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Influence of fire on reinforcement provided in R.C.C structures of buildings

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***Abstract*— This Paper aims at studying the influence of fire on reinforcement provided in R.C.C structures of various types of buildings which are under blast or fire. The Behaviour of Steel Reinforcement at various elevated temperatures from 100° C to 1000° C is studied. After the attack upon the World Trade Center of United States in New York in September 2011 , interest in the design of Buildings protect from fire greatly increased. Fire has become one of the major and greatest dangers to buildings. Concrete is a Primary Construction material used in any type of construction and it present good behavior when the concrete structure is under fire, Blast etc. However a major Problem caused by high temperatures is spalling of concrete i.e. separation of concrete masses from concrete element which results in the exposure of steel reinforcement directly to the High temperatures. Thus load bearing of steel reinforcement decreases when it is subjected to fire. If the duration and the intensity of fire are higher, the load bearing decreases to the extent of the applied load resulting in collapse of structure.**

***Keywords*— Concrete, Construction material, Reinforcement, U.T.M testing Machine, Quenching.**

I. Introduction

Now a days there are incidents of fires in buildings are often heard which are increasing day by day and also the repair and rehabilitation of fire damaged structures has become an area for study and research. Many efforts are been laid down to carry out research in these related fields. To build a structure usable again after fire damage is a discipline of great concern by civil engineering community. We totally recognize that fire cause damage in terms of deprivation of life, families and livelihoods. Structural design for fire safety is chiefly based upon “Authoritative Approach.” The Authoritative Approach involves fire resistance rating of structures & was developed almost 100 years back. The data of course is being changed with new findings, but is still cautious. Recommendations made by IS 1642:1989 (7) & Table 16 A in IS 456: 2000 (8) subscribe to the time tested prescriptive approach. After half of the nineties brought in a paradigm shift in the fire safety engineering with the onset of the performance based design approach. George Faller (3) of Arup Fire, has recommended the performance based approach. His paper presents a public presentation-based method for calculating fire resistance requirements, based on the time equivalent concept. The equivalent calculation is a mapping of fire load, compartment linings and ventilation conditions. The fire fighting period is calculated and then corrected to read account of the probability of occurrence of a flame, the effects of structural failure and the effects of an automatic suppression system.

David N. Bilow et al. (4) provide structural engineers with a summary of the complex behavior of structures in fire andThe simplified techniques which have been applied successfully for many years to design concrete structures to withstand the effects of serious fires. Later on the attack on the World Trade Center on September 2011, interest in the design of social organizations for fire greatly increased. S. C. Chakrabarti et al. (5) Conducted an extensive trial plan for measuring the residual effectiveness of concrete after the blast. As per the authors, concrete doesn’t lose a lot of its intensity level up to 500°C & in fact regains 90% of lost strength up to this temperature after about a yr. (The theory of fire affected concrete regaining some of its strength with time is not an installed one). After further increase in temperature the concrete spalling starts.

Figure 1 (Showing spalling of Concrete)

Concrete during the high temperature event has a complex behavior due to the differences in coefficient of thermal expansion of each composition. Proportioning of con- create mixtures to achieve high effectiveness and maintaining durability requirements during service live led to production of dense concrete mixtures with less water-cementitious material ratio (w/cm). Consequently, mechanical properties of HSC at elevated temperature are different from that of conventional concrete in two principal areas: first, strength loss in the intermediate temperature ranges 100°C to 400°C and second the occurrence of explosive spalling of the HSC. Strength loss should be considered by in- corporating the code and design specifications during the invention phase. In addition, explosive spalling of the HSC and loss of the concrete cover during fire leads to direct exposure of the steel reinforcement to heat leading to a loss of overall structural capacity Therefore, high strength concrete (HSC) and normal strength concrete (NSC) will cause a substantial difference in fire performance. Various genes that bear upon the fire resistance of concrete are con- create strength, moisture content, concrete density, and aggregate type.

Take strength and modulus of elasticity of steel are re-decade by nearly 12% to 14% when exposed to 482°C temperatures, beyond this temperature a rapid reduction in both properties will occur. In increase, the reduction in yield strength and modulus of elasticity at high temperature is also regarded by the carbon percentage and stress level of the steel member.

Steel reinforcement if protected by the minimum cover specified by the code it is expected that the consequence of high temperature on the reinforcement bars will be trifling. However, distortion due to thermal expansion and loss

High Strength Steel

The decrease in yield strength is referred to the stock level; consequently, a decrease in the yield strength of the high strength steel is smaller than that of the low strength steel. In increase, reduction in the modulus of elasticity is related to the carbon content of higher strength steel.

Cold Formed Steel

Cold forged steel structure when exposed to elevated temperature; the steel grade is the main parameter that controls the yield strength, while the steel thickness has a modest issue on the strength loss. In summation, there is no clear relationship between the elastic modulus and the steel grade or thickness.

DESIGN OF STRUCTURES AND THEIR REQUIREMENTS WITH THEIR PERFORMANCE

Performance (fire resistance) of any structure when ex- posed to fire depends on the material properties and in- solution/barriers to resist or to confine fire. Nevertheless, flame resistance rating is an indicator about the expected fire resistance of a structure in half-hour or hourly in- cerements Thermal expansion, structure and conditions (re- strained or unrestrained), and deprivation of the material's strength and stiffness affect the overall operation of a specific construction.

Concrete structures can deliver great performance during a fire event if the concrete has lower thermal conductivity which leads to a slower increase of the concrete tempera- ture. Spalling of concrete during elevated temperature could affect the mechanical attributes of concrete due to the increase of vapor pressure. This pressure leads to internal cracks and stress, which exceeds the tensile force of the concrete. Hertz and Sørensen found that concrete does not spall if the moisture content was maintained below 3% per weight, still, if the moisture con- tent is greater than 3%, spelling/explosive spelling could be averted by using cementations materials such as silica fume or fiber concrete

For steel structures, strong point, ductility, consistency of the blade material, the condition of the social system and the applied load are important elements which should be watched for fire resistance calculation. The critical temperature depends on the load ratio and steel composition. The load ratio value is the ratio of the applied design load that would generate a stress equal to yield stress at room temperature. It is necessary to use insulation material such as magnesia, vermiculite, sprayed mineral and ablative coatings to protect the steel structure from elevated temperature.

Composite structures, stresses and displacements caused by thermal expansion control the structural behavior in fire until just before failure reduction in materials' strength and stiffness control the behavior again

II. EXPERIMENTATION PROGRAMME

The specimens for testing were Sri TMT bar of 12mm diameter. 20 bars were cut to 30 cm size. Now 5 Specimens were tested for the mechanical properties using UTM before heating at normal room and the properties were tabulated. 10specimens each were heated in the electric furnace at 100°, 300°, 600°, 900°C and 1000°C for an hour without any interference. After heating, out of 10 specimens for each temperature 5 samples were quenched in cold water for rapid cooling and the other 5 were kept aside for normal cooling at atmospheric temperature. These specimens later were tested for mechanical properties with UTM

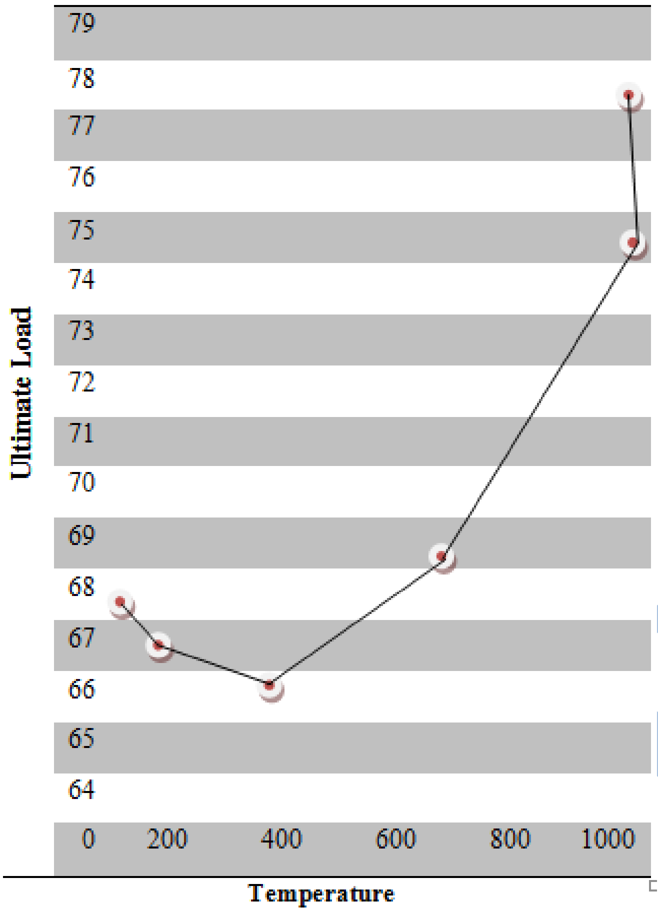
III. RESULTS AND DISCUSSIONS

S.no	Temperature in °C	Ultimate Load	Elongation (%)
1	Room temp 27	67.1	28.3
2	100	66.1	15
3	300	65.5	30
4	600	68.4	23.3
5	900	78.3	11.6
6	1000	82.4	11.8

Table 1 (Properties for rapid cooling conditions)

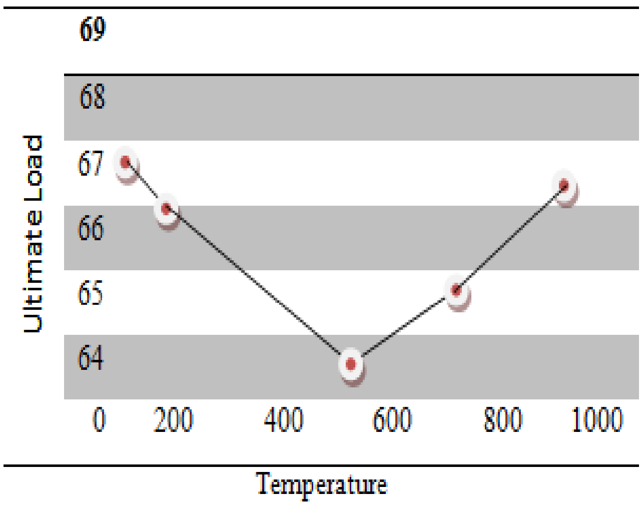
S.no	Temperature in °C	Ultimate Load	Elongation (%)
1	Room temp 27	67.1	28.3
2	100	66.5	30.2
3	300	63.7	28.3
4	600	64.3	27.4
5	900	65.5	26.6
6	1000	66.4	26.2

Table 2 (Properties for ordinary cooling conditions)



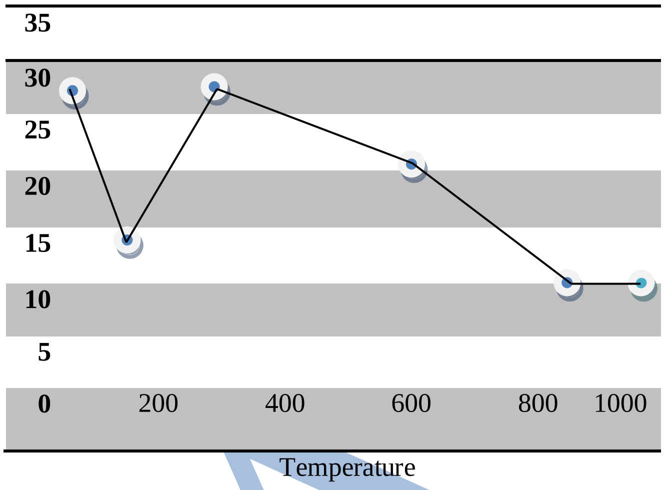
Graph between Temperature and Ultimate Load for Table 1

From the graph it can be observed that the ultimate load initially decreases from and then gradually increases , this happens due to the microstructure of the bar. For high temperatures the grain size decereases.

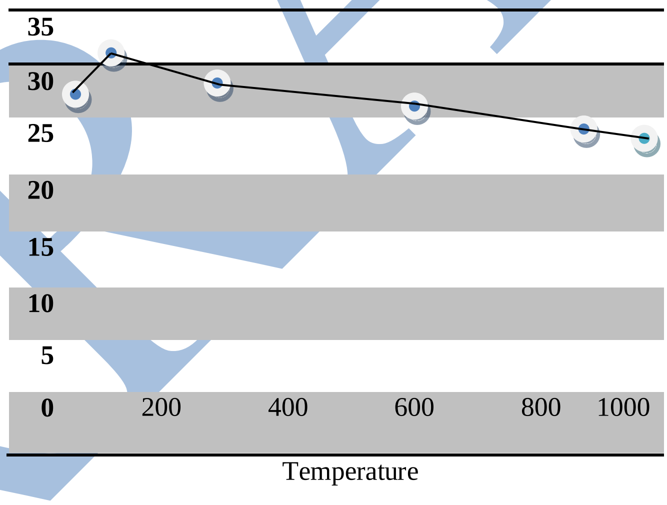


Graph between Temperature and Ultimate Load for Table 2

From the above graph the ultimate load carrying at the specimen was reduced from the specimen before heating.



Graph between Temperature and Elongation for Table 1



Graph between Temperature and Elongation for Table 2

IV. CONCLUSIONS

[1] The bars heated at various temperatures of 100° C, 300° C, 600° C, 1000° C, which are cooled quickly by quenching in cold water and other bars are normally cooled at the room temperature were studied and it is observed that the ductility of quickly cooled reinforced bars after heating to high temperature to 1000 ° C is decreasing which is dangerous for a structure.

[2] There is a detailed Study of the characteristic changes in the mechanical properties of the bars by Tensile strength testing using Universal Testing Machine readings and the graphs which are produced from the readings, shows that there is an increase in ultimate load and decrease in percentage elongation of the specimen which means that there is a significant change in ductility or we can say that ductility is decreasing as the ultimate load on the bars is increasing.

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