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Behaviour of Concrete Subjected To High Temperature

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Abstract- With the mode toward urbanization, rate of construction and hazards related to it has increased to high extend. One such major source is Fire accidents. Structure can undergo fire accident, but because of this the structure cannot be denied neither abandoned. To make a structure functionally viable after the damage due to fire has become a challenge for the civil engineering community. The problem is where to start and how to proceed. The root for such problem lies in the strength parametric study of component material that are use in construction industry. One such major item is concrete, which have very distinct chemical and physical properties because of its elemental components.

The study done in this paper is basically for normal M20 grade of concrete subjected to various temperature and thus the changes in properties are marked and highlighted. This paper aims to show the behavior of concrete at various temperature and changes in its compressive strength and physical properties. Results show markable behavior of concrete which make it further more topic of interest. The study reveals that concrete has very distinct bonding properties that change with change in exposure conditions.

Index Terms- Mean compressive strength, parametric study.

I. INTRODUCTION

The study of 16 industrialized nations (13 in Europe plus the USA, Canada and Japan) found that, in a typical year, the number of people killed by fires was 1 to 2 per 100,000 inhabitants and the total cost of fire damage amounted to 0.2% to 0.3% of GNP. In the USA specifically, statistics collected by the National Fire Protection Association (USA) for the year 2000 showed that more than 4,000 deaths, over 100,000 injuries and more than $10bn of property damage were caused by fire. The loss of business resulting from fires in commercial and office buildings runs into millions of pounds each year. The extent of such damage depends on a number of factors such as building material, design and use, structural performance, fire extinguishing devices and evacuation procedures. One such material which has major sharing is concrete. Concrete can be defined as a composite binding material having constituents as aggregate, finer sand and fine cement and water in predefined proportion so as to achieve required strength .Concrete is a composite having properties that change with time. Durability of concrete depends on many factors including its physical and chemical properties, the service environment and design life.

II. BASIC PROPERTIES OF CONCRETE

A. Basic Properties Of Normal Concrete

The composite material with ingredients like aggregate ,sand ,cement and water achieving compressive strength of 10 MPa to 40 MPa after 7 days and achieve 80 % of its strength after or about 28 days with initial setting time of 30 minutes subjected to exposed condition is termed as Normal concrete.

B. What Happens To Concrete In A Fire ?

Fires are caused by accident, energy sources or natural means, but the majority of fires in buildings are caused by human error. Once a fire starts and the contents and/or materials in a building are burning, then the fire spreads via radiation, convection or conduction with flames reaching temperatures of between 300°C and 1200°C. Harm is caused by a combination of the effects of smoke and gases, which are emitted from burning materials, and the effects of flames and high air temperatures.

Concrete does not burn – it cannot be ‘set on fire’ like other materials in a building and it does not emit any toxic fumes when affected by fire. It will also not produce smoke or drip molten particles, unlike some plastics and metals, so it does not add to the fire load. For these reasons concrete is said to have a high degree of fire resistance and, in the majority of applications, concrete can be described as virtually ‘fireproof’.

The rate of increase of temperature through the cross section of a concrete element is relatively slow and so internal zones do not reach the same high temperatures as a surface exposed to flames. Even after a prolonged period, the internal temperature of concrete remains relatively low; this enables it to retain structural capacity and fire shielding properties as a separating element.

The surface appearance of structural members give an idea on the extent of heat to which these members might have been subjected to during the fire. The structural conditions as observed give a great deal of information on its physical condition and help to assess the physical damage suffered by the members.

III. EXPERIMENTAL WORK DONE

A. Sample/ Specimen Preparation

The M20 grade concrete as per IS 10262-2009 were prepared.

Type of Cement = OPC 53 grade confirming to IS-12269-1987

Maximum Nominal Aggregate Size = 20 mm

Minimum Cement Content = 250 kg/m^3

Maximum Water Cement Ratio = 0.5%

Workability (MORT&H 1700-4) = 25 mm (Slump)
Exposure Condition = Normal
Degree of Supervision = Good
Type of Aggregate = Crushed Angular Aggregate
Maximum Cement Content (MORT&H Cl. 1703.2) = 540 kg/m^3

B. The procedure of making the test cubes is as follows -

The clean cube mold of standard dimension 50 mm is used. After fixing and application of proprietary mold oil on internal faces of mold the sample concrete is poured say about 45-50 mm thick and then tempered. same procedure is followed till the cube if filled up to top , Further the surplus concrete is removed and with marking number it is kept to achieve initial setting time. The cubes were placed in water tank for curing up to 28 days.

C. Thermo-Effect Methodology and Process

Pit Type tempering furnace

The electric furnace is used to heat the specimens. The maximum temperature attained in this furnace is 1000°C. The inner depth of the furnace is 2.5m.

1) Initially 3no. of cubes were kept in the furnace.
2) Furnace closed tightly so that no air enters inside.
3) Furnace was set at required temperature i.e. 150˚C and duration was 1 hour.
4) 35 minutes were required to reach the desired temperature.
5) After one hour the specimen were removed from furnace.
6) Specimen was allowed to come up to room temperature i.e. 34˚C.
7) Again other 3 specimen were kept in the furnace.
8) Furnace closed tightly so that no air enters inside.
9) Furnace was set at required temperature i.e. 300˚C and duration was 1 hour.
10) 45 minutes were required to reach the desired temperature.
11) After one hour the specimen were removed from furnace.
12) Specimen was allowed to come up to room temperature.
13) Same procedure was repeated for other temperatures i.e. 450˚C and 600˚C.

D. Post-parametric Test

Formula for calculation of compressive strength –

Compressive Strength = P/A

Where, P = Ultimate compressive load of concrete (KN)

A = Surface area in contact with the platens (mm^2) (150 mm × 150 mm)

IV. Observations and Calculations

Table 1: Observation tabulated.

Temp	Weight Loss	Color change	Cracks	Remark
150°C	650 gm	Light green	Absent	No white spots marked
300°C	655 gm	Yellowish Brown	Absent	Bonding moderate
450°C	800 gm	Faint Brown	Hair Cracks	Bonding moderate and no white spots marked
600°C	900 gm	Dark Brown	Present	Weak bonding and white spots marked

Various relationship observed are Plotted as below-

Compressive Strength -

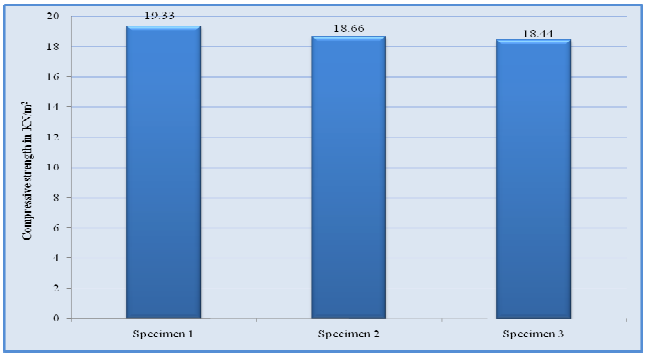

Figure no.1: At 34˚C mean value 18.81KN/m².

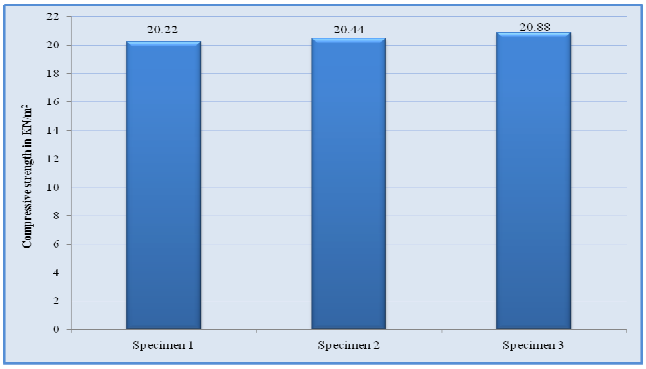

Figure no.2: At 150˚C mean value 20.51 KN/m².

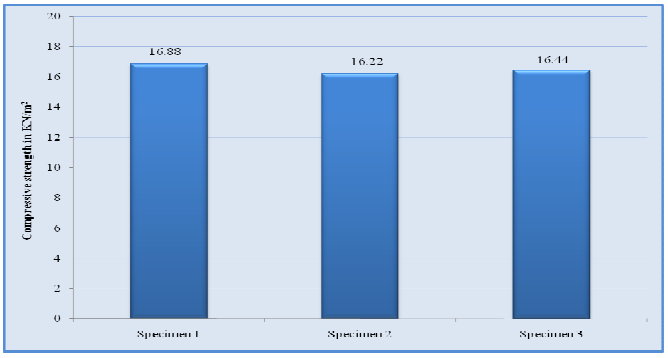

Figure no.3: At 300˚C mean value 16.51 KN/m².

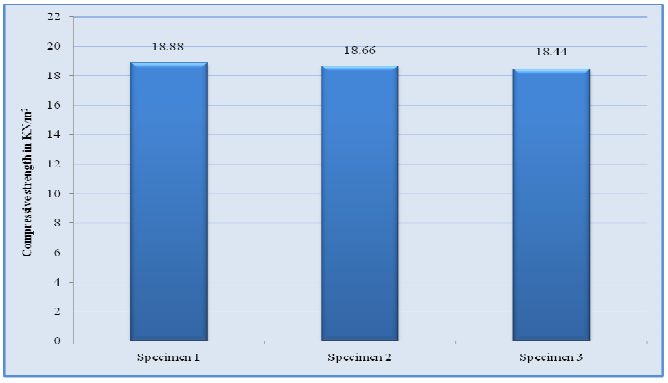

Figure no.4: At 450˚C mean value 18.66 KN/m².

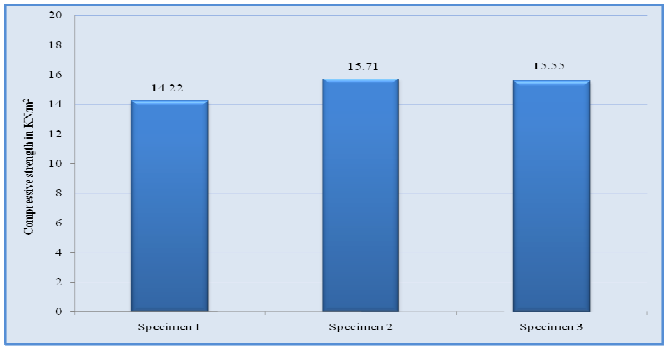

Figure no.5: At 600˚C mean value 16.16 KN/m².

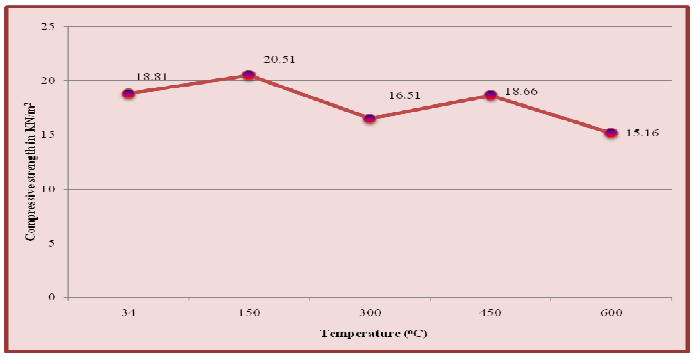

Figure no.6: Relation between Compressive strength and Temperature of experimental

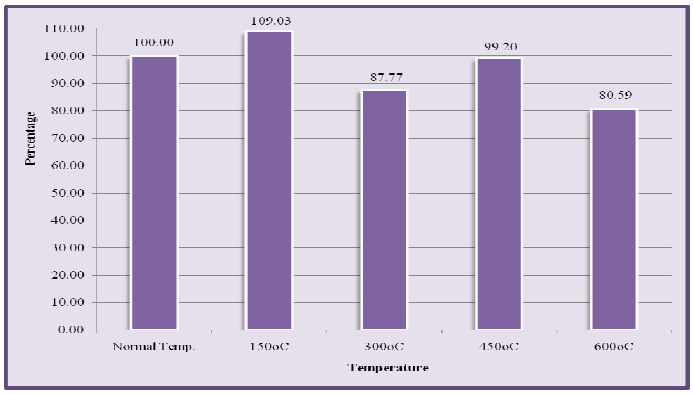

Figure no.7: Relative Compressive strength relation at various Temperatures

CONCLUSION

As per the test results of compressive strength of specimens, it can be seen that at Room temperature i.e. 34˚C strength obtained is18.81 KN/m^2 where as when the specimen is subjected to 150˚C the compressive strength increases up to 20.57 KN/m².However at 300 ˚C the compressive strength got decreased up to 16.51K N/m². Further increase in temperature increased the strength of concrete cube to the value 18.66K N/m² at 450˚C. At the temperature of 600˚C the specimen got damaged , showing weak bond ,cracks white spots and resulted decreased compressive strength of 15.16 KN/m².

Thus it can be seen that at 150 ˚C the strength increases by 9.03% and at 300˚C it got decreased by 12.23%. Further at 450˚C the strength was decreased by 0.80% and at 600˚C the concrete got poorly damaged. The reduction in the strength was 19.41%. This means that up to 150˚C the strength of concrete increases to some extend after that strength decreases.

The behavior of Normal concrete is distinct and requires further more attention so as to mitigate accidents due to fire hazards , since the failure of structure occurs at its collapsible strength , the study over here highlight the strength parametric behavior of concrete at various temperature.

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