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Study of Collapse Behavior of Building Under Fire Condition

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Abstract - *Reinforced concrete structures are generally considered to have intrinsic resistance to fire. However, a number of concrete structures around the world have experienced partial completely collapse under fire. It is necessary for a building to maintain structural stability when subjected to multiple and chronological rearmost loads. Safety and economic considerations fescue that structures are built to resist extreme events, i.e. a earth-quakes, impacts, blasts or fires, without collapse and to provide sufficient time for evacuation of the occupants. However, during i.e. events, some structural damage may be sufficient. Design codes do not consider for the scenario where two extreme events occur consecutively on a structure or do they address the situation of the structure having some initial damage sooner to being applied a fire load.*

This work starts by detailing the major inconsistencies between designing reinforced concrete structures for rearmost mechanical loads and designing for fire. The material behavior and traits of the constitutive parts such as the concrete and the steel, including post yielding behavior, thermal relationships and their interaction with each other are all explored in detail. Comprehensive numerical and practically investigations are undertaken to determine whether, and to what extent, phenomenon such as tensile cracking and loss of the concrete cover affected the local and global opposition of fire by component of buildings.

***Key Words*: Reinforcement, Intrinsic, Rearmost, Damage, concrete cover, Components of Buildings**

1. INTRODUCTION

Concrete is a material when we bring it in contact with fire, it looks like tremendous behavior It does not burn, it means it is non-combustible and has a lot of thermal mass, which makes significantly spread of heat through the medium of concrete elements. In general, when a fire initiate in reinforced concrete structure, the outer layer of concrete section of thickness approximate damaged 3cm to 5 cm depth of the reinforced section. Therefore, a lot of reinforced concrete structures that damaged by fire, be capable of easily repaired & can be reuse. An instance of a good behavior towards the fire of reinforcement concrete structures is the Windsor Tower of Madrid. Due to the fire on February 14, 2005, the building was badly damaged. After this the fire was spread over several floors of the building and the fire continued for 26 hrs, still the building remained standing, Which can be seen in figure 1.1 & 1.2..

The only section that fall down where the steel columns on top of 20th storey, Which was sustaining the floors.

Fig.1.1 Windsor Tower(madrid)

Fig.1.2 Windsor Tower After Fire

It has been observed that fire can have devastating effects on concrete structures, so while designing it should not be ignored.

Table-I : Effect of Temperature on Concrete

Temperature (^{0}C)	What Happens
1400	Concrete melt down. Bonding of SiO_2 with Al_2O_3
1200	Air temperature in fires rarely exceeds this level but flame temperature can rise to 1200^{0}C And beyond.
900	Total loss of chemically bonded water from CSH
700	Dissociation of calcium carbonate calcinations $CaCO_3 \longrightarrow CaO + CO_2$
600	At this temperature the concrete can't work on completely structural capacity
550-600	Cement based materials experience considerable creep and lose their loading capacity.
400	Dissociation of calcium hydroxide $Ca(OH)_2 \longrightarrow CaO + H_2O$
300	Loss of strength but in reality only the first few cm of concrete exposed to fire

	will get any hotter than this and internally the temperature is will below this.
250-450	Some spalling may take place, with piece of concrete breaking away.

2. Literature Survey

Fire hazard can be a key factor that triggers progressive collapse because elevated temperatures have tremendous effects on construction materials such as concrete & steel. Modulus of elasticity and construction material decreases, with increasing in temperatures. Major codes have detailed descriptions of the behavior of steel under elevated temperatures. With regard to concrete, the material properties under high temperatures depend on the constituents, the duration under fire condition as well as the temperature elevation rate. These are fully introduced in major concrete codes. Due to the despoiled properties of concrete & steel, the robustness of structures subject to fire can considerably deteriorate.

1. K N Sharma, S C Chakrbati - The authors performed some practical exercises to know the remaining strength in the concrete after the fire since the results of the test, the authors said that in reality, concrete has achieved some strength between 200 to 600 in the siliceous & carbonaceous aggregate. According to the authors, the concrete does not fall in large quantities of its strength till 1000°F and in fact, about 90 percent of the strength lost to this temperature gets cured. Concrete cubes heated up to 1400°F for four hrs 2 to 3 days after the crumbling started. The hypothesis of fire exaggerated concrete retrieval some of its strength with time is not an established.

2. B Balakrishna Bharth – The researchers did perform research task on the influence of fire on the strength of reinforced cement concrete structures of various types of buildings under fire & explosion. The performance of Reinforcement at different eminent temperatures from 210°F to 1800°F. The specimens for testing were Thermo Mechanical Treated diameter bar of 12mm. Cut 20 number of specimen 300 mm size. After this, using the universal testing machine before heating the temperature at room temperature, tested the mechanical properties of sample were note down the properties of sample. Number of 10 specimens was heated in the electric furnace at the temperature of 210°F, 570°F, 1110°F, 1650°F & 1830°F for an hrs with no any barrier. After heating, 5 out of 10 specimens to cool the sample quickly and pour in the cold water and remaining 5 specimens were kept them for normal cooling in atmospheric temperature. Later these specimens were tested in Universal Testing Machine. The Authors find out the results, ductility of rapidly cooled reinforced bars after heating to high temperature of 1830°F decreased which is could be hazardous for a structure. Considerable change in ductility was experiential at high temperatures & near ultimate load. A major problem caused by high temperatures was spalling of concrete i.e. separation of concrete mass from concrete element which resulted in the exposure of steel reinforcement directly to high temperatures. If the period and the force of fire are higher, the load bearing decreased to the extent of the applied load resulting in collapse of structure.

3. Case Study

a. Fire Accident in Stadium Fire-

Fire happen in reinforcement cement stadium and intensity of fire is high. After the department of fire accepted the area for access, primary investigation was arranged. The fire severely damaged the estimated area of concrete by about 25 meters × 25 meters. The concrete beam was extremely damaged, the beam section was separated from the slab, and severe cracking was present.

The fire was acute to the range that the seating area straightly on top of the fire suffers heat damage.

In Destructive test notice that the strength of reinforcement concrete & reinforcing steel on the fire was compromises. Repairs of concrete structure were designed to rebound the slab & beam using L-shaped dowels to hook the slab & beam webs jointly. Repair the load bearing capability of the affected beam and slab.

3.1 Seperation of Slab & Joist Spalling

b. Fire in Egyptian Clothing Factory-

A 6th storey clothing factory (Fig 3.3) in Alexandria, Egypt collapsed after a fire in July 2000. Authorities believed the fire was initiated by an electric short circuit within the RCC building. The fire spread rapidly and took firefighters 7 hrs to extinguish. When the fire appeared to be put out, the building rapidly collapsed, killing at least 15 people and injuring many others. The expected cost of the destruction was $2.5 million.

Fig.3.2 Collapse of Clothing

4. Conclusion & Remedy

Due to excessive thermal effects, changes in reinforcement concrete were examined. The work has been focused on geometrical phenomena i.e. tensile cracking and loss in concrete cover, with special reference to the coupling of these effects to the thermal and thermo-mechanical behavior. In addition, a method is proposed to eliminate or reduce these effects and to increase the stability and integrity of the concrete throughout thermally extreme events, even when these events happen consecutively.
Preliminary investigations were carried out into the inconsistencies within the design of reinforced concrete structures under a variety of extreme thermal loads. The design for thermal loads is accomplished under the main theory that the concrete cover is present and remains whole throughout. This is in direct contradiction to the design philosophy undertaken for reinforced concrete structures subjected to extreme thermal loads, where there is an allowable level of damage the structure can endure with the aim of dissipating the kinetic energy.
These preliminary investigations clearly demonstrated the fundamental and main inconsistencies between the design philosophies.

Remedy-

1. Masonry walls & column must be made of thicker segment that these can resist fire for longer time and can also act as a barrier against spread of fire to the adjacent areas.
2. In case of load bearing walls, bricks must be chosen to stones.
3. In the case of building with framed structure, reinforcement concrete should be chosen to steel, if steel is used in for framed structure, the steel structure, the steel structure components should be properly enclosed or embedded into concrete, terracotta, bricks, plaster boards, gypsum or other suitable materials.
4. If frame work is constructed by R.C.C. thicker cover used, so that the member can be resist firer load longer time. It is necessary to from IS 456:2000 is 35 to 40 mm cover for beam & long span slabs,40 to 50 mm cover for columns and 25 mm for short span slabs.

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