STUDY OF R.C.C. STRUCTURES AGAINST FIRE

ARUN MALIK

M.Tech. Student, CBS GROUP OF INSTITUTION, JHAJJAR,
Maharashi Dayanand University (MDU), Rohtak

ABSTRACT : *With the exaggerated incidents of major fires in buildings; repairs, assessment and rehabilitation of fireplace broken structures has become a topical interest. This can be a specialised field involves experience in several areas like material science, testing and concrete technology, structural engineering, repair techniques and materials etc. analysis and biological process efforts square measure being applied during this space and different connected disciplines. During this topic the expertise of reality issues square measure conferred that add large price to the current. this subject additionally offers a comprehensive data on the overall strategy for the restoration of fireplace broken buildings and additionally presents a assessment of the assessment procedures by completely different non damaging techniques, specifications and execution of repair techniques.*

The experimentation has been done to search out the impact of the hearth on reinforcement steel bars by heating the bars to 100°,300°,600°,900° C of six samples each. The heated samples square measure quickly cooled by extinguishing in water and ordinarily by air cooling. The modification within the mechanical properties square measure studied victimisation universal testing machine (UTM) and also the microscopic study of grain size and grain structure is studied by scanning microscope (SEM).

The general conclusion is that majority of fireplace broken RCC structures square measure serviceable. However the impact of elevated temperature higher than 900°C on the reinforcement bars was discovered that there's important reduction in malleability once quickly cooled by extinguishing. Within the same case once cooled in traditional atmospherical conditions the impact of temperature on malleability isn't high. By heating the reinforcement bars, the mechanical properties will be modified while not variable the chemical composition.

Keywords: Fireplace, Hearth, Victimisation, Ferroconcrete, Spalling.

1. INTODUCTION

With the inflated incidents of major hearths and fire accidents in buildings; assessment, repair and rehabilitation of fireside broken structures has become a topical interest. This specialized field involves experience in several areas like concrete technology, material science and testing, structural engineering, repair materials and techniques etc. Analysis and development efforts are being carried out in these connected disciplines. Any structure will endure hearth accident, however thanks to this the structure can't be denied neither abandoned. To form a structure functionally viable once the harm thanks to hearth has become a challenge for the technology community. The matter is wherever to begin and the way to proceed. It's vitally vital that we tend to produce buildings and structures that defend each individuals and property as effectively as potential. Annual statistics on losses caused by hearths in homes et al. work some unpleasant readings and sadly through these events we tend to learn a lot of regarding fire safety design.

We are all responsive to the harm that fireplace will cause in terms of loss of life, homes and livelihoods. A study of sixteen industrial nations (13 in Europe and the USA, North American country and Japan) found that, during a typical year, the quantity of individuals killed by fires was one to two per 100,000 inhabitants and therefore the total price of fireside harm amounted to 0.2% to 0.3% of GNP. Within the USA specifically, statistics collected by the National hearth Protection Association (USA) for the year 2000 showed that quite 4,000 deaths, over 100,000 injuries and quite $10bn of property harm were caused by hearth. Great Britain statistics counsel that of the 500,000 fires once a year attended by firefighters, regarding one third occur in occupied buildings and these end in around 600 fatalities (almost all of that happen in dwellings). The loss of business ensuing from fires in business and workplace buildings runs into many pounds every year. The extent of such harm depends on variety of things like building style and use, structural performance, hearth termination devices and evacuation procedures. Though hearth safety standards are written with this categorical purpose, it's intelligibly the security of individuals that assumes the bigger importance. Applicable style and selection of materials is crucial in guaranteeing hearth safe construction. Codes and laws a fire safety are updated regularly, sometimes as a results of analysis and development.

An original methodology s illustrated for assessing the hearth harm to reinforced-concrete buildings by Pietro Croce et al. Microstructure of fireside broken concrete is investigated by Wei Lin et al [13] by victimisation scanning negatron magnifier and stereo magnifier for the concrete that has been heated to a temperature of 900°C to induce the visual data that may} well be not possible to visualize with the eye will facilitate to grasp the behavior of concrete in hearth. A case of assessment of the structure of Novi unhappy Open was given by R. Folic et al [11]. Strength and sturdiness recovery of fireside broken concrete once post-fire- activity was given by Chi-Sun poon et al [3] in 2001. M. A. Riley from Sir William Halcrow & partners Ltd has given a ape on potential new methodology for the assessment of fire-damaged concrete [8]. N. R. Short et al [9] worked within the space of assessment of fireside broken concrete victimisation color image analysis. The effects of speedy cooling by water ending on the stiffness properties of fire-damaged concrete was studied by A. Y Nassif et al [10] of Londan University within the year 1999.

1.1 EXPERIENCE OF FIRES:

1. Most of the structures were repaired. Of these that weren't, several might are however were destroyed for reasons aside from the harm sustained.
2. Nearly while not exception, the structures performed well throughout and once the hearth.

1.2 CHANGES OF CONCRETE IN FIRE:

Concrete doesn't burn – it can't be 'set on hearth' like different materials during a building and it doesn't emit any venomous fumes once stricken by fire. It'll additionally not manufacture smoke or drip liquified particles, in contrast to some plastics and metals, thus it doesn't boost the hearth load. For these reasons concrete is claimed to own a high degree of fireside resistance and, within the majority of applications, concrete is delineate as nearly 'fireproof'. This glorious performance is due within the main to concrete's constituent materials (i.e. cement and aggregates) that, once with chemicals combined inside concrete, type a material that is basically inert and, significantly for hearth safety style, features a comparatively poor thermal conduction. it's this slow rate of warmth transfer (conductivity) that allows concrete to act as an efficient hearth defend not solely between adjacent areas, however additionally to guard itself from hearth harm. The speed of increase of temperature through the cross section of a concrete part is comparatively slow so internal zones don't reach constant high temperatures as a surface exposed to flames. a typical ISO 834/BS 476 hearth take a look at on 160 mm wide x 300 mm deep concrete beams has shown that, once one hour of exposure on 3 sides, whereas a temperature of 600°C is reached at 16 mm from the surface, this worth halves to only 300°C at 42 mm from the surface – a gradient of three hundred degrees in regarding an in. of concrete! Even once a protracted amount, the interior temperature of concrete remains comparatively low; this allows it to retain structural capability and hearth shielding properties as a separating part.

The surface look of structural members provide an inspiration on the extent of warmth to that these members might need been subjected to throughout the hearth. The structural conditions as determined provides a wad of data on its wholeness and facilitate to assess the physical harm suffered by the members. As declared earlier, these data are terribly important for distribution the acceptable harm classifications and coming up with the repair techniques. It's but to be unbroken seeable that these are subjective observations and results would rely on the expertise and ability of the person ending the investigations. Inspite of those drawbacks, this data is critical and once examined with the knowledge received from different strategies, offer a valuable tool taking choices on form of repairs to be disbursed. The varied aspects coated by the unfold sheets are in brief mentioned below.

A) Condition of plaster and finish

The ferroconcrete structural members are either unbroken exposed or rendered with cement mortar that, normally during this building is 1:3 (1 cement :3 sand) in some locations these members have additionally been cladded with different materials (wood/marble). The condition of these finishes are catogerised and recorded into 5 groups; unaffected, peeling, substantial loss, total loss and destroyed.

B) Color

The color of concrete could modification as a results of heat thanks to hearth could and should provide an inspiration of the most temperature earned. A correlation between the decolouration thanks to hearth and a potential temperature earned is accessible in technical report no.33: assessment and repair of concrete structures by concrete society, U.K. thanks to hearth decolouration takes place and therefore the potential modification in concrete is traditional, pink, whitish gray and puff.

C) Crazing

The development of fine cracks on the surface of the concrete thanks to explosive cooling of surface with water is termed as crazing. These fine cracks are restricted to surface layer and no structural significance on material has been accounted for. These are recorded in unfold sheets beneath four categories; unaffected, slight, moderate, intensive and surface lost.

D) Spalling of concrete

Spalling is that the deteriotion method during which some of concrete (particularly cover) has separated and fallen out from the body of the concrete member. Thanks to spalling, the reinforcement gets exposed, composite action between concrete and steel reinforcement is reduced. The spalling seriously affects strength, stiffness and sturdiness of member and is very important parameter decide the degree of injury. 5 sorts of spalling considered; unaffected, minor, localized to corners, wide to corners and every one surface spalled.

E) Exposure condition of reinforcements correlation

The extent of exposure condition of the most reinforcement and links (stirrups) of structural members are recorded in the unfold sheets with the classifications of exposure as twenty fifth, five hundredth and five hundredth with the indication of the buckling condition of the most reinforcements.

F) Cracks

Concrete members exposed to high temperature throughout hearth could develop severe cracks that could extend across the body of the member. These cracks determined throughout visual inspections are recorded in unfold sheets and additionally within the sketches of the members. Cracking is classed as minor and major with the recording of length of cracks.

G) Distortion

The extent of distortion of the structural members affected by hearth within the style of deformations (deflections, twisting etc) are recorded into 3 categories; none, slight however insignificant and severe and important.

H) Delamination of concrete

Delamination of concrete implies that a layer or some a part of concrete has separated out from the parent body however still not fallen out. The delamination is detected by sound of concrete surface with lightweight hammer. A 'dull thud' sound of concrete would indicate delamination. within the unfold sheets extent of delamination in terms of expanse has got to be recorded.

1.3 DAMAGE CLASSIFICATION OF STRUCTURAL MEMBERS:

Based on the knowledge collected from the unfold sheets indicating the condition of surface look of concrete (plaster/finish, colour, crazing), structural conditions and additional correlative with the results of NDTS and laboratory tests, the structural members are selected with varied harm classifications. Combined with the private expertise of the skilled, the visual scrutiny and therefore the varied tests gift a reasonably correct condition of the broken structural part. Since the strengthened concrete could be a extremely variable matrix, someday the results of various tests seem to grant somewhat contradictory results however with experience, these will be reconciled. based mostly on the harm classifications, the repair classification and repair needs are given below;

CRITERIA FOR DAMAGE CLASSIFICATIONS:

Table 1: Damage classifications

Class of damage	Repair classification	Repair Requirements
Class 1	Superficial	For repair, use cement mortar trowelling using cement slurry bonding
Class 2	General	Non-structural or minor structural repairs like restoring cover to reinforcement using cement polymer slurry as bonding layer and nominal light fabric reinforcement or using epoxy mortar over the primary coat of epoxy primer. No fabric for small patches of area less than 0.09 sq.m

Class 3	Principal Repair	Where concrete strength is significantly reduced, strengthening to be carried out with shotcreting in case of slabs and beams and jacking in case of columns. For less damaged columns shotcreting is also proposed. The bonding material used shall be epoxy formulation Additional reinforcement shall be provided in accordance with load carrying requirement of the member. Both residual and final strength to be checked by design procedure.
Class 4	Major repair	Repair method is demolition

2. SPALLING:

One of the foremost advanced and therefore poorly understood behavioral characteristics within the reaction of concrete to high temperatures or hearth is that the development of "spalling". This method is usually assumed to occur solely at high temperatures; nevertheless it's additionally been determined within the early stages of a hearth, and at temperatures as low as two hundred Cº. If severe, spalling will have a hurtful result on the strength of ferroconcrete structures; attributable to increased heating of the steel reinforcement. Spalling could considerably cut back or maybe eliminate the layer of concrete cowl to the reinforcement bars, thereby exposing the reinforcement to high temperatures, resulting in a discount of strength of the steel and therefore a deterioration of the mechanical properties of the structure as an entire. Another important impact of spalling upon the physical strength of structures happens via reduction of the cross-sectional of concrete obtainable to support the obligatory loading, increasing the strain on the remaining areas of concrete. This will be necessary, as spalling could crop up at comparatively low temperatures, before the other negative effects of heating on the strength of concrete have taken place [4].

2.1- Mechanisms of Spalling

Spalling of concrete is usually classified as: pore pressure induced spalling, thermal stress induced spalling or a mix of the 2.

Spalling of concrete surfaces could have 2 reasons:

(1) Increased internal pressure (mainly for traditional strength concretes) and.
(2) Overloading of concrete compressed zones (mainly for prime strength concretes).

The spalling mechanism of concrete cowl is pictured in Fig (1).

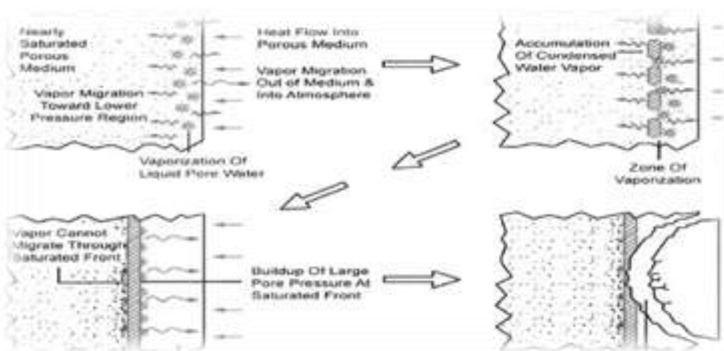

Fig.1. The Spalling mechanism of concrete covers [1].

As concrete is heated, the free water vaporizes at_100 Cº and expands; thereby leading to increased pore pressures. Migration of a number of this vapor to the inside of the concrete member, wherever it cools and condenses, can lead to associate degree progressively

'wet' zone sometimes spoken as wet clog. At a long way from the new surface the vapor front reaches a crossroads at that a most pore pressure is achieved (further movement can result in an exceedingly reduction in pressure).

The distance of this point from the heated surface can depend upon different concrete's porosity. Pore pressure spalling happens if the most pore pressure is bigger than the local tensile strength of the concrete. However, no pore pressures have nevertheless been measured which might exceed the enduringness of concrete that suggests_ that pore pressure in isolation doesn't result in the occurrence of spalling.

Strong thermal gradients develop in concrete because it is heated, attributable to its low thermal physical phenomenon and high specific heat. These thermal gradients induce compressive stresses near the surface attributable to restrained thermal growth and tensile stresses in the cooler interior regions [7].

It is possibly that spalling happens attributable to the mixture of tensile stresses induced by thermal growth and redoubled pore pressure. A lot of debate still surrounds the identification of the key mechanism (pore pressure or thermal stress). However, it's noted that the key mechanism could modification relying upon the section size, material and wet content [2].

2.2. - SPALLING PREVENTION MEASURES:

There are some principal ways by that the incidence of spalling can be reduced.

2.2.1. - Polypropylene (plastic) fibers:

One well-known methodology is that the addition of plastic (pp) fibers to the concrete combine. This approach works on the premise that, because the concrete is heated by hearth, the plastic fibers soften at concerning one hundred sixty Cº - a hundred and seventy Cº therefore making channels for vapor to flee and thereby unharnessed pore pressures. The influence of compressive load throughout heating is very important Fig (2).

Fig.2. Polypropylene fibers give protection against Spalling [12].

Tests have indicated that, for unloaded concrete, 1kg of fibers per m³ of concrete is also enough to eliminate spalling. For a load of 3 N/mm² the fiber content has to be redoubled to 1.5-2 kg/m³ and for a load of 6 N/mm² an extra increase to 3 kg/m³ is also needed to combat explosive spalling. though concrete segments are gently stressed below traditional conditions, it ought to be found out that a circumferential compressive hoop stress can develop within the concrete throughout heating that may be a operate of the thermal growth of the mixture [12].

2.2.2. - Thermal barriers:

Another anti-spalling live is to put heat barrier over the concrete surface a technique generally utilized in tunnel construction. Thermal barriers cut back the speed of heating (and peak temperatures) among the concrete and therefore cut back the danger of explosive spalling further as loss of mechanical strength. They're thus the foremost effective methodology (pp fibers don't cut back temperatures). However, there are 2 potential drawbacks: (a) the price of the insulation is probably going to be quite that of the fibers and (b) with a number of the makers there has been a drag with delaminating throughout traditional service conditions.

The design criteria unremarkably are to use a enough thickness of coating therefore on cut back temperature at the surface of the concrete to below concerning three hundred Cº and also the maximum temperature at the steel rebar to concerning 250 Cº among 2- hours of the fireplace. It ought to be noted that have indicates that whereas twenty five metric linear unit of coating is also adequate for concrete strength up to concerning C60 a coating thickness of 35mm is also needed for prime strength concrete to avoid explosive spalling.

Also, there are some ways as:

1- Spray coating of finished concrete with a substance that slows down the speed of warmth transfer from hearth. It's the speed of natural action within the concrete that has been proved to be a minimum of as necessary a explanation for spalling because the in progress exposure to warm temperature itself.
2- The comparatively new conception to counter the spalling threat is to produce vents within the concrete to alleviate pore pressure [7].

2.3. - EFFECT OF FIRE ON FIBER REINFORCED POLYMERS (FRP) COLUMNS:

Kodur et al. [5] conferred the results of a complete hearth resistance experiments on 3 insulated FRP-strengthened ferroconcrete columns. A comparison was created between the fireplace performances of FRP-strengthened RC columns and traditional unstrengthened ferroconcrete columns.

Data obtained throughout the experiments is employed to indicate that the hearth behavior of FRP-wrapped concrete columns incorporating applicable fire protection systems was nearly as good as that of unstrengthened RC columns. Thus, satisfactory hearth resistance ratings for FRP-wrapped concrete columns might be obtained by properly incorporating applicable hearth protection measures into the general FRP-strengthened structural systems. Hearth endurance criteria and preliminary style recommendations for hearth safety of FRP-strengthened RC columns were additionally in brief mentioned. The performance of protected FRP-strengthened sq. RC columns at high temperatures is kind of like, or higher than, that of typical RC columns.

Chowdhurya et al. [6] incontestable that fiber-reinforced polymers (FRPs) might be used with efficiency and safely in strengthening and rehabilitation of ferroconcrete structures. In there study they were conferred the recent results of Associate in Nursing experimental study of the fireplace performance of FRP-wrapped ferroconcrete circular columns. The results of fireside tests on 2 columns were conferred, one among that was tested while not supplemental hearth protection, and one among that was protected by a supplemental hearth protection system applied to the outside of the FRP-strengthening system. The first objective of those tests was to match hearth behavior of the 2 FRP-wrapped columns and to research the effectiveness of the supplemental insulation systems.

The thermal and structural behaviors of the 2 columns were mentioned. The results show that, though FRP systems are sensitive to high temperatures, satisfactory hearth endurance ratings might be achieved for ferroconcrete columns that were strong with FRP systems by providing adequate supplemental hearth protection. Particularly, the insulated FRP-strengthened column was ready to resist elevated temperatures throughout the fireplace tests for a minimum of ninety minutes longer than the equivalent uninsulated FRP-strengthened column.

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