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REVIEW ON EFFECT OF ELEVATED TEMPERATURE AND SUDDEN COOLING ON STRENGTH PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE

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Abstract— ***Concrete loses its strength in case of accidental fires. The residual strength of normal strength concrete is of vital importance for ascertaining serviceability of buildings after the event of accidental fires. Strength loss in concrete is dependent on temperature of exposure, its duration and the way it gets cooled. Since last two decades the combination of different fibers and analysis of different cooling regimes had been studied to reduce the risk of damages and improve the residual strength of concrete after exposure of fire. The purpose of this study is to present a constructive critical review of the use of different fibers to make a fire resistant concrete.***

Keywords—Concrete, Elevated temperature, Fibers, Compressive strength, cooling regimes

I. INTRODUCTION

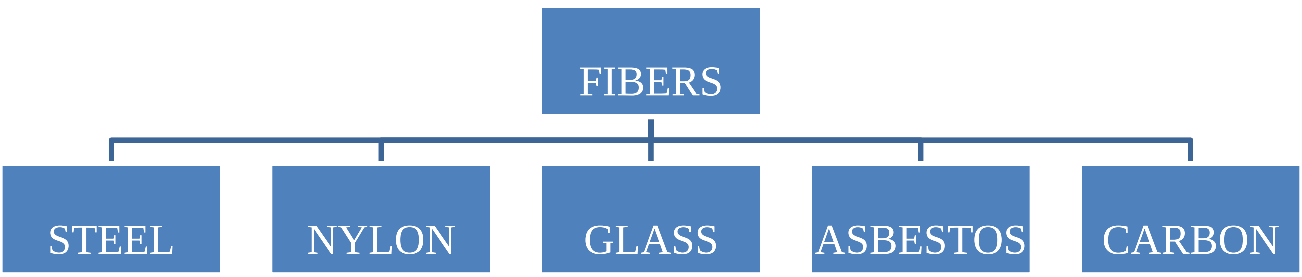
Concrete at elevated temperature is sensitive to the temperature level, heating rate, thermal cycling and temperature duration (as long as chemical and physical transformations occur). Its mechanical properties such as strength, modulus of elasticity decreases remarkably and this results in structural deterioration of concrete. When exposed to high temperature, chemical composition and physical structure of the concrete change considerably.

Apart from heating history of concrete and different cooling regimes, it is important to research or to determine whether a fire exposed concrete structure and its components are still structurally sound or not. There are many ways to extinguish fire. Fire is generally extinguished by water. Due to water Cao(calcium oxide) changes into $Ca(OH)_2$ causing cracking and crumbling of concrete. Therefore, the effects of high temperatures are generally visible in form of surface cracking and spalling. Some changes in colour may also occur during the exposure. Most of the changes experienced by the concrete after 500˚C, CSH gel, which is the strength giving compound of cement paste, decompose further above 500˚C. As a result, severe microstructural changes are induced and concrete loses its strength and durability.

A. HYBRID FIBER REINFORCED CONCRETE

The addition of more than one type of fiber in concrete is known as Hybrid Fiber Reinforced Concrete. The concept of using fibers as reinforcement in the concrete mixture is not a new study. The use of fibers has been carried out from ancient times.

B. TYPES OF FIBERS



C. POLYPROPYLENE FIBER

Polypropylene (PP) is a thermoplastic polymer used in a huge variety of applications including packaging and labeling, textiles, stationery and reusable containers of various types, laboratory equipment, automotive components and polymer banknotes. The polypropylene (PP) fiber puts effect on various properties of concrete in fresh and hardened state such as compressive strength, tensile strength, flexural strength, workability, bond strength, fracture properties, creep strain, impact and chloride penetration. It is chemically inert and any chemical that can harm these fibers will probably be much more detrimental to the concrete matrix. Monofilament fibers were the first type of polypropylene fiber introduced as an additive in Polypropylene Fiber Reinforced Concrete (PFRC). Monofilament fibers are available in lengths of 1/2, 3/4, and 1-1/2 inches .The monofilament fibers have also been produced with end buttons or in twisted form to provide for greater mechanical anchorage and better performance.

D. PROPERTIES OF POLYPROPYLENE FIBER REINFORCED CONCRETE

- Polypropylene fibers are used for secondary temperature shrinkage reinforcement, overlays and pavements, slabs, flooring systems, crash barriers, precast pile shells and shotcrete for tunnel lining, canals and reservoirs.
- Polypropylene fibers are hydrophobic in nature, which protect them against wetting with cement paste. The hydrophobic nature of polypropylene has no effect on the amount of water needed for concrete. The water demand of PP fibers is almost negligible.
- The hydrophobic nature of PP fiber helps to prevent chopped fibers from balling effect during mixing like other fibers.
- As it is chemically inactive, the fibers are resistant to most chemicals. Any chemical which does not attack the concrete matrix will also have no adverse effect on the fiber.

E. STEEL FIBER

Steel fiber is an alloy of iron and carbon. The most important properties of steel are great formability and durability, good tensile and yield strength and good thermal conductivity. As well as these important properties the most characteristic of the stainless steel properties is its resistance to corrosion. Because of its high tensile strength and low cost, it is a major component of structural and non-structural element. Fibers are generally classified according to their length, diameter and aspect ratio. For reinforced concrete different types of steel fibers can be used like straight, hooked ended, corrugated, microfibers, twisted etc.

F. PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE

- Good impact strength
- Good ductility
- High load bearing capacity after being cracked
- Good tensile, bending and shear strength

II. RELATED WORKS

Xin lua *et al.* 2000 performed a research to compare the residual compressive strength of high performance concrete (HPC) and normal strength concrete after they were subjected to high temperatures and different cooling regimes. The cubes with dimensions of 100×100×100mm were casted and after 24 hours the concrete cubes were de-moulded and stored in fresh water at 20±5˚C for 90 days. After 90 days the specimens were exposed to two selected high temperatures (i.e. 800˚C and 1100˚C) and two cooling regimes, one was furnace cooling i.e. natural cooling in the furnace to room temperature and other was water cooling i.e. immediate cooling. After the compressive strength test the result obtained showed that the residual compressive strength of both HPC and NSC dropped sharply after exposed to high temperatures. Thermal shock showed a bit more severe deterioration in strength compared to furnace cooling. It was also observed that the HPC is more susceptible to spalling than that of NSC.

Wu yao *et al.* 2003 compared the mechanical strengths (compressive, split tensile, and flexural properties) of concretes containing different types of hybrid fibres at the same volume fraction (0.5%). Three types of hybrid composites were constructed using fibre combinations of polypropylene (PP) and carbon, carbon and steel and steel and polypropylene. Cubes, beams and cylinders were casted and de-moulded 24 hours afterward placed in a curing room for 27 days. For 12 hours prior to the test the specimens were allowed to air dry in the laboratory. The following points were concluded after the experiment:-

- Among the three hybrids carbon steel fibre gave the highest strength and steel-polypropylene gave the lowest strength and same result obtained in case of flexural strength.
- At low fibre volume fraction, it is possible to obtain material with enhance strength and improved toughness with hybrid fibre.
- The best composite properties were obtained from the hybrid containing carbon and steel fibre.

Bingol A.Ferhat and Gul Rustam, 2008 studied the residual compressive strength of conventional concrete having characteristics strengths 20mpa and 35Mpa respectively had been investigated at different temperatures and different cooling regimes. The elevated temperatures ranging from 50˚C to 700˚C and sudden cooling (thermal shock) and gradual cooling (thermal gradient) at room temperature were two cooling regimes. The cylinders of 100mm diameter and 200mm height for two different mixture groups were casted by using river sand, normal aggregate and Portland cement. After 24 hours of casting the specimens were DE moulded and cured for 27 days in a water tank at 23±2˚C. Then these specimens were heated for 3 hours at each temperature. After heating the specimens were cooled to room temperature by water rapidly and in laboratory condition gradually. The following conclusions were derived from this study:-

- At temperature range 50-100˚C a slight increase of strength observed in M20 grade of concrete and slight decrease observed in M35.
- At 400˚C, the air cooled concrete maintains 80% of its strength while 70% residual strength observed in water cooled specimen.
- After 400˚C both the grades lost their strengths rapidly and the strength loss was more in water cooled specimen.

Subhash C. Yaragal *et al.* 2012 investigated the surface detailing, mechanical properties and weight loss of concrete on the temperature of exposure, its duration and the way it gets cooled. In this experiment concrete cubes of size 100mm had been casted for M25 grade of concrete, 28 days water cured. The specimens were subjected to elevated temperatures of 150˚, 250˚, 350˚, 450˚ and 550˚ with a retention period of 1 hour. After 1 hour of exposure specimens were allowed to cool under in different cooling regimes to ambient temperature. The cooling regimes included furnace cooling, sand bath, air cooling, sprinkling of water for 5 minutes, sprinkling water for 10 minutes and sudden cooling (thermal shock). The following conclusions were derived from the experiment:-

- The total percentage of weight loss increases as the exposure temperature increases. For all the cases of cooling regimes this is maximum for furnace cooled and minimum for sudden cooling.
- The residual co efficient of compressive strength decreases with increase in temperature.
- The loss of compressive strength and split tensile strength is minimum under furnace cooling as the heat gradient is gradual and maximum under sudden cooling.

S. K. Handoo *et al.* 2012 summarised the effect of elevated temperatures on the mineralogical schanges in physical state of concrete, consequent deterioration in compressive strength. X-ray diffraction used to study the mineralogical changes, UPV was used to change in physical state and scanning electron microscopy (SEM) was used to show the distinct morphological changes. M20 grade of concrete was prepared and after 28 days of curing the specimens were taken out and getting exposed to a high temperature regime up to 1000˚C in step of 100˚C in a hot air oven for a constant retention period of 5 hours. The air dried pre and post fired concrete cubes were assessed for their physical deterioration by UPV. The following conclusions were derived from the experiment:-

- The drastic reduction in pulse velocity across the concrete cubes between 300˚C and 700˚C from 3.5 to 0.33 km/h, established that the physical state of concrete deteriorates rapidly beyond 300˚C
- Reduction of compressive strength beyond 500˚C rapidly and complete decomposition after 700˚C.
- Morphological study confirmed clear deformation of well-developed calcium hydroxide crystals and C-S-H gel beyond 600˚C

III. **CONCLUSIONS**

The previous results as shown in research represents that high temperatures can be divided into distinct ranges in terms of effect on concrete strength. In the starting of the range 50-200˚C, an increase in strength was observed in normal strength concrete. Until 400˚C, air cooled concrete maintained 80% of its initial strength, while 70% was maintained in water cooled specimens. After 400˚C concrete lost their strength rapidly and strength loss was more in water cooled specimens.

IV. REFERENCES

[I] Xin lua, Wei Sun, Sammy Yin Nin Chan, "Effect of heating and cooling regimes on residual strength and microstructure of normal strength and high performance concrete", Journal of cement and concrete research, Vol. 30, Issue 3, march2000, pp.379-383.

[II] WuYao[a], JieLi[b], KeruWu[a], "Mechanical properties of hybrid fibre-reinforced concrete at low fibre volume fraction", journal of cement concrete and research, Vol. 33, Issue 1, Jan2003, pp. 27-30.

[III] Bingol A. Farhat and Gul Rustem, "Effect of elevated temperatures and cooling regimes on normal strength concrete", Journal of fire and materials, Vol. 33, Issue 2, March2009, pp. 79-88.

[IV] Subhash C. Yaragal1, K S Babu Narayan2 and Adari S3, "Strength Characteristics of Concrete Exposed to Elevated Temperatures and Cooled Under Different Regimes", journal of structural fire engineering Vol. 3, Issue 4, 2012, pp. 301-310

[V] S.K. Handoo, S. Agarwal, S.K. Agarwal, "Physicochemical, mineralogical, and morphological characteristics of concrete exposed to elevated temperature",journal of cement and concrete research, Vol. 32, Issue 7, july2012, pp. 1009-1018.

[VI] Mucteba Usyal, Kemalettin Yilmaz, Metin Ipek, "Properties and behaviour of self-compacting concrete produced with GBFS and FA additives subjected to high temperatures", construction and building materials, Vol. 28, Issue 1, march2012, pp. 321-326.

[VII] S. Deepa Shri, R. Thenmozhi, M. Anitha, "Mechanical properties of SCC with polypropylene fibres", international journal of advanced scientific research and technology, Vol. 3, Issue 2, june2012, pp.2249-9954.

[VIII] Hadi Mashhadban, Saman Soleimani Kutanaei, Mohammad Ali Sayarinejad, "Prediction and modelling of mechanical properties in fibre reinforced concrete using particle swarm optimization algorithm and artificial neural network", journal of construction and building materials, Vol. 119, Issue 30, august2016, pp. 277-287.

[IX] Jin Tao, Yong Youn, Luc Taerwe, "Compressive strength of self-compacting concrete during high temperature exposure", journal of materials in civil engineering Vol. 22, Issue 10, March2016, pp.1005-1011.

[X] Gai-Fei Peng[a], Song-HuaBian[a], Zhan-QiGuo[b], JieZhao[a], Xin-LaiPeng[a], Yu-ChuangJiang, "Effect of thermal shock due to rapid cooling on residual mechanical properties of fibre concrete exposed to high temperatures", journal of materials in civil engineering Vol. 22, Issue 5, may2008, pp.948-955.