A Survey Paper on- Effect of High temperature in Reinforced Cement Concrete Structure

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Abstract— This topic also gives a comprehensive knowledge on the overall strategy for the restoration of fire damaged buildings and also presents a critical appraisal of the assessment procedures by different nondestructive techniques, specifications and execution of repair techniques. The experimentation has been done to find out the impact of the fire on reinforcement steel bars by heating the bars to 100°,300°,600°,900° centigrade of 6 samples each. The heated samples are rapidly cooled by quenching in water and normally by air cooling. The change in the mechanical properties are studied using universal testing machine (UTM). The general conclusion is that majority of fire damaged RCC structures are repairable. But the impact of elevated temperature above 900°C on the reinforcement bars was observed that there is significant reduction in ductility when rapidly cooled by quenching. In the same case when cooled in normal atmospheric conditions the impact of temperature on ductility is not high. By heating the reinforcement bars, the mechanical properties can be changed without varying the chemical composition.

Keywords: Concrete, Steel, Fire, Design, UTM, Modeling, Review

I. Introduction

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 design and use, structural performance, fire extinguishing devices and evacuation procedures. Although fire safety standards are written with this express purpose, it is understandably the safety of people that assumes the greater importance. Appropriate design and choice of materials is crucial in ensuring fire safe construction. Codes and regulations on fire safety are updated continually, usually as a result of research and development. An original method s illustrated for assessing the fire damage to reinforced-concrete buildings.

The behaviour of structures exposed to fire is usually described in terms of the concept of fire resistance, which is the period of time under exposure to a standard fire time-temperature curve at which some prescribed form of limiting behaviour occurs. In performance-based design this limiting behaviour may be defined as real structural collapse or as a failure of integrity (which allows fire-spread to occur), but is more usually defined in terms of a deflection limit. Current design codes have taken a step towards full performance-based design by allowing designers to treat fire as one of the basic design limit states, taking account of:

– Non-uniform heating due to partial protection, which may be inherent in the framing system or specially applied.
– The level of loading in the fire limit state, using partial safety factors lower than those used for ultimate limit states, because of the relative improbability of such accidental conditions.
– Realistic stress-strain characteristics of materials at elevated temperatures.

Fig. 1: concreting of fire damaged slab

1) Most of the structures were repaired. Of those that were not, many could have been but were demolished for reasons other than the damage sustained.
2) Almost without exception, the structures performed well during and after the fire.

II. Literature review

This section is a review of the literature on the instruments or measures will use as part of our study.

[Cone & Foster, (2009); Newman et al., (2019)] You need to present evidence that supports your choice of instrument over those not chosen. This section should be focused on relevant literature specific to the study. One suggestion is to examine the most current instruments first and work back from there. You need to include reliability and validity estimates and a description of the samples that have received the instrument. When dealing with many variables, it is useful to write a separate section on each variable in the review.

[Denoël, (2018)] can only start when the following three elements are present simultaneously: oxygen (21 % volume in air), combustible materials and a heat source. Together, they make up what is commonly called the fire triangle, which is also shown in Figure 2.1. The first two elements will only start the process of combustion when the inflammation temperature is reached.

[Buchanan (2012) and Denoël (2017)] The combustion of carbon produces carbon dioxide (CO2) and, in case of a lack of oxygen, the well-known gas carbon monoxide (CO) which is very dangerous to man. This Section discusses the behaviour and the different stages of fires in rooms. The stages are ignition, growth, flashover, fully-developed fire and decay, as can be seen. Since their behaviour is completely different, a distinction is made between pre- and post-flashover fires. The information in this Section is based on

[Wade and Barnett (2017)] Generally it is found that, when structurally designing a building, the postflashover fire is of the essence. When designing for life safety in buildings, an understanding of the pre-flashover fire is essential. The previous description presumes only one single item burning. However, combustible materials on floor, walls and ceiling may significantly influence the development of the fire due to rapid spread of flames. In this case, temperatures will be higher and the fire will grow significantly faster in a well-insulated room where the bounding elements absorb the heat less. Computer models predicting the behaviour of a fire in a room with combustible lining are under development.

[Drysdale (2016)] The definition of a flashover is the transition from a localised fire to combustion of all exposed combustible surfaces in a room. Thus, it is not possible for a flashover to occur in an open unenclosed space since, by definition, it can only occur in an enclosed compartment. Furthermore, it may be pointed out that the term flashover describes a transition rather than a precise event.

[Buchanan (2013)]Unwanted fire is a destructive force that causes many thousands of deaths and billions of dollars of property loss each year. Although the probability is low, fire may occur anywhere, in any season, in any phase in the lifetime of a building and often when least expected. The safety of the occupants relies on many factors in the design and construction of the buildings, including the expectation that a certain building or a part of a building subjected to fire will not collapse or allow the fire to spread.

[Brandpreventie (2012)] Given that some fires will always occur, there are many strategies for reducing their impact. The best proven fire safety technology is automatic fire sprinkler systems because they have been shown to have a very high probability of controlling or extinguishing fires. Other necessary measures are for example to provide facilities for the detection and notification of fires, safe travel paths for the movement of occupants and fire-fighters, barriers to control the spread of fire and smoke, and structures which will not collapse prematurely when exposed to fire. The proper selection, design and use of building materials are crucial.

[Keshavarz and Taheri (2011)] have analyzed the transient one-dimensional heat conduction of slab by employing polynomial approximation method. In their paper, an improved lumped model is being implemented for a typical long slab, long cylinder and sphere. It has been shown that in comparison to a finite difference solution, the improved model is able to calculate average temperature as a function of time for higher value of Biot numbers. The comparison also presents model in better accuracy when compared with others recently developed models.

III. Research Methodology

The specimens for testing were Kamdhenu TMT bar of 12mm diameter. 54 bars were cut to 40 cm size. 6 Specimens were tested for the mechanical properties using UTM before heating at normal temperature and the properties were tabulated. 12 specimens each were heated in the electrical furnace at 100°, 300°, 600° and 900°C for an hour without any disturbance. After heating, out of 12 specimens for each temperature 6 samples were quenched in water for rapid cooling and the other 6 were kept aside for normal cooling at atmospheric temperature. These specimens later were tested for mechanical properties with UTM.

IV. Analysis of Reinforced Concrete Structure with Whole Floor Heated

It is assumed that all the reinforced concrete cross-sections remain intact. The temperatures of the cross-sections of the members, generated by thermal analysis, are then used to carry out the structural analysis. The deflections of some key positions within the structure analyzed are presented in is evident that the maximum deflection of the floor slabs at 120min is about 250mm, which is span of 30mm. The vertical deflections at the tops of three ground floor columns, A1, B2 and C3. It is evident that the columns initially extend upwards due to thermal expansion, then downwards after about 110min because of the reduction of the strength and stiffness of their concrete. It is very clear that, as in composite structures, some fire protection of columns within reinforced concrete buildings is crucial for the extended survival of such structures in fire conditions

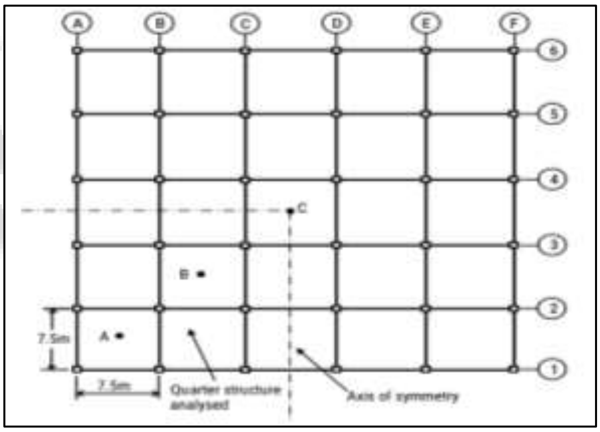

Fig. 2: Concrete structure layout for whole ground floor heated by the ISO384 fire

The deflection profile of the structure modelled at 150min. A vector plot of the distribution of principal membrane tractions (forces per unit width of slab). The figure shows repeated patterns clearly indicating tension fields in the central region of each floor panel, together with the peripheral compression ‘rings’ which are characteristic of tensile membrane action. It is obvious that the area in tension is rather smaller than the compression region. This is because the deflections are relatively small, less than span/30, so tensile membrane action is not very significant.

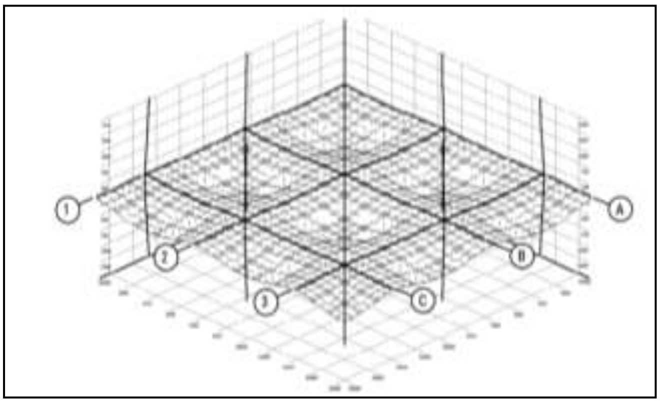

Fig. 3: Deflection profiles at 150min, with cracking patterns of bottom layer of floor slab

On detailed inspection of the compression and tension forces across the cut-lines it is clear that the compressive membrane forces are much larger than the tensile membrane forces. Hence, in order to maintain the equilibrium at this advanced stage of the fire, the reinforced concrete beams should probably carry tensile forces, since it is unlikely that the whole resultant of the slab forces is balanced by column shear. It is evident from the figure that even after 150min the tensile forces of the beams are about twice their values at ambient temperature. Hence the possibility of tensile failure of the beam reinforcement in the initial stages of the fire is quite high, depending on the type of fire and dimensions of cross-sections of the beam and slabs.

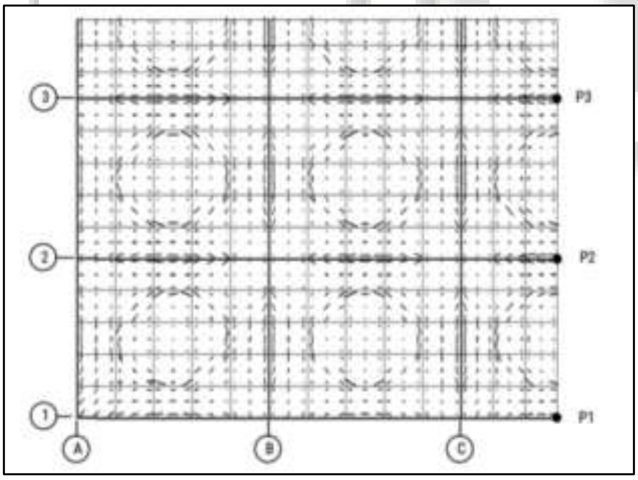

Fig. 4: Distribution of principal membrane tractions at 150min (thick line=compression; thin line=tension).

V. STRUCTURAL BEHAVIOUR WITH FIRE COMPARTMENTS IN DIFFERENT LOCATIONS

In order to study the interactions between the cool and hot zones of the structure, a series of analyses has been carried out for different extents and positions of localised fire compartments. Three different locations are modelled, as indicated. The temperature distributions for the structural members within the fire compartment are assumed to remain the same as above. The structure beyond the fire compartment is assumed to remain at 20°C.

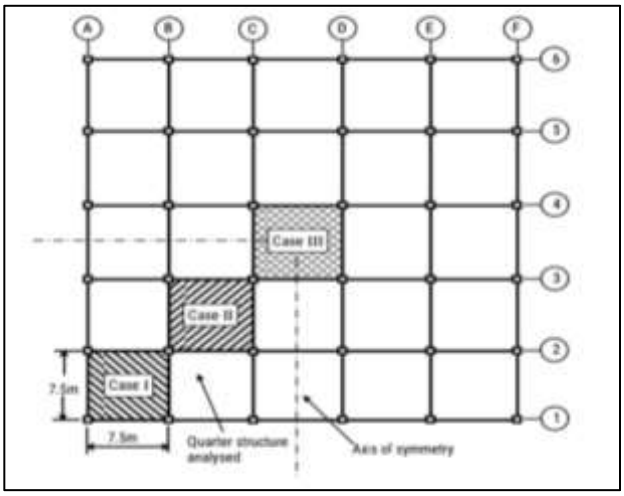

Fig. 5: Concrete structure layout, with different fire compartment positions marked.

VI. UTM TESTING

The 12mm steel bar is cut to a length of 40 cm and gave a gauge length of 60mm. The specimen is fixed on the machine and the required data on the computer is given. Test is conducted at a load rate of 300 kg/min for all the specimens. The data of the test is noted in computer during the test by default s it is setup. After the test all the other parameters like ultimate load, maximum extension in mm, area in mm2, ultimate stress, elongation in percent, reduction in in area, young's modulus, yield stress, .1% and .2% stress and many other parameters can be observed.

Fig. 6: UTM testing setup

VII. DISCUSSION

In this study and validated against the experimental program conducted as can be seen in the previous sections. Good agreement between the measured experimental and predicted FE simulation was obtained for the average temperature in the GFRP bars at all stages of fire exposure. Although the Building Regulations for fire safety recommends the minimum periods of the fire resistance for the most structural elements to be of 90 min, the fire tests and FE simulation results showed that concrete beams reinforced with GFRP bars can achieve a fire endurance of about 130 minutes. Thus, using GFRP bars as concrete reinforcement seems to meet the fire design requirements.

VIII. Conclusion

- Polynomial approximation method can be used to obtain solution of more complex problem involving variable properties and variable heat transfer coefficients, radiation at the surface of the slab.
- Other approximation method, such as Heat Balance Integral method, Biots variation method can be used to obtain the solution for various complex heat transfer problems.
- Efforts can be made to analyze two dimensional unsteady problems by employing various approximate methods.

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