International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
Research Symposium on
"Advancements in Engineering, Science, Management, and Technology"
Volume 5, Special Issue 04, April-2019.

IMPACT OF FIRE ON STEEL REINFORCEMENT IN REINFORCED CONCRETE BUILDINGS: A REVIEW

Samina Nusrat[1], Nishant Kumar[2]
[1,2]*Department of Civil Engineering, Sharda University*

Abstract: With the increased incidents of fire in the buildings, it has become important to asses, repair and rehabilitate RCC buildings damaged due to fire. Fire incidents can damage a structure to extent that it can collapse, the structures however well build are not immune to fire and hence design considerations for fire becomes very important part of structural engineering. Stirrup spacing plays an important role in designing a structure. The fire caused in building results in spalling of concrete. Spalling of concrete means separation of concrete mass from concrete elements thus making the reinforcement visible and in turn coming in contact with the fire destroys the cover and decreasing the overall stability of the structure. Secondly it decreases the overall strength of the structure. Load bearing capacity of steel decreases when it is subjected to fire. If duration and intensity is higher it may lead to the collapse of the buildings. In this review, the effect of rise in temperature on reinforcement in reinforced concrete buildings is studied. The factors that influence the thermal and structural behaviour of RCC buildings under various temperatures are discussed.

Keywords—UTM, TMT, Quenching, Spalling, RCC beam, Fire Resistance, Temperature Variation

INTRODUCTION

Now 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. . It is vitally important that we create buildings and structures that protect both people and property as effectively as possible. The attack on the World Trade Centre on September 2011, interest in the design of social organizations for fire greatly increased.

It is necessary to have safe, economical, and easily applicable design methods for steel members subjected to fire. However, without fire protection, steel structures may suffer serious damage or even collapse in a fire catastrophe. This is because the mechanical properties of steel deteriorate by heat during fires, and the yield strength of conventional steel at 600°C is less than 1/3 of the specified yield strength at room temperature. Therefore, conventional steels normally require fire-resistant coating to be applied. The temperature increase in the steel member is governed by the principles of heat transfer. Consequently, it must be recognized that the temperature of the steel member will not usually be the same as the fire temperature in a compartment or in the exterior flame plume. Protected steel will experience a much slower temperature rise during a fire exposure than unprotected steel. Also, fire effect on steel member is influenced with its distance from the center of the fire, and if more ventilation occurs near the steel in a fuel-controlled condition, wherein the ventilation helps to cool the steel by dissipating heat to the surrounding environment.

LITERATURE REVIEW

Chakrabarti et al (1994), conducted an extensive trial plan for measuring the residual effectiveness of concrete after the intensity level up to 500°C & in fact regains 90% of lost strength up to this temperature after about a year. After further increase in temperature the concrete spalling starts. Concrete during the high temperature event has a complex behaviour 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. Various genes that bear upon the fire resistance of concrete are con- create strength, moisture content, concrete density, and aggregate type.

Kodur et al (2003), investigated that the behaviour of HSC columns at high temperature is significantly different from that of NSC columns.HSC has low fire resistance than NSC. Type of aggregate has an influence on the HSC columns at higher temperatures. Presence of carbonate aggregate in HSC increases the fire resistance. Addition of steel and polypropylene fibres in HSC can improve the ductility of HSC columns and increases their resistance to fire. It also reduces spalling of concrete.

Mansour,**et al (2010),** investigated that large proportion of drop in compressive strength occurs at the first 1.0-hour period of exposure. After the beams were subjected to fire flame, two types of cracks developed. The first was thermal cracks, which appeared in honey comb fashion all over the surface. The second cracks originated at mid-span region due to bending from the applied load and called flexural cracks. At temperature of (400°C), both burning and subsequent cooling did not affect the mechanical properties of steel reinforcement; the effect was observed at 600 and 800°C. The residual yield tensile stress and residual ultimate stress was (90.6%, 78.8% and 89.8%, 81.4%) respectively. Modulus of elasticity of concrete is the most affected by fire flame temperature rather than compressive strength.

Bekir et *al* (2008), the mechanical properties of steel rebars were investigated which exposed to high temperatures and cooled to room temperature. According to test results, the most common reinforcing steel rebar S420 showed a brittle fracture mechanism under elevated temperatures. Splitting yield strength, tensile strength, elongation, and toughness values were low for S220 steel. These results demonstrate that S220 type of steel rebar is less affected than S420 steel under elevated temperatures.

Esref, et *al* (2007), determined the variation in mechanical properties of structural reinforcing steel with 25 mm cover after the exposure to high temperatures. Cover of 25 mm thick provides protection to reinforcing steel when the structure is exposed to high temperatures. It reduces the yield strength and tensile strength losses of the steel and gives it higher strengths compared to the plain reinforcing steel. Also that 25 mm cover thickness was not sufficient to protect the mechanical properties of reinforcing steel when the structure is exposed to temperatures over 500^{o}C.Also plain reinforcements react at temperatures that are approximately 250^{o}C less than those of the reinforcements with a 25 mm cover. A cover of 25 mm thickness protects the reinforcing steel at a temperature 250^{o}C below the outside exposure temperature.

Kodur et *al* (2017), investigated that peak reinforcing steel temperatures can occur upto 90 mins and 80 mins after exposing to fire.The residual capacity of RC columns, similar to the ones tested in this study, can be up to 34% and 29% o f its nominal (un-factored) capacity for a 90-minute and 120-minute fire exposure, respectively. While much of the ACI design capacity is retained in the columns tested has the realistic nominal (un-factored) capacity, calculated by using actual compressive strength of concrete, and shows a significant drop in residual capacity.

Ravindrarajah et al (2012), investigated that high strength concrete mixtures generally have low water to cement ratio and high binder material content. They used high-water reducing admixture (super plasticiser) to achieve workable concrete at low water cement ratio which resulted in producing concrete having its 28-day compressive strength well over 100MPa. For testing they used four types of mixes having varying binder materials. For all four mixes, the water to binder ratio was kept at 0.30. Concrete test specimens were heated at temperatures of 200^{o}C, 400^{o}C, 600^{o}C, 800^{o}C, and 1000^{o}C. High-strength concrete, independent of the binder material type used, experienced weight loss and the relationship between the weight loss and maximum temperature was non-linear. Compressive and tensile strengths showed noticeable losses (above 15%) even at the temperature of 200^{o}C, however the elastic modulus dropped marginally by about 5%.

Thamaraiselvan et al, (2017), in this author specifically addressed three types of concretes viz. normal, high strength and fly ash concrete. These specimens were tested in two separate condition states. The first representing air-cooled state involves heating the specimen to the required temperature for prescribed duration and air cooled to the room temperature. Phase two involves heating the specimen to the required temperature for the prescribed duration and immediately cooled to the room temperature by immersing it in the water (called water quenched). The strength and stiffness degradation of concretes for various grades has been studied and compared with the similar studies carried by other researchers. About 8% weight loss was observed in high strength concrete specimens at 1000°C.

CONCLUSIONS

It can be concluded that it becomes clear, no matter how well is the structure designed, it is not safe from fire. Concrete and temperature are directly related to each other, higher the temperature, higher the damage. The theory of fire affected concrete regaining some of its strength with time. Concrete's performance under fire is robust & up to $500^{o}C$, it only requires minor repairs. Stirrups spacing is very important in designing the structure for earthquake. Closely spaced stirrups leading to better confinement are beneficial for structural members. However during the event of fire, closely spaced stirrups may heat the core of structure sooner and hence may lead to faster degradation of concrete. It was further concluded that,the loss in compressive strength at elevated temperature is more in case of High strength concrete compared to Normal strength concrete. Decrease in compressive strength is more at high temperatures of 900°C. Studying the characteristic changes in the mechanical properties of the bars by tensile strength testing using Universal Testing Machine shows that the increase in ultimate load and decrease in percentage elongation of the specimen which mean that there is significant decrease in ductility of the specimen.

REFERENCES

[1]. Kodur, V. K. R. ~2001, ''Fibre-reinforced concrete for enhancing the structural fire resistance of columns.'' ACI Special Publ., in press.

[2]. Mohammed Mansur Kadhum, "The fire endurance of reinforced concrete beams", Babylon University. www.uobabylon.edu.iq/publications/applied_edition7/paper_ed7_14.doc.

[3]. İlker Bekir Topçu and Cenk Karakurt Department of Civil Engineering, Eskişehir Osmangazi University, 26480 Eskişehir, Turkey, Research Letters in Materials Science Volume 2008, Article ID 814137.

[4]. Ünlüoğlu, E., Topçu, İ. B., & Yalaman, B. (2007), "Concrete cover effect on reinforced concrete bars exposed to high temperatures", Construction and Building Materials, 21(6), 1155–1160.

[5]. Kodur, V., Hibner, D., & Agrawal, A. (2017), "Residual response of reinforced concrete columns exposed to design fires", Procedia Engineering, 210, 574–581.

[6]. R. Sri Ravindrarajah, R. Lopez, H. Reslan "Effect of Elevated temperature on the properties of High strength concrete containing cement supplementary materials". 9th International Conference on Durability of Building Material & Components, 17-20th March 2002, Paper 81, 8 pages, Rotterdam, Netherlands.

[7]. K. Thamaraiselvan, V. Jeevanantham, A. Parthiban, "Experimental Study on Strength Reduction Factor in Concrete Specimen Subjected to High Temperature", IOSR Journal of Mechanical & Civil Engineering (IOSR-JMCE) Volume 14, Issue 3 Version 7 (MayJune 2017), pp 60-64.

[8]. S. C. Chakrabarti, K. N. Sharma, Abha Mittal, "Residual strength in concrete after Exposure to elevated temperatures", The Indian Concrete Journal, December 1994, pp. 713-717.

[9]. Ashraf Mohi Ud Din Mir, Megha Gupta, "Effect of Bamboo Fibre on the properties of pavement quality concrete", IJTIMES, Vol 5, Issue 2, February 2019.