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INVESTIGATION OF PERMEABILITY ON FLYSASH BASED CONCERETE

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Abstract:

This study investigates the effect of open fire on mechanical properties of fly ash based concrete. Permeability and compressive strength are the two important properties investigated. The fly ash is employed as a substitute for cement in the composition of concrete. Replacement of cement is done up to 10 %. The concrete cubes of standard size 150mmx150mmx150xx are casted and tested after 28 days of curing. The concrete cubes specimens of fly ash based concrete are exposed to open fire at elevated temperature of (100^o C, 200^o C, 300^o C, 400^o C, 500^o C, 600^o C, and 700^o C). After temperature regimes the permeability and compressive strength of concrete incorporating fly ash is assessed, It is observed that compressive strength for normal and fly ash based concrete are reduced as the temperature rise in open fire increases. Up to 400 the reduction in strength is optimum and beyond it major loss in strength is observed. On the other hand coefficient of permeability values for normal and normal and fly ash based concrete increases due to rise in temperature of open fire permeability.

Keywords: Concrete, Fly ash, open fire, permeability.

Introduction

Concretes containing mineral admixtures are used extensively throughout the world for their good performance and for ecological and economic reason. Pozzolanic concretes are used wide throughout the world and the applications of such concretes are increasing day by day attributable to their superior structural performance, environmental friendliness, and energy conserving implications. For the most part cement is associated as a brilliant insulating material, yet there is serious harm or maybe sudden failure at high temperatures. At high temperatures, chemical change of the gel happens bringing on shortcoming in the matrix bonding, resulting in reduction in strength of fly ash concrete. The effect of high temperature on concrete containing ash or natural pozzolans has not been investigated very well. There are changes in the properties of concretes, particularly in temp. ranging from 100– 300°C. Above 300°C, there is decrease in mechanical characteristics. However, there is a decrease in strength attributable to the range of heat condition tested, and the type of constituent materials of concrete used. The behavior of concrete subjected to high temperatures is a results of many factors; like heating rate, peak temperatures, dehydration of C–S–H gel, phase transformations, and thermal incompatibility between aggregates and cement paste.

1. EFFECTS OF HIGH TEMPERATURE

Under typical circumstances, the majority of concrete structures experience temperature variations within the range dictated by ambient environmental conditions. However, there are crucial instances where these structures might face considerably higher temperatures, such as during building fires, chemical and metallurgical industrial processes where concrete is in close proximity to furnaces, and certain nuclear power-related accident scenarios. Concrete's thermal characteristics are more intricate compared to most materials. This complexity arises not only from concrete being a composite material with diverse constituent properties but also from its properties being influenced by moisture and porosity. Elevated temperature exposure impacts the mechanical and physical properties of concrete.

2. EFFECTS 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. EXPERIMENTAL WORK

Physical 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 : Ordinary Portland Cement .

Fly Ash: obtain from deepnagar thermal power station

Coarse aggregate: Crushed basalt stones
Fine aggregate: Sand obtained locally
Water: 175 Liters (Water-to-Cement ratio = 0.50)
Curing period: 28 days

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Mix proportion: The mix proportion for M25 grade of concrete carried out by using IS 10262:2019 are as follows

Description	Cement	Fine Aggregates	Coarse Aggregates	Water
Mix Proportion(by weight)	1	1.09	3.34	W/c=0.54
Quantities of Material (Kg/M3)	354.78	740.94	1182.65	191.58

3.1 Casting of Specimens

Concrete cubes with dimensions of 150 x 150 x 150 mm were casted with each beam cast in three layers. The entire construction utilized M25 grade concrete. The specimens were casted by replacing the fly ash with cement the percentage replacement of fly ash is 10% kept constant for all specimens. The properties of fresh concrete are studied during casting work. All cubes specimens are tested after 28days of curing.

3.2 Specimens Exposed To open Fire:

Each concrete cubes specimens 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 1.Concrete Specimens exposed to open fire

The apparatus thermocouple is used to determine the temperature of open fire. The thermocouple is connected to digital meter which shows the temperature readings.

Figure 2: Fire Temperature Reading

3.3 Observations & Test Setup

The system completely filled with water, the desired test pressure shall be applied to the water reservoir and the initial reading of the gauge-glass recorded. At the same time a clean collection bottle shall be weighed and placed in position to collect the water percolating through the specimen. The quantity of percolate and the gauge-glass readings shall be recorded at periodic intervals. In the beginning, the rate of water intake is larger than the rate of outflow. As the steady state of flow is approached, the two rates tend to become equal and the outflow reaches a maximum and stabilizes. With further passage of time, both the inflow and outflow generally register a gradual drop. Permeability test shall be continued for about 100 hours after the steady state of flow has been reached and the outflow shall be considered as average of all the outflows measured during this period of 100 hours. The steady state of flow is defined as the stage at which the outflow and inflow of water become equal for the first time. The temperature corrections are also made as per the recommendations given in IS 3085:1965

3.4 Permeability Measurement:

The coefficient of permeability shall be calculated as follows

$$= \frac{Q}{.\ .(-)}$$

where ,

K = coefficient of permeability in cm/sec

Q = quantity of water in millilitres percolating over the entire period of test after the steady state has been reached

A = area of the specimen face in cm

T = time in seconds over which Q is measured

H/L = ratio of the pressure head to thickness of specimen, bothL expressed in the same units.

3.5 Pressure Head

The standard test pressure head to be applied to the water in the reservoir should be 10 kg/cm”. This may, however, be reduced up to 5 kg/cm^2 in the case of relatively more permeable specimens where steady state of flow is obtained in a reasonable time, and may be increased up to 15 kg/cm” for relatively less permeable .

Figure 3 Permeability Test apparatus

4. Results & Discussion

The tabulated data presents the compressive strength of both the fly ash-based concrete specimens and the controlled beam specimens before and after heating.

Table 2 : Results for Compressive strength

Sr.no	Designation	Temperature (°c)	Average Load (N)	Avg. Compressive strength (N/mm^2)	Loss of compressive strength %
1	NC	-	776250	34.5	0
2	NC - 100	100°c	763972.6	33.95	1.58
3	NC -200	200°c	776250	34.50	6.12
4	NC-300	300°c	697040.8	30.98	10.20
5	NC-400	400°c	649515.3	28.87	16.33
6	NC-500	500°c	601989.8	26.76	22.45
7	NC-600	600°c	514859.7	22.88	33.67
8	NC-700	700°c	467334.2	20.77	39.80
9	FC	-	744525	33.09	0
10	FC-100	100°c	760409	33.80	2.13
11	FC-200	200°c	701928.2	31.20	9.57
12	FC-300	300°c	660638.3	29.36	14.89
13	FC-400	400°c	619348.4	27.53	20.21
14	FC-500	500°c	503736.7	22.39	35.11
15	FC-600	600°c	454188.8	20.19	41.49
16	FC-700	700°c	371609	16.52	52.13

4.1 Compressive Strength

For normal concrete cube compressive strength is 34.5 N/mm^2 it is observed that there is optimum reduction in strength is up to 400^{0}c. When the specimens are exposed to fire above 400^{0}c there is major loss in strength is observed at 700^{0}c and the loss is about 39.80%. Similarly for fly ash based concrete Compressive strength is 33.09 N/mm^2 It is noted that the optimal reduction in strength occurs up to a temperature of 400 degrees Celsius. When the specimens are exposed to fire above 400^0 c there is major loss in strength is observed at 700^{0}c and the loss is about 52.13%.

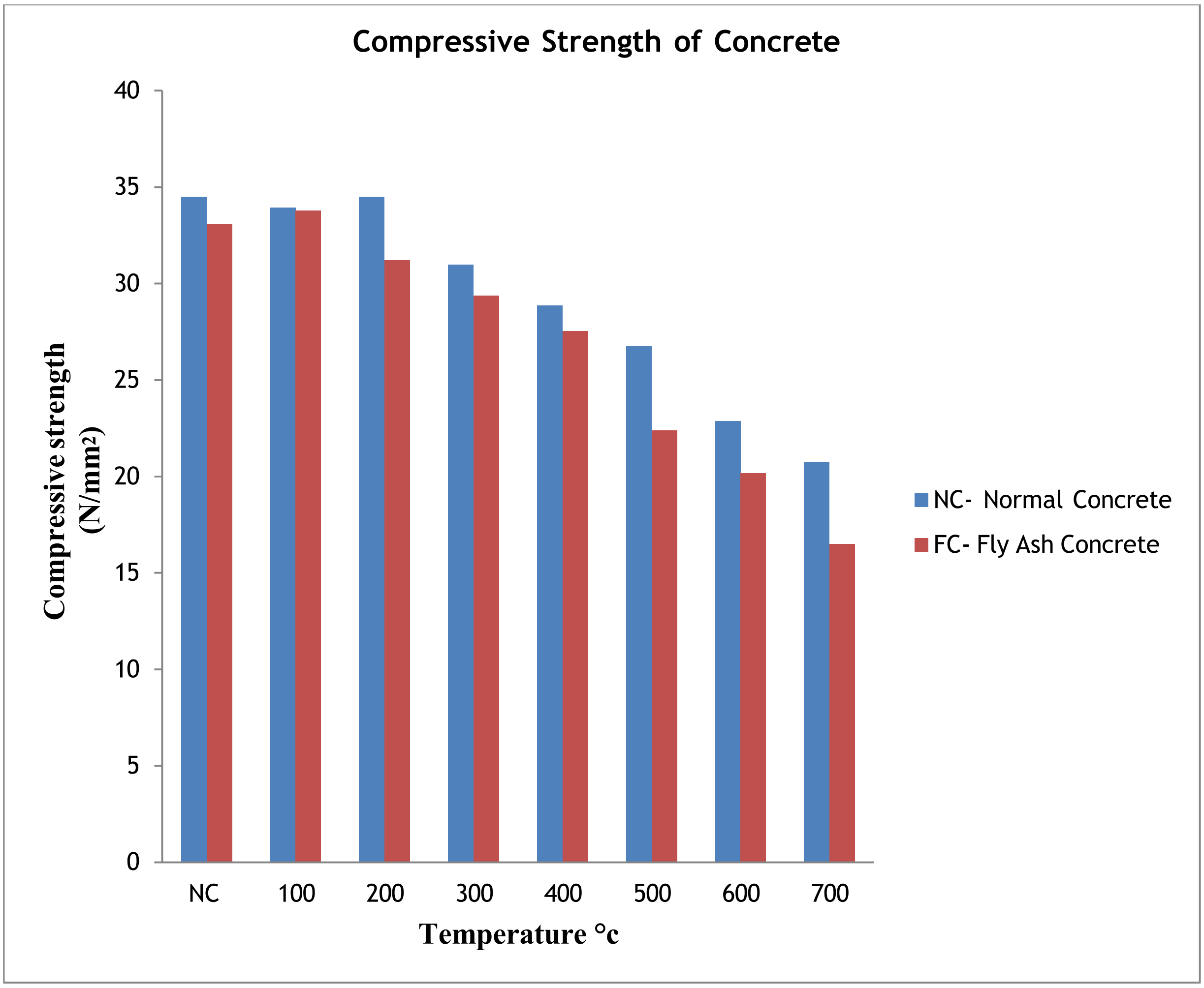

Figure 4 Graph comparison of Compressive strength

Table 3 Results for Permeability

Sr.no	Designation	Temperature (°c)	Average Discharge (Q) in ml	coefficient of permeability (K) in x 10^{-10}Cm/Sec
1	NC	-	11	1.358
2	NC - 100	100°c	16	1.975
3	NC -200	200°c	23	2.839
4	NC-300	300°c	41	5.061
5	NC-400	400°c	67	8.271
6	NC-500	500°c	84	10.37
7	NC-600	600°c	140	17.283
8	NC-700	700°c	235	29.012
9	FC	-	13	1.604

10	FC-100	100°c	19	2.345
11	FC-200	200°c	29	3.582
12	FC-300	300°c	53	6.543
13	FC-400	400°c	75	9.259
14	FC-500	500°c	90	11.111
15	FC-600	600°c	160	19.753
16	FC-700	700°c	290	35.581

4.2 Permeability of concrete

The coefficient of permeability for normal and fly ash based concrete is determined according to IS 3085-1965. The discharge is measured during the 100 hours test after the flow becomes steady. It is observed that initially up to 400 °C; the permeability of concrete increases gradually but beyond the 400 °C; there is huge increase in the values of permeability up to 700 °C;. It is observed that as the temperature increases the coefficient of permeability values increases for both types concrete.

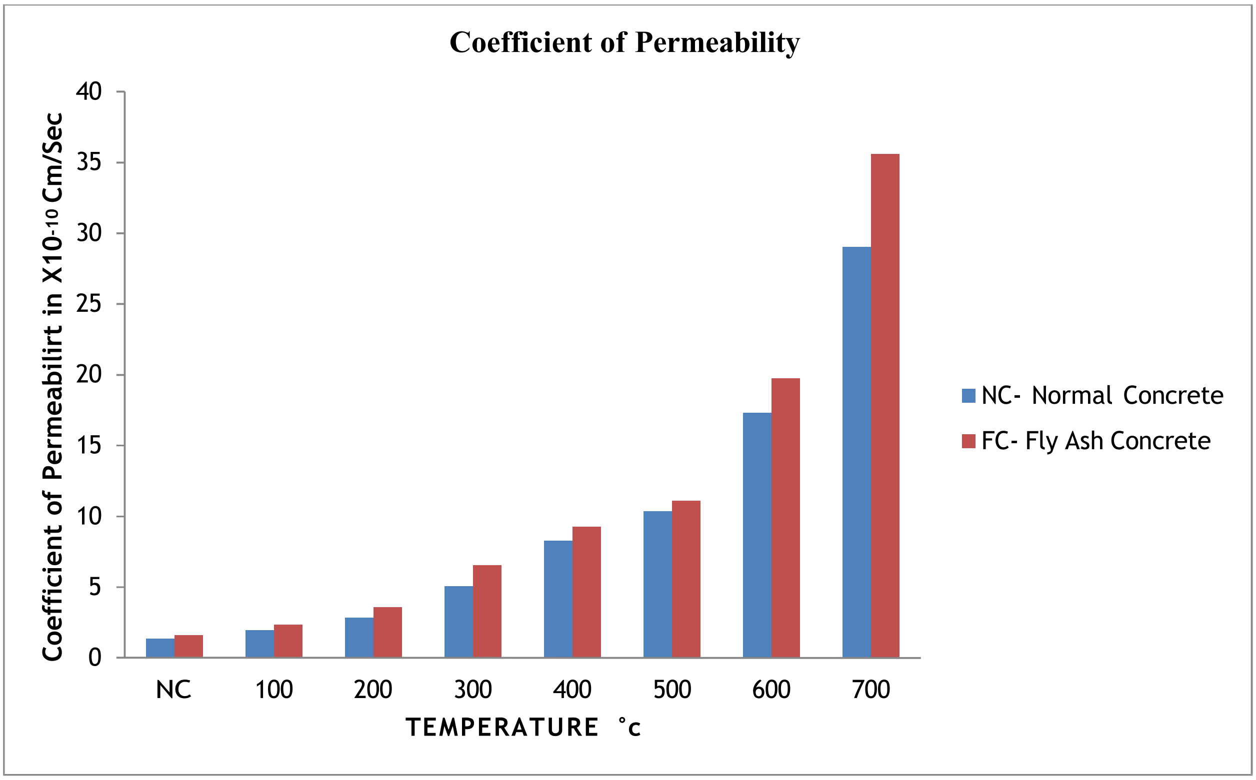

Figure 5 Graph comparison of coefficient of permeability (K)

5. Conclusion

Drawing conclusions from the outcomes of this experimental study, the following observations can be made: Elevated temperatures represent a significant physical degradation process that impacts the durability of concrete structures and may lead to undesirable structural failures. The exposure to high temperatures brings about substantial alterations in the physical structure of concrete cubes specimens..

In general, it can be concluded that the majority of fire-affected RCC structures can undergo repairs. However, when subjected to elevated temperatures exceeding 400°C, reinforced concrete beams experience a notable decrease in flexural strength.

The compressive strength of concrete remained unaffected up to a temperature of 400 °C; however, beyond this threshold, it experienced substantial deterioration. This deterioration significantly impacted the yielding strength of the steel, Additionally, there was a significant increase in permeability of the normal and fly ash based concrete beyond 400 °C.

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