International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 5, May-2018

BEHAVIOUR OF REINFORCED CONCRETE BEAM WHEN EXPOSED TO HIGH TEMPERATURE WITH 20% REPLACEMENT OF CEMENT BY FLY ASH

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Abstract— Though concrete structures have good fire resistance properties, the structures when exposed to high temperatures for longer duration may lose its strength resulting failure in the structural members. Many structures get damage due to fire accidents. So, to resist the structural damage against fire, Alkali resistance glass fibers were added in concrete mix for different percentages (0%, 1% and 2%) by weight of cement since the glass fiber is good crack arrester and fire resistant material. Some mechanical properties and flexural behaviour of reinforced concrete beams under the effect of high temperature with 20% replacement of cement by fly ash has discussed and M30 grade of concrete is used. The concrete specimens like cubes, cylinders and beams were subjected to high temperatures ranging from (27℃-200℃) for standard duration at the age of 28 days. From this study it is concluded that (20%FA+2%GF) is the best combination among all proportions, which shows maximum compressive strength, tensile strength and better flexural strength at the age of 28 days.

Keywords—Fly Ash (FA); Alkali Resistance Glass Fiber (GF), reinforced concrete beams, fire resistance, flexural strength.

I. INTRODUCTION

Concrete has been used as construction material in structures due to various advantages, such as strength, durability and non-combustibility properties. Concrete is a good fire resistant material, but when it is used in buildings have to satisfy the appropriate fire safety requirements, because fire represents one of the most severe environmental condition. When concrete is exposed to high temperatures for longer durations the structures loses its strength and stiffness. To increase the tensile and flexural strength, fibers are added in concrete. Adding of fibers to concrete will arrest the cracks and improves tensile strength. In this investigation Alkali resistant glass fibers are used as temperature resistant material in concrete structure to increase the tensile and flexural strength and also to arrest the cracks when subject to high temperature.

Now-a-days, for many reasons, concrete construction industry is not sustainable. Mainly it requires very large amount of materials which can again require for next generations. The main building material in concrete is Portland cement, the production of Portland cement produces huge amount of carbon dioxides, which causes green house effect, global warming, and climatic change. So, use of agricultural and industrial waste products for partial replacement of Portland cement is sustainable. One of the most important and sustainable material of mineral admixture among the industrial waste is fly ash, as it is available in larger quantities and relatively contains a huge amount of silica.

Cement is replaced with 20% of fly ash in the concrete mix of M30 grade with proportions of 1:1.32:2.97:0.45 (cement: fine aggregate: coarse aggregate: w/c) and alkali resistant glass fibers were added in concrete mix by weight of cement with different percentages (0, 1, and 2). The concrete specimens like 27 cubes, 9 cylinders and 9 beams were casted and tested for compressive, tensile and flexural strength with different temperature exposures ranging from 27℃-200℃ for standard duration in hot air oven after 28 days of curing.

Objectives

- To study the flexural behaviour of Reinforced concrete beams when exposed to high temperature with 20% replacement of cement by fly ash were glass fibers are added as temperature resistant.
- To study the various properties of concrete by using fly ash as a mineral admixture with 20% replacement of cement when exposed to high temperature were glass fibers are added as temperature resistant.

II. MATERIALS AND MATERIAL PROPERTIES

Ordinary Portland cement conforming to BIS 12269-2013 53 grade (Birla A1) was used. The basic properties of cement as per the code IS456:2000 are tested. The results obtained were fineness 4%, specific gravity 3.07, standard consistency of cement 33% and initial setting time of 38mins.Class F fly ash was used as partial replacement of cement by 20% in concrete, It was collected from kakatiya thermal power station, Warangal. The basic properties of fly ash are tested as per the code IS3812 (part1) and the results obtained as fineness 5% and specific gravity 2.29. River sand of size below 4.75mm conforming to zone II of IS 383-1970 was used. Natural crushed stone of 20mm and 10mm was used as coarse aggregate. AR glass fibers of 12mm length, diameter of 0.014mm fibers usually round and straight are used. The glass fibers used in this experimental study is collected from Monika Internationals, Jaipur. Ordinary portable water with pH 7 is taken for concrete mixing and curing. The concrete mix M30 confirming to IS 10262-2009 is made with 20% replacement of cement by fly ash where glass fibers are added with different percentages (0%, 1%, and 2%) respectively. Mix proportion used in this study is 1:1.32:2.97 with water-cement ratio of 0.45.

III. EXPERIMENTAL WORK

The main aim of this experimental work is to study the flexural behaviour of reinforced concrete beams and some properties of concrete where cement is replaced by 20% with fly ash and glass fibers are added as fire resistant material as well as crack arrester by weight of cement in concrete. Thus, it is expected that use of fly ash and glass fiber in concrete shows better strength and other properties of concrete. Class F fly ash was used in this study which is collected from kakatiya thermal power station and glass fibers are collected from Monika Internationals, Jaipur. Various basic properties tests are conducted on all the materials used in this study during the progress of work. The materials are weighed according to the proportions and hand mixing of materials is done. Materials were added accordingly and water is added for mixing the materials with the water cement ratio of 0.45. After mixing of concrete the slump is checked for each mix. For each mix proportion 9 cubes of size 150*150*150mm, 3 cylinders of 150mm diameter and 300mm in height and 3 beams of 1200*100*150mm are casted. Totally 27 cubes, 9 cylinders, 9 beams are casted. After casting, specimens are kept a side and unmolded after 24 hours of casting. The specimens are then cured in water for 28 days. After 28 days of curing, the specimens are subjected to high temperatures ranging from 27-200°C in hot air oven for the standard duration to reach its required temperature. Then the specimens are cooled for 24hours and tested under compression, tension and flexure.

Testing of specimens

Compressive strength test on cubes, split tensile strength test on cylinders and flexural strength test on beams are carried out as shown in figure.

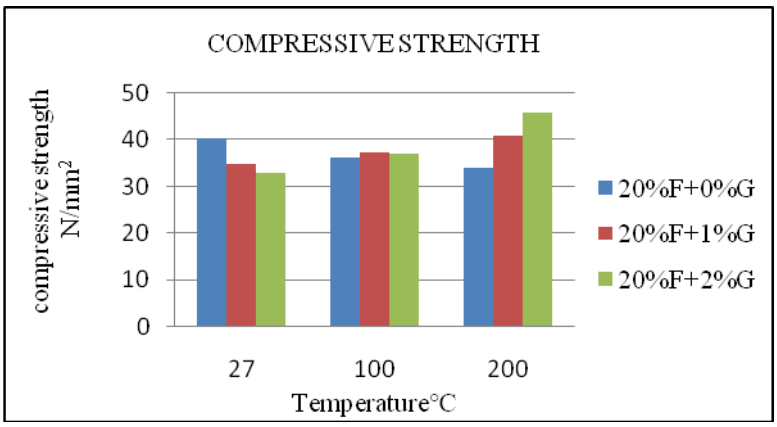
Figure 1 Testing of cube strength

Figure 2 Testing of cylindrical strength

Figure 3 Testing of beam strength

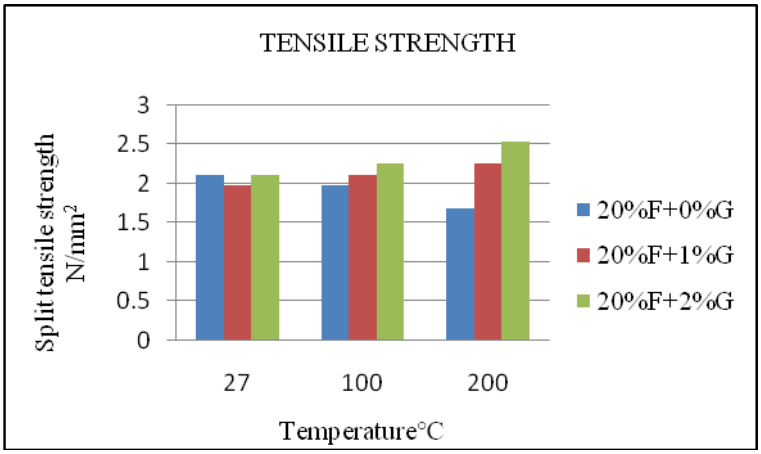
Figure 4 Beams after testing

IV. RESULTS AND DISCUSSIONS



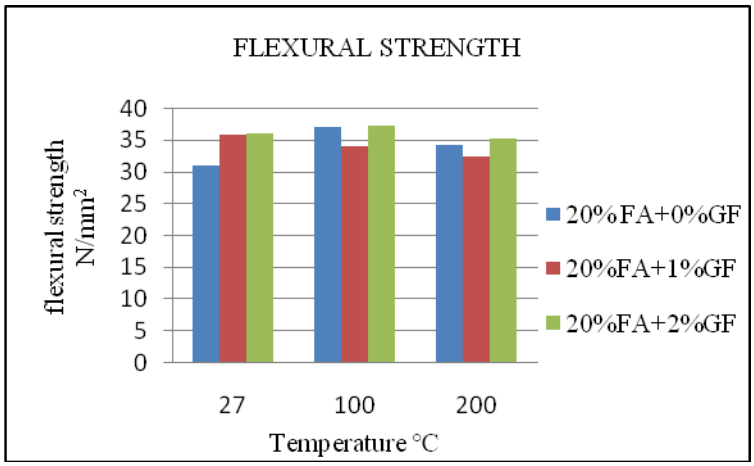
Graph 1 Compressive Strength of concrete for 28 days

Graph 1 represents the compressive strength of concrete with 20% replacement of cement by fly ash with different glass fiber percentages when exposed to high temperatures. The compressive strength of 20% F+2%G at 200℃ is increased than other concrete mix. The optimum percentage of concrete was obtained at 20%F+2%G at 200℃ for 28 days



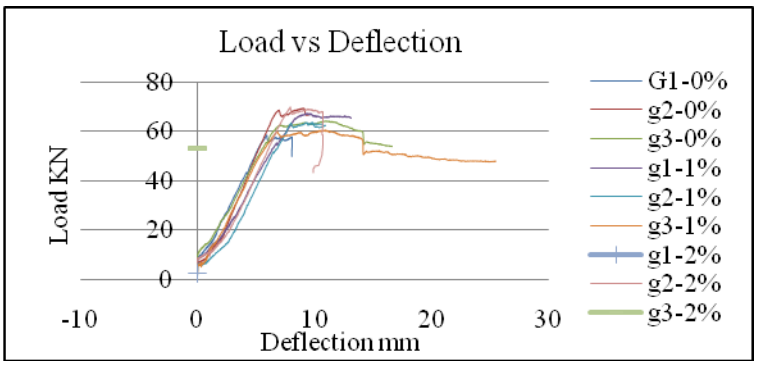
Graph 2 Tensile Strength of concrete for 28 days

The above graph 2 shows that fly ash mix and addition of glass fibers gives greater strength than the strength compared to the fly ash mix concrete. The maximum tensile strength of the concrete is obtained at 20%F+2%G at 200℃ for 28 days. The tensile strength for 20%F+0%G was observed decreasing as the temperature increased.



Graph 3 Flexural strength of concrete for 28 days

From the graph 3, it was concluded that 20%F+2%G combination gives the optimum strength when exposed to high temperature than other fly ash concrete mixes. The flexural strength is found to be increased for 20%F+2%G at 100℃ for 28 days.



Graph 4 Load vs Deflection

Graph 4 represents the load deflection curve of reinforced concrete beam with different percentages of glass fibers added in fly ash concrete and exposed for various temperatures. Maximum deflection is occurred in g3-2% i.e, 2% glass fiber at 200℃ which is greater than the theoritical deflection.

V. CONCLUSIONS

Based on the experimental study and test results on fresh and hardened concrete following conclusions are drawn

- Addition of glass fibers as fire resistant material in the fly ash concrete gives better results than fly ash concrete and reduced its workability and increased the strength at 28 days when it was exposed to high temperatures.
- The compressive strength of 20%F+2%G at 200℃ is 45.92N/mm which is greater than 20%F+0%G and 20%F+1%G at 200℃ about 21.29% and 10.64% respectively. The compressive strength for 2%G cubes exposed to temperature at 200℃ is greater than the cubes exposed to temperature at 27℃ and 100℃ about 28% and 19.35% respectively.
- The tensile strength of concrete for 20%F+2%G at 200℃ is 2.54 N/mm^2 which is greater than the 20%F+0%G and 20%F+1%G at 200℃ about 33.46% and 11.02% respectively. The tensile strength for 2%G cylinders exposed to temperature at 200℃ is greater than the cylinders exposed to temperature at 27℃ and 100℃ about 16.53% and 11% respectively.
- The flexural strength of 20%FA+2%GF at 100℃ is 37.46 N/m^{m2} which is greater than the 20%FA+0%G and 20%FA+1%GF at 100℃ about 0.77% and 8.88% respectively. The flexural strength for 2%GF beams exposed to fire at 100℃ is greater than the beam exposed at 27℃ and 200℃ about 3.33% and 5.55% respectively.
- Maximum deflection is occurred in g3-0% i.e, 0% glass fiber at 200℃ which is greater than the theoritical deflection.
- The combination of 20% fly ash and 2% glass fiber i.e, 20%FA+2%GF gives good compressive, tensile and flexural strength than other fly ash concrete and fly ash combination mixes.
- Use of fly ash in concrete reduces the heat of hydration and cement content. Thus, the construction work with fly ash concrete becomes environmentally safe and also economical.

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