

Performance evaluation of high performance concrete beams under cyclic loading

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Abstract

High performance concrete essentially consists of the same ingredients as in conventional concrete but the proportions are designed to provide the strength and durability which are needed for the structural and environmental requirements of the structure. Fiber-reinforced concrete is a concrete containing ingredients of conventional concrete and fibres which increases its structural integrity. Fibers act as crack arrester which are primarily due to plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete. The main aim of the present experimental investigation is to combine different fibres namely crimped stainless steel fibre and Aramid fibre to produce HFRC and thus to evaluate its mechanical performance. In Addition Micro silica and Quartz powder is added to obtain high performance. Based on I.S. Code method of mix design, proportion of different ingredients was obtained to get M60 grade concrete. Samples were prepared by varying the volume fraction of Steelfibre and aramid fibre from 0 to 1.5%. Three specimens of Cubes, Cylinders, and Prisms for each volume fraction of fibers are casted. Mechanical properties of each concrete composite were studied. The structural parameters such as load carrying capacity, ductility characteristics and energy absorption capacity of HPHFRC beams were assessed.

Keywords: High Performance Concrete, Load Carrying Capacity, Ductility, Energy Absorption Capacity.

1. Introduction

For civil engineering structures of all kinds, concrete is the second most widely used construction material in the world after water. Numerous advances in all areas of concrete technology including materials, mixture proportioning, recycling, structural design, durability requirements, testing and specifications have been made.

In recent years, researchers have focused on the improvement of concrete quality regarding its mechanical and durability properties, service life and environmental aspects. In a tropical country like India that has more than 3000 km of coastline where approximately 80% of the annual rainfall takes place in the two monsoon months, corrosion related problems are alarming in chloride-rich environmental zones.

Moreover in metro cities, the carbon and nitrogen oxide emissions aggravate the situation further by neutralizing the concrete cover. In recent years, the concrete construction industry has faced a very significant challenges in view of the rapid rate of deterioration of infrastructure in terms of spalling of the cover, rebar corrosion, cracking, loss in bond, loss in ductility, etc., A composite can be termed as hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that derives benefits from each of the individual fibres and exhibits a synergetic response. Addition of hybrid fibres generally Contributed towards the energy absorbing mechanism (bridging action) whereas, the non-metallic fibres resulted in delaying the formation of micro-cracks. Here an attempt is made to study the mechanical and flexural behaviour of high performance concrete

reinforced with aramid and steel fiber along with micro silica and Quartz powder.

2. Materials and mix proportion

In developing the concrete mix for high strength concrete, it is important to select proper ingredients, evaluate their properties and understand the interaction among different material for optimum usage. The different materials used in this investigation are Cement, Micro silica, Quartz Powder, Water, Fine aggregate, Coarse aggregate, Aramidfibre, crimped Steel Fibre and Chemical admixture. Ordinary Portland Cement of 53 grades available in local market is used in the investigation. A quartz powder with a diameter smaller than 1.0 μm was used as micro filler. Its particle fills the lack between the cement particles and makes the grading curve of the mixture composed of cement and quartz powder continuous. Superplasticizer used in this investigation is Master Glenium SKY 8233.Mix proportion was arrived based on the guidelines given in Indian standard code 10262 : 2009. Various trial mixes were tried by varying Micro silica and fibre volume. The final mix proportion used for the present research is Mix 1, 2 and 3, 1: 1.91:2.1 and water cement ratio of 0.3. Optimum micro silica used is 10% by weight of cement and 5% of Quartz powder by weight of cement is used as an additive.

3. Experimental investigation

Mechanical properties such as compressive strength, split tensile strength and flexural strength were assessed. The wooden beam mould of (100x170) mm in cross section and 1200mm long was

selected for the casting of beam specimen. Two numbers of 10mm diameter rods at both top and bottom and 8 mm diameter stirrups spaced at 100mm centre as shear reinforcement grill was used as shown in figure 3.1. High performance hybrid fibre reinforced beams were cast and cured for 28 days. Beams were tested in loading frame under cyclic loading to assess the strength parameters such as load carrying capacity, ductility characteristics and energy absorption capacity.

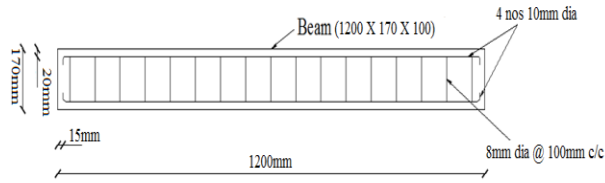


Fig. 3.1: Reinforcement details

4. Test results

Test results on companion specimen are given in Table 4.1.

Table 4.1: Test Results at 28 Days

Mix	Compressive strength(MPa)	Split tensile strength (MPa)	Flexural strength at (MPa)
Mix 1	67.5	5.6	6.8
Mix 2	72.1	6.2	7.4
Mix 3	69.4	5.9	7.1

Mix 1 – 0.5% steel fibre and 1.5% aramid fibre, Mix 2 – 1% steel fibre and 1% aramid fibre, Mix 3 – 1.5% steel fibre and 0.5% aramid fibre

4.1. Test results on HPHFRC beams

The results of the experimental investigation on the flexural behavior of HPHFRC beams are discussed. The load carrying capacity of beams were found to be 76.4 kN, 86.25kN and 83.25kN. Variation of Energy absorption capacity of beams under cyclic loading were shown in figure 4.1.3.

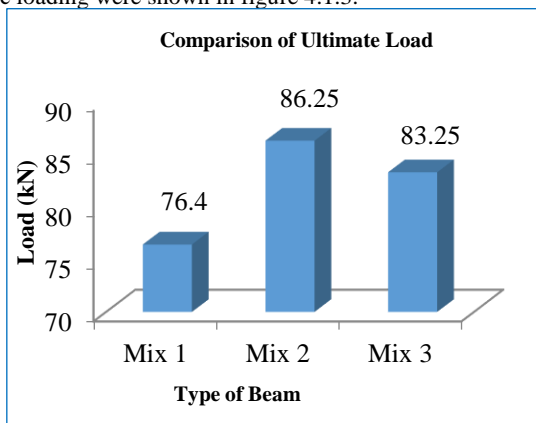


Fig. 4.1.1: Ultimate load

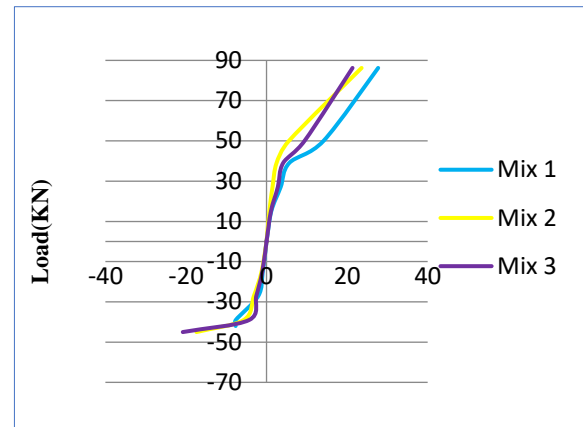


Fig. 4.1.2: Load deflection curve

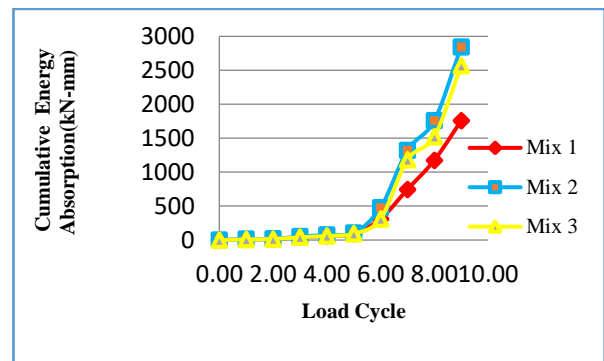


Fig. 4.1.3: Energy absorption

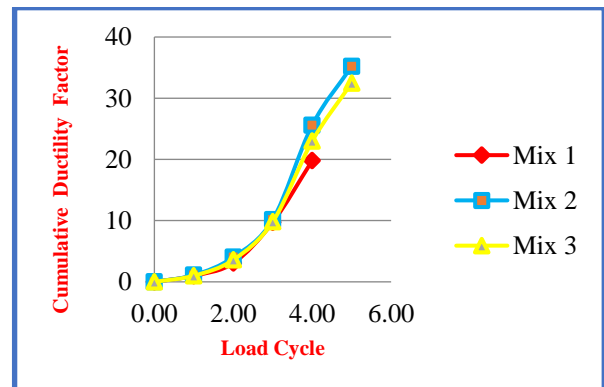


Fig. 4.1.4: Variation of cumulative ductility factor with load cycles

5. Conclusion

Based on the experimental results, the following conclusions are drawn.

- The mix 2 by inclusion of 1% of steel fibre and aramid fibre was identified effective in compression, tension and flexure .
- The ultimate load carrying capacity of Mix 2 beam is about 1.12 times that of Mix 1 beam.
- The hybrid fibre reinforced concrete specimens exhibit reduced crack width at all load levels, the maximum reduction in crack width was found.
- Instead of adding single fibre, the combination of different types of fibres(Hybrid fibres) increases the energy absorption capacity substantially. This phenomenon is particularly advantageous in case of structures situated in Earth quake prone areas.
- Thus overall observation of this study shows that it advantageous to use High Performance Hybrid Fibre Reinforced Concrete mix with (1% of steel + 1 % of aramid fibre + 5% of Quartz Powder) which gives satisfactory results in all conducted tests for concrete Grade M60.

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