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Experimental Behavior of High Performance Fiber Reinforced Concrete

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ABSTRACT

An experimental investigation of the behavior of concrete beams reinforced with conventional beams subjected to flexural loading is presented. An experimental program consisting of tests on steel fibre reinforced concrete (SFRC) beams with conventional reinforcement and reinforced concrete (RC) beams was conducted under flexural loading. SFRC beams include two types of beams containing beams with fully hybrid fibres and beams with fibers only in hinged zones. The cross sectional dimensions and span of beams were fixed same for all types of beams. The dimensions of the beams were 80mm x 120mm x 2200mm. Tests on conventionally reinforced concrete beam specimens, containing Steel fibers in different proportions, have been conducted to establish load deflection curves. The various parameters, such as, first crack load, ultimate load and stiffness characteristics, energy absorption, toughness index of beams with and without steel fibers have been carried out and a quantitative comparison was made on significant stages of loading. It was observed that SFRC beams showed enhanced properties compared to that of RC beam. Finally calculate the ultimate strength of the conventionally reinforced beams with steel fibers. The ultimate loads obtained in the experimental investigation were also compared for all types of beams.

1. INTRODUCTION

General : Concrete is a structural components exist in buildings and bridges in different forms. Understanding the response of these components during loading is crucial to the development of an overall efficient and safe structure. Different methods have been utilized to study the response of structural components. Experimental based testing has been widely used as a means to analyze individual elements and the effects of concrete strength under loading. It has now become the choice method to analyze concrete structural components. Concrete can withstand whatever compressive forces, more over its workable and durable material, can be formed to any shape, also it's a cheap material. At the same time it require special care and precaution during casting otherwise it could cause cracks and failure. Load-Deformation Response of control beam and Application of Effective Prestress, Self-Weight, Zero Deflection, Decompression, Initial Cracking, Secondary Linear Region, Behavior of Steel Yielding and Beyond, Flexural Limit State of prestressed concrete beam . Firstly, literature review was conducted to evaluate previous experimental procedures related to reinforced concrete. The observation was focused on reinforced concrete beam behavior at first cracking, behavior beyond first cracking, behavior of reinforcement yielding and beyond, strength limit state, load-deformation response, and crack pattern. High performance fiber reinforced concrete is developing quickly to a modern structural material with a high potential. At this moment studies are carried out with the aim to come to an international recommendation for the design of structures with HPFRC. The results obtained was focused on the same as before also comparison of first cracking load, ultimate load, work-done in linear and nonlinear region, and load deflection nature between these different reinforcement ratio of the analytical beam. An experimental program conducted to study the flexural behavior and redistribution in moment of reinforced high strength concrete (RHSC) continuous beams. Comparisons between experimental and predicted moment and load capacity show that the proposed model agrees very well with the test results, thus justifying the use of the proposed model for HSC and NSC in strengthened beams. Natural disasters like earthquakes, cyclones, tsunami, etc, destroy the high rise buildings, bridges, monumental structures, world wonders, etc. To protect the world from that kind of devastation, the field of civil engineering require some innovations in both materials and construction techniques. One such development has two phase composite materials i.e. fiber reinforced concrete, in which cement based matrix acts as cracks arresters which restricts the growth of flaws in the matrix, preventing these from enlarging under load into cracks. The weakness can be removed by inclusion of fibers in concrete the fibers help to transfer loads at the internal micro cracks. The fibers can be imagined as aggregate with an extreme deviation in shape from the smooth aggregate. Increases flexural toughness / residual strength. Provides post-crack performance with Increased impact and abrasion resistance, load bearing capacity of concrete and Potential reduction of concrete beam depth to the Concrete retains load carrying capability after cracking has occurred in Increased durability and reduced maintenance costs with no requirement for crack control steel mesh, Concrete placement and crack control in one operation. Cost effective alternative to conventional steel mesh reinforcement no need to purchase and store additional material and no delays to fast track schedule with Easier positioning of joints to Reduced site labour requirement for on-site handling and cutting of steel reinforcement also no secondary steel mesh is required and reinforcement is automatically positioned Controls cracking which occurs in the hardened state even distribution of fibers throughout the concrete. A tougher surface with fewer bleed holes Enhanced load bearing capability which Improved flexural properties.

2. HIGH PERFORMANCE CONCRETE

High performance concrete has more uniform and also homogeneous micro structures than that of normal concrete. When silica fume is mixed with ordinary Portland cement low water cement ratio micro structure of such mixture has mainly crystalline hydrants, forming the dense matrix of low porosity. As the content of the silica fume is increased in concrete, major part of calcium hydroxide is transformed into calcium silicate hydrates while the left over calcium hydroxide has the tendency to for smaller crystals compared to those present in the OPC paste. All these three phases must be optimized, which means that each must be considered explicitly in the design process. It is very important to pay careful attention to all the aspects of concrete production (i.e. selection of materials, mix design, handling and placing). It indicates that quality control is an essential part of the production of high performance concrete and requires full co-operation among the materials, ready mixed supplier, the engineer and the contractor. High performance concrete has various advantages such as high modulus of elasticity, high abrasion resistance, high durability, and long life in severe environments Low permeability and diffusion Resistance to chemical attack high resistance to frost and de-icier scaling damage Toughness and impact resistance.

3. MATERIALS USED

Cement - Ordinary Portland cement of review 53 is utilized as a part of the pervious cement and the concrete is utilized as a coupling material.

Coarse aggregate - Locally accessible pulverized blue rock stones adjusting to reviewed total of ostensible size 12.5 mm according to Seems to be: 383 – 1970. Smashed rock total with particular gravity of 2.77 and going through 4.75 mm strainer and will be utilized for throwing all examples. A few examinations infer that most extreme size of coarse total ought to be confined in quality of the composite. Notwithstanding bond glue – total proportion, total sort impacts concrete dimensional dependability.

Water **-** Water utilized for blending ought to be compact drinking water having pH values between 6 to 8 and it ought to be free from natural matters and the strong substance ought to be inside as far as possible according to IS 456-2000 and fitting in with IS 3025-1964. In the present test concentrate the water accessible inside the school grounds is utilized for all reasons.

Silica Fume **-** This by-result of silicone generation comprises of superfine round particles which altogether increment the quality and solidness of cement. It can supplant concrete in amounts of 5-12%.

Hooked End Fiber **-** The length of the fiber is 30 mm. The aspect ratio of fiber is 48.4.The diameter of hooked end fibers is 0.62mm. The tensile strength of the fiber is 1100Mpa. Fig 4.1 shows the view of the hooked end fibers.

Fig: Hooked end fibers

Crimped Fiber **-** The length of the fiber is 38 mm. The aspect ratio is 69.09). The diameter of crimped fiber 0.55mm. The tensile strength is 600Mpa. The Material type of crimped fiber is low carbon drawn flat wire. The crimped fiber as shown in the Fig

Fig : Crimped fiber

4. MIX PROPORTION

Based on IS Method:

Characteristic strength of concrete is 40Mpa

Design average cube strength at 28 days

40/0.75 = 53.33 N/mm2

Optimum W/C ratio = 0.40

Density of Concrete = 2500 Kg/m3

Bulk Density of Cement = 1700 Kg/m3

Bulk Density of coarse aggregate = 1670 Kg/m3

Cement: F.A : C.A - 1: 1.05 : 2.28

Quantities of materials per m3 concrete:

Cement: 490 Kg/m3

Coarse aggregate: 1121.74 Kg/m3

Water: 196 Kg/m3

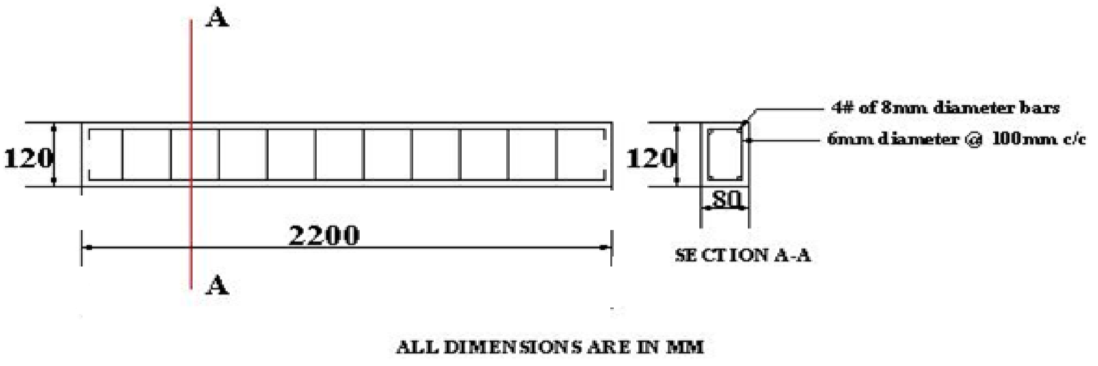
Silica fume (10%): 41Kg/m3

Fiber (10% & 20%): 60Kg/m3, 130Kg/m3

5. EXPERIMENTAL ANALYSIS

A. Dimensions of beams

The beam mould was prepared by standard steel mould having cross section. It is used for casting the beams with and without fibers. Hence the size of the beam is of 80 x 120 x 2200mm.



All the beams were cast with following reinforcement details. Four bars of 8mm diameter are used as main reinforcement 2 numbers at top and 2 numbers at bottom, 6mm diameter stirrups are spaced at 100mm c/c to act as shear reinforcement. The reinforcement details for the beam specimens shown in fig.

B. Casting of specimen

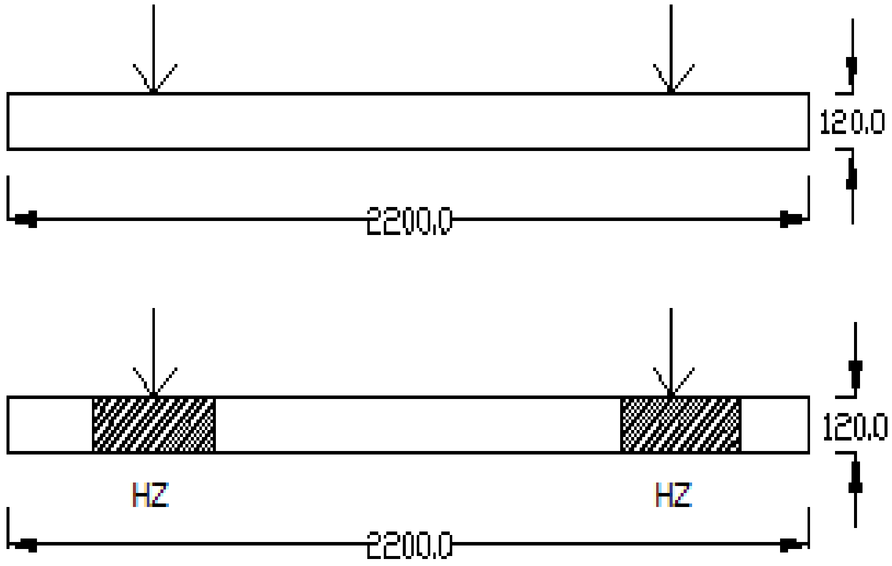
The exact quantities of materials for the specimen were weighted and kept separately before the mixing started. Machine mixing was adopted and the concrete mix was placed in mould layer by layer and compacted well. Hand mixing was adopted for convenient handling of steel fibre. Sand and cement with silica fume were mixed dry and kept separately. Then coarse aggregate was added and approximately quantity of water was sprinkled on the dry mix. In order to avoid the formation of lumps by gentle sprinkling the fibres were randomly oriented in the concrete mix. Beams casted with fully hybrid fibres and fibres only in hinged zone for flexural strength of plain concrete with and without fibres. Fig shows the casting of beams.

C. Experimental program testing specimens

Test specimens consist of four conventional HPC beams with two different reinforcement with 10mm diameter main reinforcement and 8mm diameter as stirrups and 8mm diameter as main reinforcement and 6mm diameter as stirrups.

Then the five SFRC beams are casted with one conventional beam and four SFRC containing0.8% hybrid steel fibers by volume of concrete. The cross sectional dimensions and span of beams were fixed same for all types of beams. The dimensions of the beams were80mm x 120mm x 2200mm. Two types of SFRC beams specimens were cast using hybrid steel fibers for full length of beams with volume fractions of 1.5% with the described reinforcements. The ultimate tensile strength of steel fibers was 584.59 MPa.

The aspect ratio of all fibers was kept constant at 75. The reinforced concrete beams were designated as C and the two types of steel fiber reinforced beams were designated as FH and FHZ respectively.



D. Preparation of test specimens

For the preparation of specimens the concrete mix proportion was adopted was 1:1.2:2.2 by weight (cement: sand: coarse aggregate) with water cement ratio of 0.4. The concrete mix was designed to achieve strength of 40 MPa. A suitable dose of admixture named cera-hipher plasticizer and silica fume was added in mixes to improve the workability of mixes. For casting of beams steel moulds were used. Beams were filled in 4-5 layers, each of approximately 50mm deep, ramming heavily and vibrating the specimens on vibrating table till slurry appears at surface of the specimen. In this way concrete was very well compacted. The side forms of moulds were stripped after 24 hours and then these beams were cured for 28 days in curing pond specially constructed for the investigation.

E. Loading arrangement

All beam specimens were tested under a loading frame of500 kN capacity. Beams were continuous over a span of 2200 mm. The load was applied through a screw jack which is connected with proving ring for applying manual loading. The load was distributed as two point loads kept apart symmetrical to centerline of beam on the top face. An I section has been place over the beam for the application of two point loading.

Then three dial gauge on the loading point for normal deflection and dial three will be used to measure upward deflection. A proving ring of 10 Ton capacity was placed between test frame and load distributor placed on the test specimen. Gap between test frame and plate was filled by spacers. Loading arrangement for beam specimens is shown in Fig

F. CONCRETE CASTING

Casting **-** The round and hollow form and cubical shape of standard example size is utilized for the throwing reason.

Cube shaped form – 150*300 mm

Cylindrical form – 150*150*150 mm

At first the solid is threw for various test outcomes and the casting depends on routine, in part utilizing silica rage, supplanting flotsam and jetsam with silica smolder, somewhat supplanting totals with garbage of 10% and supplanting trash with 20% along the steel fiber is threw. While throwing legitimate blending and less water substance is utilized as a part of specific.

The casting system is same for the all blend extents and it is important to apply oil before throwing.

Compacting **-** Normally standard cement requires more compaction where great compaction will bring about great quality angle though in pervious the whole cement is took into account less compaction as over compaction will diminish the porousness of water stream level.

Curing **-** Curing is took into consideration three diverse days and according to standard curing for 7 days,14 days, and 28 days is permitted according to IS method. The test results are acquired for nowadays and results demonstrates a significant increment in the quality in 14 and 28 days contrasting with 7 day quality outcome where 28 days curing is recommended for the great quality level.

6. TEST ON HARDENDED CONCRETE

A. Compressive strength test

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.

The compressive strength is calculated by using the formula.

$$\text{Compressive strength} = \frac{\textbf{load (P)}}{\textbf{area(A)}}$$

Where,

P - load is in KN

A - Area of cube in mm^2.

B. Spilt tensile strength test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The tensile strength of the specimen is calculated using the mentioned formula.

$$\text{Split Tensile Strength} = \frac{2P}{\pi\, DL}$$

Where ,

P = compressive load on the cylinder,

L = Length of the cylinder,

D = Diameter of the cylinder.

C. Permeability test

The permeability test is a measure of the rate of the flow of water through soil. In this test, water is forced by a known constant pressure through a soil specimen of known dimensions and the rate of flow is determined.

The coefficient of permeability (k) was determined by Equation:

$$k = (aL/At)LN(h1/h2)$$

Where,

k = coefficient of permeability (mm/min)

a = cross sectional area of the standpipe (mm2)

L = length of the specimen (mm)

A = cross sectional area of the specimen (mm2)

t = time for water level to reach from h1 to h2 (sec.)

h1 = initial water level (mm)

h2 = final water level (mm)

7. CONCLUSION

The experimental investigation is carried out to study the behavior of High Performance Fibre Reinforced Concrete Beam. The test results are compared with that of the Conventional high performance reinforced concrete beam. It based on study parameters such as first crack load, ultimate load, ductility factor and energy absorption, we compare all the beams with that of conventional concrete beam.

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