating these components into regular concrete mixtures.
Production Method
Both regular and fire-resistant concrete were made using a methodical, multi-step procedure:

Proportioning and Material Preparation:
Cement, sand, gravel, lime, crushed glass, clay, and other raw materials were acquired, cleaned, and gr aded.
The M25 grade mix ratio (1:1:2) was maintained by carefully calculating the proportions while incorpo rating fire-resistant additives to either completely or partially replace the traditional aggregates.
Mixing with cement and water:
To guarantee that the cement, aggregates, and additives were distributed uniformly, dry mixing was do ne.
Until a uniform and workable concrete mix was obtained, water was added gradually while wet mixing was done.
Forming Standard Specimens via Moulding:
For several testing, freshly mixed concrete was put into conventional molds:
Cubes for evaluating compressive strength. Cylinders or slabs for assessing fire resistance.
To ensure equal density and remove air pockets, the concrete was crushed in molds.

De-Molding Following the First Setting:

Once the specimens had reached initial setting, usually within 24 hours, they were carefully de-molded.
Curing in a Controlled Environment:
To ensure optimum hydration and strength development, demolded specimens were cured for 28 days while immersed in clean water tanks.

Evaluation of Performance:

Specimens underwent extensive performance testing after curing, which included:
A Universal Testing Machine (UTM) is used to assess compressive strength.
tests for fire resistance by exposing specimens to regulated high temperatures.
To assess thermal behavior, weight and deformation measurements are performed both before and after fire exposure.

Figure 1- Materials used (Lime, Glass and Clay)

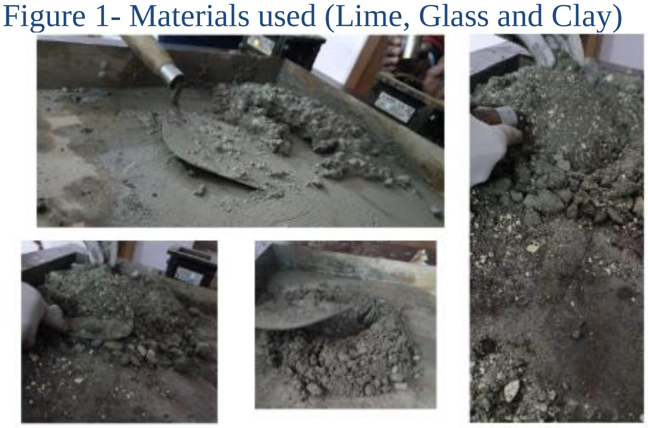

Figure 2 Mixing of concrete materials

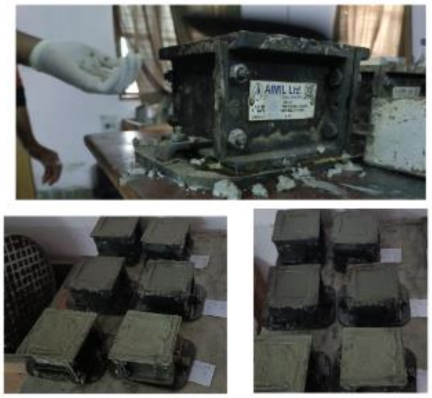

Figure 3 Moulding of Concrete

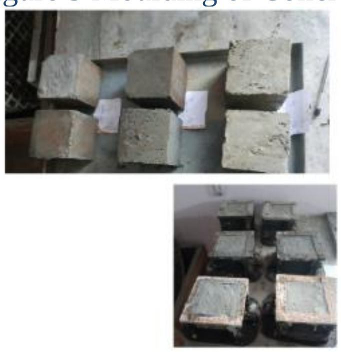

Figure 4 De-Moulding of concrete

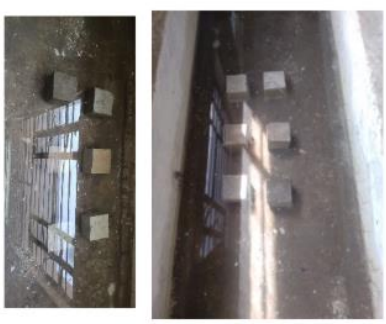

Figure5 Curing of Concrete

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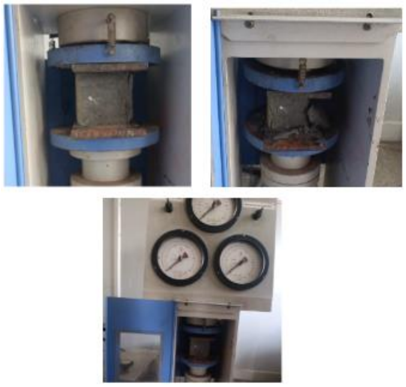

Figure 6 Compression Test

Figure 7 Weight Test

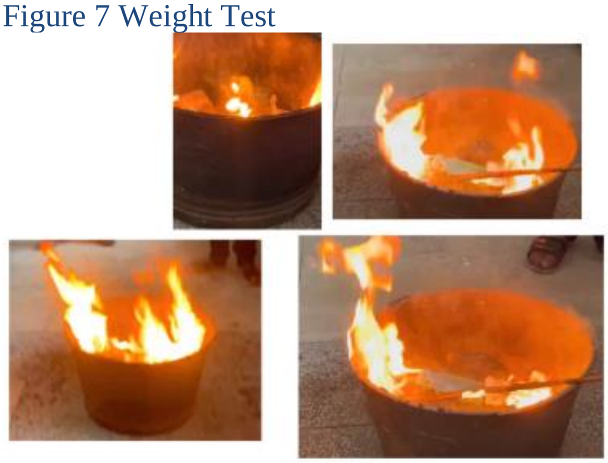

Figure8 Fire Test

Results and Conclusion:

Findings

The following significant results were predicted based on the methodical experimental protocols and fir st analyses:

Performance of Fire-Resilient Concrete Increased Resistance to Fire:

In comparison to regular concrete, the fire-resilient concrete specimens showed less surface spalling, fewer cracks, and less structural deformation , indicating improved resistance to high temperatures.

Acceptable Structural Performance:
Although fire-resilient concrete showed a minor decrease in compressive strength when compared to regular concrete, the results were still within allowable bounds for construction applications, particularly in buildings where fire safety is a top concern.UTM stands for Universal Testing Machine.
tests for fire resistance by exposing specimens to regulated high temperatures.
To assess thermal behavior, weight and deformation measurements are performed both before and after fire exposure.

Comparative Analysis Outcomes
Sturdiness and PowerData:
Before and after being exposed to fire, extensive data was gathered on physical appearance, weight loss, and compressive strength. Under high temperatures, fire-resilient concrete performed consistently, confirming the structural stability of the material.

Thermal Resistance Findings:
In comparison to traditional mixes, specimens comprising lime, glass, and clay demonstrated superior mechanical integrity and preservation of physical form under heat stress.

Material Validation:
The results of the experiment demonstrated that clay, glass, and lime are effective fire-resilient additives, hence facilitating their application in real-world construction situations where fire safety is crucial.

Economic and Resource Feasibility:
The study also emphasized the availability and economic feasibility of these substitute materials, which may help lessen environmental impact by recycling natural materials like clay and lime and industrial waste like glass.

S.No.	Parameters	Normal Concrete	Glass Concrete	Clay Concrete	Lime Concrete
1	Strength	25 N/mm²	28 N/mm²	30 N/mm²	32 N/mm²
2	Fire Resilience (Temperature) [in °C]	1,000 °C	800 °C	1,800 °C	1,600 °C
3	Cost	₹3,800–₹4,700 per cubic meter	₹2,000–₹2,500 per cubic meter	₹1,800-2,400 per cubic meter	₹2,500 –₹3,100 per cubic meter
4	Weight	300 kg/m³	250 kg/m³	150 kg/m³	180 kg/m³

Table 1- Results with Comparative Parameters