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EFFECT OF FIRE ON CONCRETE AND ENHANCEMENT IN FIRE RESISTANCE CAPACITY OF CONCRETE

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Abstract:- *Concrete is widely used for the construction of infrastructures such as buildings, bridges, cooling towers, chimneys, industrial and other numerical structures. Fire is one of the most destructive accidental loads that a structure can be subjected during its lifetime. The amount of damage caused will depend mainly on the severity and the duration. The physical properties of concrete and the reinforcing steel are modified by the temperature and duration of fire. Assessment of fire damaged concrete usually starts with visual observation followed by ultrasonic pulse velocity measurements and tests on core samples. This paper outlines a methodology for assessing the concrete cubes at laboratory on samples prepared. A number of cubes samples heated i.e on variable fire temperatures and tested in two conditions. 1.M20 Grade design mix normal concrete cube samples. 2. M20 grade design mix with added carbonated aggregate. The evaluation of the cube samples after heating on varies temperature was also carried out using compressive test followed by load test.*

Key Word: Thermal Analysis, Strength Analysis

1. INTRODUCTION

Fire is a physical event, which is difficult to extinguish once, started and most of the time compensatory damages and losses to be formed by is impossible. A building exposed to fire fighting continues, long hours, and then service of the building after the disaster has become impossible. The loss of life and property are bigger when the structure of building fails before evacuating all of the users. And it shall be also provided that to minimize damages caused by fire, to ensure sustainability of performance after fire and to have a value of compressive strength allowing users to evacuate in time to ensure survival during the fire. Especially in our country, a large part of the buildings is constructed as concrete structures. Because of this fact, concrete must be designed to provide high performance, which is used in buildings having high risk of fire, building structure and in fire compartments. At high temperatures, the most important mechanisms that effect losing the values of the compressive strength of concrete and bearing capacity are losing the quality of components in the concrete microstructures which occurs at the end of chemical reactions and creating surface cracks and explosions. The best optimal mix of concrete should aim to provide desirable thermal properties while struggling to minimize the potential for explosion fragmentation and decreasing the values of compressive strength.

Choosing components to develop the properties of at high temperatures.

1.1 CONCRETE BEHAVIOR IN FIRE

It is regarded as a fireproof because of its incombustibility and its ability to withstand high temperature without collapse. However, its properties can change dramatically when exposed to high temperatures and many problems were experienced with concrete in fire such as deterioration in mechanical properties. Concrete temperatures up to 95°C have little effect on the strength and other properties of concrete. Above this threshold cement paste undergoes shrinkage (contraction) due to dehydration and aggregates expand due to temperature rise which results in overall expansion of concrete and reduction in its strength.

Fig.1.1 Fire Damage

Table 1.1: The table below summarizes the change in concrete as function of temperature.

100 °C	simple dilatation
100 - 150 °C	Loss of evaporable water
150-500°C	-Contraction of cement paste after liberation of hydration water - above 300 °C, large reduction in density

Fuel type	Temperature reached in °C
Electrical spark	1316
Methanol	1910
Methane	1920
Butane	1977
Propane	1977
Wood or most organic material (textiles ,paper, leather)	1977
Hydrogen	2210
Acetylene	2632
TNT explosion	3400

400- 500 °C	- Decomposition of calcium hydroxide $Ca(OH)_2$ -----> $CaO + H_2O$
500 -1300°C	Decomposition of calcium silicate hydrate (CSH) At 500°C Reduction of 50 % of the concrete strength.

1.2 FIRE TYPES AND REACHED TEMPERATURES

The temperatures reached in fires depend on the type of combustible materials.

Table 1.1.1: The table below shows the temperatures reached in different kinds of fires.

1.3 FACTORS THAT AFFECT THE RESISTANCE OF CONCRETE IN FIRE:

The behaviour of reinforced concrete (concrete with embedded steel bars) in fire depends on its mix proportions, constituents (the type of aggregate used) and on the cover of reinforcement.

- Aggregates used in concrete can be classified into two types: carbonate, siliceous. Carbonate aggregates include limestone and dolomite. Siliceous aggregate includes materials consisting of silica and include granite and sandstone. The strength of concrete containing
- siliceous aggregates is reduced to about 55% at 650°C .On the other hand, Concrete containing carbonate aggregates retains most of its compressive strength up to about 650°C . Concrete with carbonate aggregates transmits heat at a slower rate than normal weight concrete with the same thickness, and therefore generally provides increased fire resistance.
- Steel melts at temperatures between 1153 and 1538 °C, depending on its carbon content. The Design for fire resistance aims to ensure an average concrete cover to the reinforcement sufficient to keep the temperature of the reinforcement below these critical values. During a fire, the temperature reached at the surface of concrete is greater than the temperature at 3 cm inside the concrete mass where the reinforcement is embedded. This is due to the slow rise of temperature in concrete. Therefore, to increase the reinforced concrete resistance in fire, a larger cover is required.

2. SCOPE AND OBJECTIVE

In general, this investigation will have carried out to study the Impact of Fire on Concrete & Concrete Structures and Improvement in fire resistance capacity of concrete by incorporating smart material having fire resistance property which are easily available.

In more specific terms this research shall be conducted to achieve the following objectives: -

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

3. METHODOLOGY FOR ANALYTICAL WORK

The experimental program consists of casting of concrete cube with additional ingredient from material sample having good fire resistance capacity and testing concrete cubes having compressive strength 30Mpa (M20) grades at completely different temperatures. A complete number of 12 cubes of 150×150×150 mm size cast with grade M20. 3 specimens will have exposed to

100°C for hour and will be tested instantly at hot state Similar testing will be conducted on specimens exposed to 300°C, 600°C, and 900°C using various material/ingredient having similar property.

The experimental program consists of casting and testing concrete cubes of M20 Grade at different temperatures.

- The Concrete cubes of size 150mm x 150mm x 150mm will be casted and heated to 100°, 300°, 600°, and 900° centigrade in Electric Furnace.
- A total number of 12 cubes will be casted for each sample of material of M20 grade of concrete.
- The 3 cubes of M20 grade exposed to 100°C for 60 minutes in Electric Furnace and will be tested immediately at hot state.
- The Compressive Strength will be tested at normal room temperature condition for 3 cubes of concrete on Compression Testing Machine and then comparing these cubes with concrete cubes (without admixture) which were exposed to similar temperature.
- Similar testing will be conducted on remaining cubes exposed to 300°C, 600°C, and 900°C respectively and compare with concrete cubes (without admixture) which were exposed to same temperature.
- Same procedure shall be conducted by adding different material in concrete while mixing.

3.1 PREPARATION OF CONCRETE SPECIMEN

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

- The moulds of 150mm x 150mm x 150mm dimensions will be prepared to cast the concrete cubes of M20 grade by oiling the inner sides of moulds.
- The matrix will be poured into the moulds with each corner properly filled and well tamping with tamping rod to prevent any voids and honeycombing.
- The moulds will keep for 24 hours at room temperature.
- The cubes will be then taken out from the moulds and keep in the water tank for 28 days for curing.
- After 28 days the cubes will be taken out from the tank and 3 cubes shall be tested for compressive strength on Compression Testing Machine.
- Similarly remaining cubes will be tested after exposed to different temperatures.

4. MATERIAL USING

Cement utilization in the investigation will be 53 Grade standard Portland cement confirming to Indian standard (IS): 12269. Specific gravity of the cement shall be find out. Fine aggregate conforming to zone II of IS: 383 will be used. The bulk density, relative density of sand to be use will be 1.56g/cc and 2.65 respectively. River sand shall be as per IS sieves (i.e. 2.36mm, 1.18mm, 600µ, 300µ, and 150µ). Coarse aggregate will be procured from a local crushing unit having 20mm nominal size.

To obtain a well graded aggregate, 85% of coarse aggregate passing through 20mm size and retained on 12.5mm sieve will be added to 15% of coarse aggregate passing through 25mm sieve and retained on 20mm sieve. Potable water will be utilized in the experimental work for each mixing and curing.

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