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Investigation of Compressive Strength For the Concrete Exposed To Fire

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Abstract: Concrete is one of the most extensively used construction material all over the world. Many scientists and researchers are in quest for developing alternate construction material that are environment friendly and contribute towards sustainable development. Huge amount of fly ash is generating day by day which creates the disposal problem and has many environmental issues

Also, building are accidently subjected to fire hazards,during fire the temperature of concrete may go high. Elevated temperature have the potential to induce the formation of cracks in concrete .Similar to cracks in any other material , these cracks can propagate and , over time , result in the compromise of structural integrity , leading to a shortened service life.

In this investigation,The effect of open fire on mechanical strength of fly ash added concrete is studied. The fly ash added concrete is prepared by replacing the cement in concrete by 10% of the cement. The concrete cube specimens of standard size are casted and tested after 28 days of curing. Each concrete cube specimen of normal and fly ash added concrete is exposed to open fire at elevated temperature of (100°C , 200°C, 300°C, 400°C, 500°C, 600°C, 700°C). After temperature regimes the compressive strength is determined for each specimen.

1.0 INTRODUCTION

Concrete is one of the most widely used construction materials in civil engineering due to its high compressive strength, durability, and fire resistance. During a fire incident, concrete structures are exposed to very high temperatures which can significantly affect their physical and mechanical properties. When concrete is subjected to elevated temperatures, several changes occur such as loss of strength, cracking, spalling, and noticeable changes in colour.

The colour change in concrete after exposure to fire can act as an important visual indicator of the temperature level experienced by the structure. Different temperature ranges cause different colour variations in concrete due to chemical and mineralogical changes in cement paste and aggregates. For example, concrete may change from its normal grey colour to pink, reddish, or whitish shades when exposed to increasing temperatures. These colour codes can help engineers estimate the severity of fire damage without immediately performing complex laboratory tests.

An experimental investigation on colour codes of concrete after fire exposure is therefore important to understand the relationship between temperaturee and colour change. In this study ,concrete specimens are exposed to different temperature levels under controlled conditions and the corresponding colour variations are observed and recorded. The results help in identifying temperature ranges based on visible colour changes and in assessing the residual strength of fire-damaged concrete structures.

2.0 LITERATURE SURVEY

1.Daniela Ruta ;(2019) In the present work the dynamic behaviour of thermally exposed concrete and reinforced concrete structures has been numerically and experimentally tested in order to investigate the influence of different levels of fire exposure on concrete response at high loading rates. 2. Sheng 2.Du a, Yuchun Zhang a, Qiang Sun b, Weiyi Gong a, Jishi Geng b, (2015) In this paper, an experimental study on the physical and chemical properties of concrete exposed to a fuel fire has been carried out. In particular, the effects of fire on neutralization and the compressive strength of concrete have been analyzed in detail. Based on the present results, the following conclusions can be reached 3.Ruchita Bawankar ,V.D. Vaidya , Valsson Varghese,(2005) Based on the limited experimental work carried out in this particular study, The Following conclusions may be drawn out. After elevated temperatures test and analysis it was found that with the increasing temperature the compressive strength, tensile strength and flexural strength of concrete gets reduced. 4. Lateef

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O. Onundi , M. Ben Oumarou, Abba M. Alkali (20066) . The fact that structures are still standing because they have not burnt to ashes is not to say that they are structurally stable and safe (MS) 14 5. Nada M. Fawzi ,Mahdi S. Essa , Mohammed M. Kadhum (2012) For the studied temperature range in this study, the compressive strength-reduction curve, recommended by the Euro codes CEN (1993, 1994) is in better agreement with the test results rather than CEB (1991) strength-reduction curve 6. J Anita Jessie1∗, K K Gaayathri1, R Sivaji2 , N Lavanya (2018) Colour change at 100 ◦C, 300 ◦C, 500 ◦C and 700 ◦C was noted to be no colour change, red, grey and whitish-grey The RSM model has been created for the weight of the specimen before temperature exposure and after temperature exposure The limitation of the prediction model is the steel fibre variable content between 0% to 1.5%, temperature can be between 28 ◦C and 700 ◦C and the concrete mix design is M 25. 7. Ravi ranade Anthony tessari (2013) This paper summarized the design, preparation, execution, and results of five fire experiments of loaded and restrained reinforced concrete slabs. Each slab was 2440 mm × 1830 mm x 300 mm. The thickness and reinforcement ratio of the slabs were selected following the design of modern tunnel concrete linings. The slabs were heated at the soffit (one sided heating) using a furnace with a fire chamber of 1530 mm × 1530 mm x 1530 mm. Three of the slabs included polypropylene fibers, and one slab 8. N.R Short , J.A Purkiss, S.E Guise (2014) Colour image analysis can be used to quantify the colour of fire damaged concrete and this method is superior to the subjective visual assessment currently used.

3.0 EFFECT OF FIRE ON STRENGTH OF CONCRETE

The findings suggest that heightened temperatures during the initial phases adversely impact the subsequent strength development of concrete. Many scholars have investigated the negative impacts of elevated temperatures on the enduring strength of concrete. The accelerated hydration rate caused by higher temperatures hinders the subsequent hydration process, leading to an uneven distribution of hydration products. This unevenness stems from the limited time available for the diffusion of hydration products away from the cement particle at a high initial hydration rate, impeding uniform precipitation in the interstitial space. As a result, this displacement of hydration products from the cement particles promotes consistent precipitation in the interstitial space. As a result, there is a buildup of the products in close proximity to the hydrating particles, leading to a subsequent postponement in hydration and impacting the development of strength.

3.1 Experimental Work

Properties of all the material use in concrete is determine and some specifications are mention below

- Cube specimens with dimensions 150*150*150 mm.
- Concrete Grade: M25
- Cement: OPC grade 53.
- Fly ash
- The fly ash required for experimental work is obtained locally
- Coarse aggregate: Crushed basalt stones
- Fine aggregate: Sand obtained locally
- Water: 175 Liters (Water-to-Cement ratio = 0.50)
- Curing period: 28 days

Calculation of Compressive Strength:

- **Formula**: The compressive strength is calculated using the formula:

$$\sigma c = \frac{P}{A}$$

Where:

σc= Compressive strength of concrete (MPa or N/mm²)
P = Maximum load applied at failure (in Newtons, N)
A = Cross-sectional area of the specimen (in mm² or cm²)
Following are the concrete cubes specimens of standard size 150x150x150 mm casted to determine compressive strength

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Table 01: Number of concrete cube specimens

Sr No	Temperature	Normal Concrete	
		Designation	No of specimens
1	40ºC	CNC	3
2	100ºC	CNC-100	3
3	200ºC	CNC-200	3
4	300ºC	CNC-300	3
5	400ºC	CNC-400	3
6	500ºC	CNC-500	3
7	600ºC	CNC-600	3
8	700ºC	CNC-700	3
Total Concrete Cube Specimens			**24**

4. SPECIMENS EXPOSED TO OPEN FIRE

Each reinforced concrete cube sample will be subjected to exposure in an open fire at temperatures ranging from 100 degrees Celsius to 700 degrees Celsius in increments of 100 degrees Celsius.

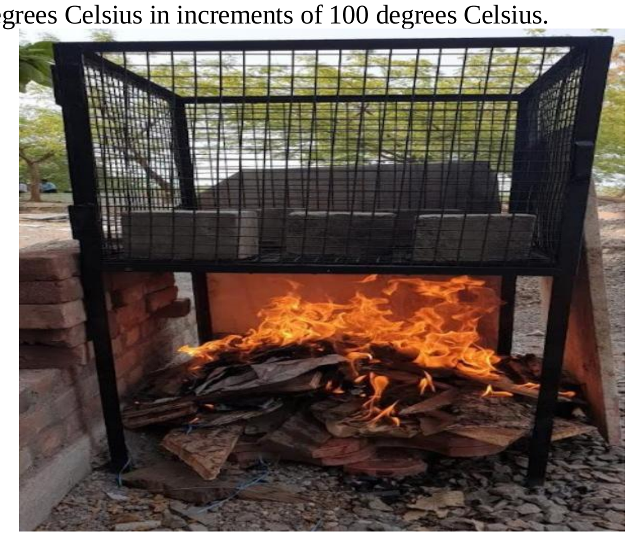

Figure 01: Fire testing of Concrete Cube Specimen

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Figure 02: Experimental Test Setup

4.1 Observations and Test Setup

The compressive strength test on concrete is one of the most important tests used to determine the load-bearing capacity of concrete. It helps assess the quality of concrete, ensuring that it meets the required specifications for structural performance. The compressive strength is measured by testing standard concrete cube or cylinder specimens under a compressive load.

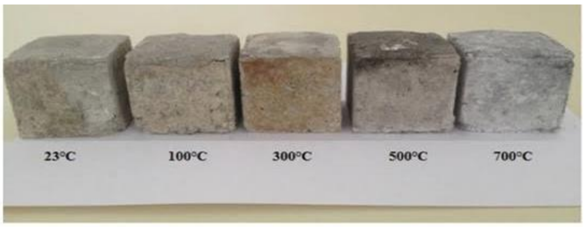

Figure 03: Colour variation

5.0 RESULTS AND DISCUSSION

The effect of fire on compressive strength of normal concrete and fly ash added concrete is tabulated as below

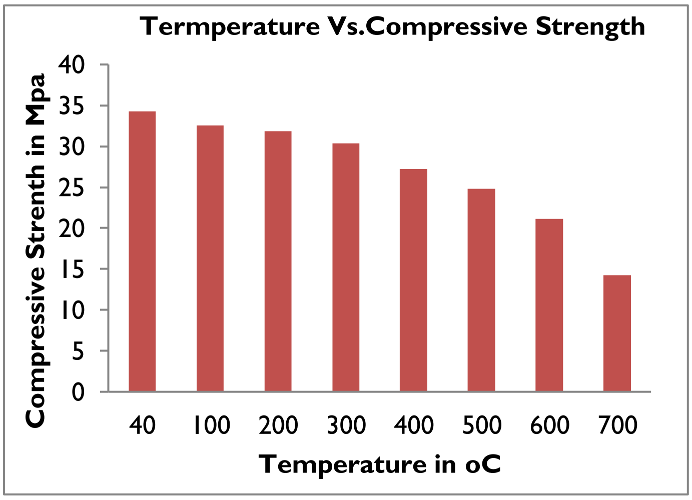

Figure 05: Graph Showing Comparative Results of Compressive Strength

Table 02: Comparative results of Compressive strength

Temp. in °C	Load in N	Compressive Strength in N/MM^2
NC	771075	34.27
100	733050	32.58
200	716625	31.85
300	682425	30.33
400	612450	27.22
500	558000	24.8
600	474750	21.1
700	321075	14.27

From the table 02 values and graphical representation shown in figure 04 it is observed that initially at 100°C for normal concrete the strength is reduced by 3.02%. It is observed that the strength get reduced as the fire exposure gets increased. For 300 °C the strength is reduced by 13.89% and upto 67.35% for 700°C. normal concrete the strength reduction is less upto 20% replacement. The optimum results are obtained upto 400°C.

6.0 CONCLUSIONS

- The present work will provide useful data base for structural designers to design a safe building even if it is exposed to fire.
- The maintenance engineer will be able to take suitable decisions based upon this data to keep a building safe, once it is exposed to fire conditions.
- The study concludes that colour codes of fire-exposed concrete provide a simple, economical, and effective method for preliminary post-fire structural assessment, though laboratory strength testing remains necessary for final structural decisions.

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