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Change in Concrete Properties due to Fire

Mr. Bhaskar Bhatt[1] and Dr. V. K. Verma[2]

PhD Scholar[1], Assistant Professor[2]
Deptt. Of Civil Engg. GBPUAT, Pantnagar

Abstract

Concrete is used for construction of infrastructures such as buildings, bridges and numerous structures. Fire is destructive load that can happen to structure. Damage depends on severity and duration. Physical properties of concrete and reinforcing steel are modified by temperature and duration of fire. Assessment of fire damaged concrete starts with visual observation then by ultrasonic pulse velocity tests. Cube samples were heated on variable fire temperatures and tested in 2 conditions: M20 Grade design mix normal concrete cube samples, M20 grade design mix with added carbonated aggregate. Check on cube samples after heating on differing temperatures was done using compressive test then load test.

Key Word: Fire, construction.

INTRODUCTION

Fire is difficult to extinguish and compensatory damages and losses formed by is impossible. A building exposed to fire continues for long hours, and then service of building after disaster becomes impossible. Loss of life and property are bigger when building falls before evacuating all users. Concrete should be designed to provide high performance in buildings having high risk of fire. At high temperatures mechanisms that affect values of compressive strength of concrete and bearing capacity are losing quality of components in concrete microstructures at end of chemical reactions and creating surface cracks and explosions. Best optimal mix of concrete should provide desirable thermal properties while struggling to minimize fragmentation and decreasing compressive strength.

CONCRETE BEHAVIOR DURING FIRE

Regarded as fireproof because of incombustibility and ability to withstand high temperatures without collapse. Properties change dramatically when exposed to high temperatures and deterioration in mechanical properties. Concrete temperatures to 95°C have little effect on strength and other properties of concrete. Above this threshold cement paste undergoes shrinkage (contraction) as dehydration and aggregates expand due temperature rise in overall expansion of concrete and reduction in strength.

Figure 1: Damage due to Fire

Table 1: Change in concrete

100 °C	simple dilation
100 - 150 °C	evaporable water loss
150 - 500°C	- cement paste contracts aftervaporization of hydration water - above 300 °C, density reduces

Table 2: Types of Fuel

Fuel type	**Temperature reached in °C**
Spark	1315
Methanol	1911
Methane	1919
Butane	1975
Propane	1975
Wood	1975
Hydrogen	2208
Acetylene	2630
TNT explosion	3401
400- 500 °C	- Decomposition of Ca(OH)2 > CaO + H2O
500 -1300°C	Decomposition of (CSH) At 500°C Reduction of 50 % concrete strength.

CONCRETE RESISTANCE IN FIRE:

- Aggregates in concrete be classified into 2 types: carbonate, siliceous. Carbonate aggregates: limestone and dolomite. Siliceous aggregates are materials of same thickness provides increased fire resistance.
- Steel melts between 1152 and 1539 °C, depending on carbon content. Design for fire resistance aims average concrete cover reinforcement sufficient to keep temperature of reinforcement below critical values. During fire, temperature reached at surface of concrete is greater than temperature at 3 cm inside concrete mass. It is due to slow rise of temperature in concrete. Increase in reinforced concrete resistance in fire, large cover is required.

OBJECTIVE

- Study changes in mechanical properties of concrete corresponding to high temperature at different rate of heating.
- Study effect of Spalling on strength, stiffness and durability of Concrete.
- Study and analyse materials having fire resistance capacity which added in concrete during mixing to improve fire resistance capacity of concrete.
- Sampling concrete cubes by incorporating material having fire resistance capacity.
- Study changes in mechanical properties of concrete corresponding to high temperature at different rate of heating and compare results with concrete cube tested after corresponding to high temperature without fire resistance material.
- Study assessment and identify material which used as additional ingredient to improve fire resistance capacity of concrete without losing strength.

ANALYSIS:

Experiment of casting concrete cubes with additional ingredient from material samples having good fire resistance capacity and testing concrete cubes having compressive strength 30MPa (M20) grades at completely varying temperatures. 12 cubes of 150×150×150 mm size of grade M20. 3 specimens exposed to 100°C for 1 hour and tested instantly at hot state. Similar tests conducted on specimens exposed to 300°C, 600°C and 900°C using ingredients having similar property.

It consists of casting and testing concrete cubes of M20 Grade at various temperatures.

- Concrete cubes of 150mm x 150mm x 150mm casted and heated to 100°, 300°, 600°, and 900° C in Electric Furnace.
- 12 cubes casted for each sample of material of M20 grade concrete.
- 3 cubes M20 grade exposed to 100°C for 60 minutes in Electric Furnace tested immediately at hot state.
- Compressive Strength tested at normal room temperature for 3 cubes of concrete on Compression Testing Machine and then comparing with concrete cubes (without admixture) exposed to similar temperature.

- Similar testing conducted on remaining cubes exposed to 300°C, 600°C, and 900°C and compare with concrete cubes (without admixture) exposed to same temperature.
- Same procedure conducted by adding different materials to concrete while mixing.

PREPARING CONCRETE SPECIMEN

All materials i.e. Cement, Fine Aggregates, Coarse Aggregates, Water and additional materials as an admixture with proportion 1:1.5:3 (Cement: Sand: Aggregate) for M20 grade mixed thoroughly on plane non porous surface.

- Moulds of 150mm x 150mm x 150mm dimensions cast concrete cubes of M20 grade by oiling inner sides of moulds.
- Matrix poured into moulds with each corner properly filled and well tamped to prevent any voids and honeycombing.
- Moulds kept for 24 hours at room temperature.
- Cubes taken out from moulds and kept in water tank for 28 days for curing.
- After 28 days cubes be taken out from tank and 3 cubes shall be tested for compressive strength on Compression Testing Machine.
- Similarly left cubes be tested after exposing to varying temperatures.

MATERIALS:

Cement utilization in investigation be 53 Grade standard Portland cement confirming to Indian standard (IS): 12269. Specific gravity of cement be found. Fine aggregates conforming to zone II of IS: 383 used. Bulk density, relative density of sand used be 1.56 g/cc and 2.65. River sand be as IS sieves (i.e. 2.36mm, 1.18mm, 600µ, 300µ, and 150µ). Coarse aggregates be procured from local crushing unit of 20mm nominal size.

To get well graded aggregate, 85% of coarse aggregates passing through 20mm size and retained on 12.5mm sieve added to 15% of coarse aggregates passing through 25mm sieve and retained on 20mm sieve. Potable water be utilized in experiment for mixing and curing.

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