EFFECT OF FIRE ON REINFORCEMENT IN BUILDING STEEL STRUCTURES

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ABSTRACT:
This paper intends to investigate the effects of fire on the reinforcement built into various R.C.C. building types that are burning or blasting. Studying the behaviour of steel reinforcement at extreme temperatures ranging from 100° C to 1000° C. The attack on the World Trade Center of the United States in New York in September 2011 considerably heightened interest in the construction of fire-resistant buildings. One of the biggest threats to buildings today is fire. Concrete is a fundamental building material that is utilized in all types of construction and has good behaviour when exposed to fire, blast, etc. However, one of the main issues brought on by high temperatures is spalling of concrete, or the separation of concrete masses from concrete elements, which exposes steel reinforcement to high temperatures directly. As a result, steel reinforcement loses some of its load-bearing capacity when exposed to fire. If the fire burns for a longer period of time or is more intense, the structure will collapse because the load bearing capacity will drop to the level of the applied load.
KEYWORDS: Concrete, Construction material, Reinforcement, U.T.M testing Machine, Quenching.

INTRODUCTION

Building fire events are more common these days and they are getting worse every day. In addition, the repair and rehabilitation of fire-damaged structures has emerged as a field of study and research. Research in these connected topics is being pursued with great effort. The civil engineering community places a high priority on the discipline of rebuilding a structure that can be used after fire damage. We fully acknowledge that fire damage results in the loss of life, families, and livelihoods. The "Authoritative Approach" is the main foundation for structural design for fire safety. The Authoritative Approach, which was created about a century ago, rates the fire resistance of buildings. New discoveries undoubtedly alter the data, but caution is still used. The recommendations in IS 1642:1989 (7) and Table 16 A in IS 456: 2000 (8) follow the tried-and-true prescriptive method. With the introduction of the performance-based design approach, the second half of the 1990s brought about a paradigm shift in the field of fire safety engineering. Arup Fire's George Faller (3) has advocated the performance-based strategy. His study outlines an approach based on the time equivalent idea for estimating fire resistance needs for public presentations. A mapping of the fire load, compartment linings, and ventilation conditions serves as the comparable calculation. The amount of time needed to put out a fire is calculated, then corrected to take into consideration the likelihood that one will break out, the implications of structural collapse, and the impacts of an automatic suppression system. The simplified procedures that have been used effectively for many years to design concrete structures to withstand the effects of major fires are summarised by David N. Bilow et al. (4) in their article for structural engineers. Following the World Trade Center incident in September 2011, interest in the creation of fire-resistant social groups has rose. Concrete actually recovers 90% of the strength that was lost up to 500°C after roughly a year, according to S. C. Chakrabarti et al. (5) who conducted a thorough trial plan to measure the residual efficacy of concrete after the intensity level up to this temperature. (The assumption that fire-damaged concrete will gradually restore some of its strength is not widely accepted.) Concrete spalling begins after a further rise in temperature.

figure 1 (Showing spalling of Concrete)

Due to the variations in each composition's coefficient of thermal expansion, concrete exhibits complex behaviour during high temperature events. The creation of thick concrete mixtures with lower water-cementitious material ratios (w/cm) resulted from proportioning concrete mixtures to achieve high effectiveness and maintain durability criteria during service life. As a result, the mechanical characteristics of HSC at high temperatures differ from those of normal concrete in two key ways: first, there is a loss of strength in the intermediate temperature ranges of 100°C to 400°C, and second, there is a risk of explosive spalling of the HSC. During the invention process, it is important to take strength loss into account when incorporating the code and design criteria. Additionally, during a fire, catastrophic spalling of the HSC and removal of the concrete cover exposes the steel reinforcement to heat directly, reducing the total structural capacity. As a result, the fire performance of high strength concrete (HSC) and normal strength concrete (NSC) will differ significantly. Concrete strength, moisture content, concrete density, and aggregate type are a few of the factors that affect concrete's fire resistance.

When steel is exposed to temperatures of 482°C, its strength and elasticity are re-decelerated by roughly 12 to 14 percent; above this temperature, both qualities will be rapidly reduced. Additionally, the carbon content and stress level of the steel part are taken into account when determining the loss in yield strength and elastic modulus at high temperatures. If the minimum cover required by the code is used to protect steel reinforcement, it is anticipated that the effects of high temperatures on the reinforcing bars will be minimal. However, loss and distortion brought on by thermal expansion

High Strength Steel

The stock level is what determines the yield strength drop, so a fall in the yield strength of high strength steel is less than that of low strength steel. The carbon content of higher strength steel affects how much the modulus of elasticity decreases.

Cold Formed Steel

When cold forged steel is exposed to high temperatures, the yield strength is mostly controlled by the steel grade, while the steel thickness has a minor impact on the strength loss. In conclusion, there is no obvious correlation between the elastic modulus and the thickness or grade of steel.

STRUCTURAL DESIGN, REQUIREMENTS, AND PERFORMANCE

Any structure's performance (fire resistance) in the face of a fire depends on the material's qualities and its ability to withstand or contain fire. However, a structure's flame resistance rating provides information about its anticipated fire resistance in half-hour or hourly increments. The total performance of a particular construction is influenced by factors such as thermal expansion, structure, and circumstances (whether constrained or unrestrained). If the concrete has less thermal conductivity, which causes the temperature to rise more gradually, concrete structures can function admirably during a fire event. Concrete's mechanical properties may be impacted by spalling when temperatures are high because of the rise in vapour pressure. This pressure causes interior fissures and tension that is greater than the concrete's tensile strength. Concrete does not spall if the moisture content is kept below 3 percent per weight, according to Hertz and Sorensen, but if the moisture content is higher than 3 percent, explosive spelling can be avoided by employing cementing elements like silica fume or fibre concrete. Strong point, ductility, consistency of the blade material, the state of the social system, and the applied load are crucial factors that should be examined while calculating fire resistance for steel structures. The load ratio and steel composition affect the critical temperature. The fraction of the applied design load that would result in a stress equal to the yield stress at room temperature. To protect the steel structure from high temperatures, insulating materials including magnesia, vermiculite, sprayed minerals, and ablative coatings are required.Thermal expansion-induced stresses and displacements in composite constructions govern structural behaviour during a fire until shortly before failure. reduction in material stiffness and strength once again controls behavior.

II. EXPERIMENTAL INVESTIGATION

The test subjects were Sri TMT bars with a 12mm diameter. The size of 20 bars was reduced to 30 cm. Prior to heating at a normal room temperature, 5 specimens were examined using UTM for their mechanical properties, and the results were tabulated. For one hour without interruption, 10 specimens of each temperature were heated in the electric furnace at 100°, 300°, 600°, 900°, and 1000°C. Ten samples were heated, and five of each temperature were quenched in cold water to cool quickly, while the other five were set aside to cool normally at room temperature. Later, mechanical characteristics of these specimens were evaluated using UTM.

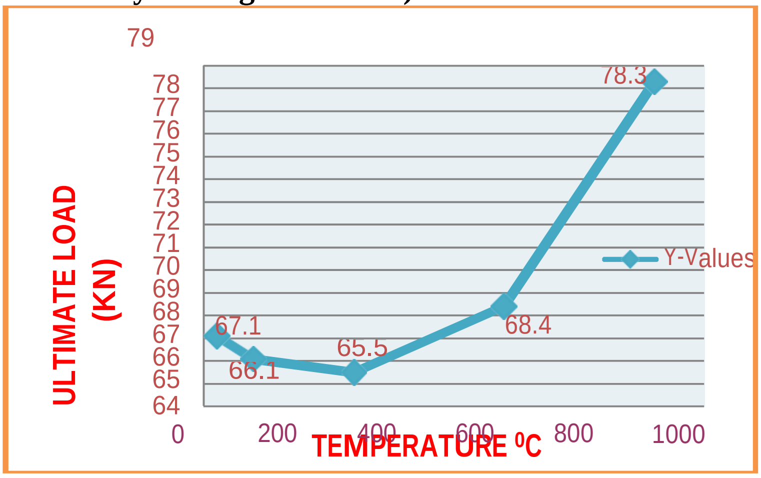
RESULTS AND ISCUSSIONS

S,no	Temperature (^{0}C)	mate load (KN)	ngation (%)
1	27(Room Temp.)	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)

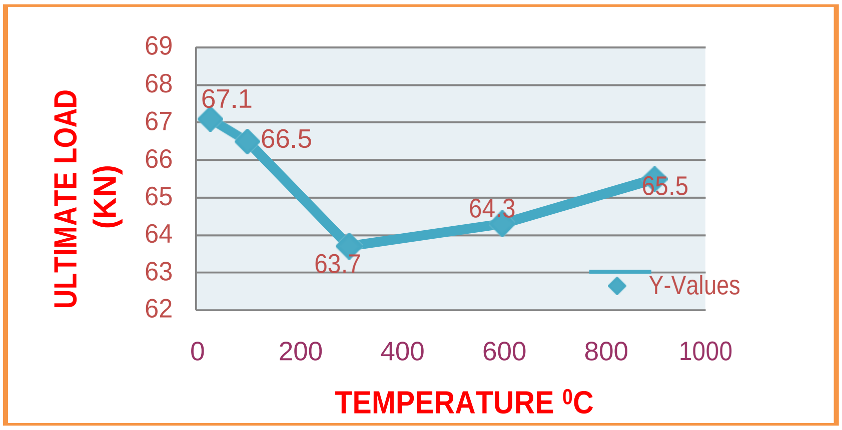
S,no	Temperature (^0C)	mate load (KN)	ngation (%)
1	27(Room Temp.)	67.1	28.3
2	100	66.5	30.2
3	300	63.7	28.3
4	600	64.3	27.4
5	900	65.5	26.6
6	1000	66.4	26.2

Table 2 (Properties for ordinary cooling conditions)



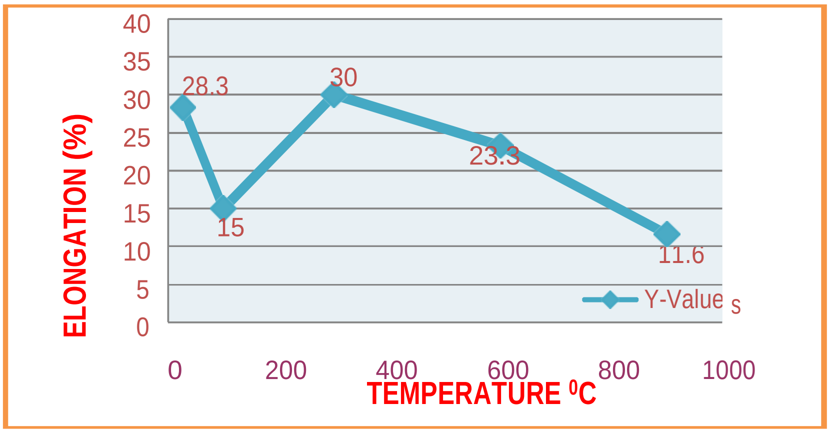
Graph between Temperature and Ultimate load for table-1

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 decreases.

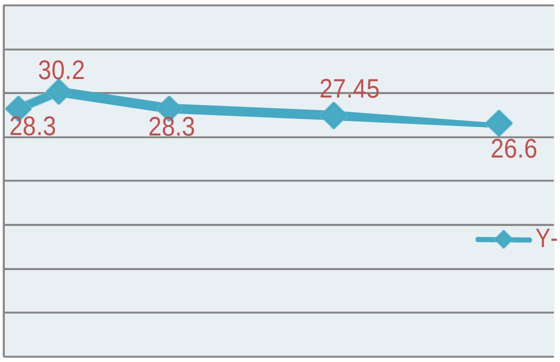


Graph between Temperature and Ultimate load for table-2

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

CONCLUSIONS

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

[2]. The graphs produced from the readings show that there is an increase in ultimate load and a 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. [1] 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.

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