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Performance of steel fiber reinforced self compacting concrete

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ABSTRACT

The present work deals with the results of experimental investigations on steel fiber reinforced self compacting concrete. Effects of these fibers on various strengths of concrete were studied with varied fiber content from 0.5 to 3% at a specific interval with weight of cement. Strengths considered for investigation were compressive strength, flexural strength, split tensile and bond strength and tests on fresh concrete were also conducted. Ductility of concrete is found to increase in the fiber reinforced self compacting concrete as observed from the load deflection study. The Poisson's ratio is found to vary within the specified limits with static modulus of concrete relation between flexural shear strength and all other strengths are developed. A comparison result of steel fiber reinforced self compacting concrete and that of normal self compacting concrete shows the significant improvement in the results of various strengths.

Introduction

To Construct durable concrete structures skilled labours are required for placing and compaction of concrete. There was acute shortage of skilled workers in Japan and Europe, at the time of their re-development so Self compacting concrete(SCC) was first developed in Japan as a mean to create uniformity in the quality of concrete and by controlling the ever present problem of insufficient compaction and by a workforce that was losing technical surrounding by the increased complexity of design and reinforcement details in modern structural members. Durability was the major concern, and the purpose was to develop a concrete mix that would reduce or eliminate the need for vibrations to achieve consolidation. Self compacting concrete achieves this, by its unique fresh state properties in the plastic state, it flows under its own weight and homogeneity while completely filling any formwork and passing around congested reinforcement. In the hardened state, it equals or excels standard concrete with respect to strength and durability. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength providing the potential for high early strength, earlier remolding and faster use of elements and structures. Modern application of SCC is focused on high performance, better, more reliable and uniform quality binder the fiber helps to carry the load and give appropriate strength to the structural member

Objectives

To study the strength properties of steel fiber reinforced self compacting concrete(SFRSCC) composite with various fiber volume fractions such as, compressive strength, split tensile strength, flexural strength and pull out strength. The basic objective behind the research is to investigate the properties of fresh concrete such as, workability and density, to compare the properties of SFRSCC with that of normal SCC,to study the deflection characteristics of SFRSCC composite beam with various volume fractions to work out elastic constants such as static and dynamic modulus, Poisson's ratio and decide quality of concrete using non destructive testing (NDT) methods.

System Modeling

Steel fibers conforming to ASTM A820 type-I were used for experimental work. RC - 80/60 – BN which are high tensile steel cold drawn wire with hooked ends, glued in bundles and specially engineered for use in concrete the physical properties of steel fibers were diameter 0.75mm, length 60mm, average aspect ratio 80, tensile strength 1050 MPa, modulus of elasticity 200 GPa, and specific gravity 7.8

Flexural test on SFRSCC

Beams of size 100 x 100 x 500mm were supported symmetrically over a span of 400mm and subjected with two points loading till failure of the specimen occures on UTM, the deflection at the midspan of the beam is measured with sensitive dial gauge and the testing assembly as shown in (figure1) The two broken pieces (prisms) of flexure test were further used for equivalent cube compressive strength.

Figure1- Two point loading setup in flexure test

The flexural strength was determined by the formula

$$f_{cr} = P_f L / bd^2$$

Where

f_{cr} = Flexural strength, MPa

P_f = Central point through two point loading system, kN

L = Span of beam, mm

b = Width of beam, mm

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d = Depth of beam, mm

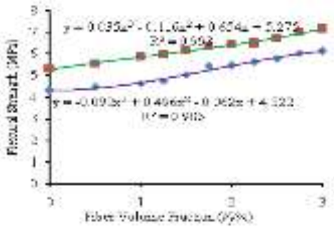
Expression for flexure strength in 3 rd degree polynomial in terms of V_f from the following equation of graph 1

7days:

$$f_{cr} = -0.092V_f^3 + 0.496V_f^2 - 0.062V_f + 4.322$$

28 days:

$$f_{cr} = 0.035V_f^3 - 0.116V_f^2 + 0.654V_f + 5.275$$



Graph 1Flextural Strength V/s Fiber Volume Fraction

Test for flexural shear strength

Maximum flexural shear strength of the beam specimen was computed by the following equation from theory of strength of materials, the flexural shear strength of concrete beam specimen was calculated as:

$$f_s = \frac{F_s}{bh}$$

where *fs*= flexural shear strength, MPa

$$F_s = \frac{P_f}{2}$$

P_f = flexural load in N

b = width of beam in mm.

h = depth of beam in mm.

Expressions for flexural shear strength in 3 rd degree polynomial in terms of V_f are given by the following equations from graph 2

7 days:

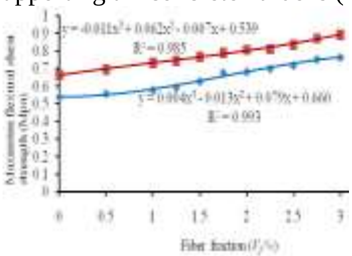
$$f_s = -0.011V_f^3 + 0.0625V_f^2 - 0.007V_f + 0.539$$

28 days:

$$f_s = 0.004V_f^3 - 0.013V_f^2 + 0.079V_f + 0.660$$

Bond Strength of Concrete (Pull Out Test)

The specimen were cast according to ASTM standard C 234-91a [58] with 12mm diameter tor steel rod embedded in 100mm x 100mm x 100mm concrete cube cast and compacted on vibrating table.The verticality of 12mm embedded tor steel rod is ensured, supporting till concrete hardens (figure2).



Graph 2. Flextural Shear Strength V/s Fiber Volume Fraction

The pull out test was carried out at 7 days and 28 days on UTM. The specimen was held between upper and middle cross head. The rod was gripped in upper cross head and cube was held below middle cross head. The tensile load was applied on steel bar for pull out purpose. The loads and slips were recorded at every 0.2 kN intervals till failure of specimen.

The maximum pull force is recorded in the test at bond failure. The deformations were recorded with sensitive dial gauge of least count 0.01mm. The maximum pull force and corresponding maximum slip gave us the work done in pulling the embedded rod out of concrete at 7 days and 28 days the bond strength is calculated for plain SCC and SFRSCC by using following equation.

$$\tau_{bd} = P/\pi dL$$

where

P = Pull out force in kN

Figure 2: Steel bar embedded in concrete cube

d = Diameter of rod embedded in concrete cube (12mm)

L = Length of rod embedded in concrete

Expressions for bond strength in 3rd degree polynomial in terms of V_f are given by the following equations from graph 3 7 days:

$$\tau_{bd} = 0.035V_f^3 - 0.184V_f^2 + 1.132V_f + 4.778$$

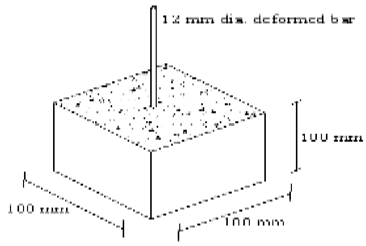
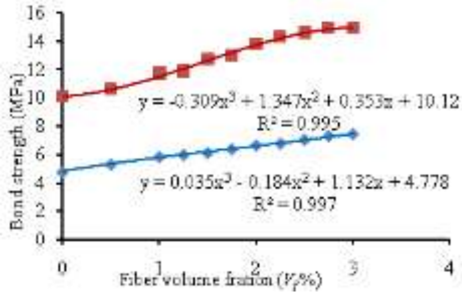


Figure2- Sample for Pull out test

28 days:

$$\tau_{bd} = -0.309V_f^3 + 1.347V_f^2 + 0.353V_f + 10.12$$



Graph 3. Bond Strength V/s Fiber Volume Fraction

Conclusions

This paper presents a summary of present study, the major conclusions and future scope of the investigation with the applications of SFRSCC.

Following conclusion are drawn based on the result discussed in the previous chapter:

The wet and dry density at 7 and 28 days has increased marginally for SFRSCC over normal SCC. This may be due to partial cement replacement by fly ash, which densifies the concrete because of its micro filler effect due to the relatively finer particle size.

Elastic constants of SFRSCC are obtained by various methods. Empirical expressions for modulus of elasticity i.e. static and dynamic have been developed in terms of fiber volume fraction and cube compressive strength of SFRSCC. Predicted values of modulus of elasticity are in excellent agreement with those of law of mixtur

In general, the significant improvement in various strengths is observed with the inclusion of Hooked end steel fibres in the plain concrete. However, maximum gain in strength of concrete is found to depend upon the amount of fibre content. The optimum fibre content to impart maximum gain in various strengths varies with type of the strengths.

The increase in compressive strength is 25.75% and increase in flexural strength is 19.47% of SFRSCC over normal SCC.

The split tensile strength went on increasing with the addition of fibers. The optimum fiber content for increase in split tensile strength is 1.75% and percentage increase is 24.49% of SFRSCC over normal SCC.

The optimum fiber content for bond strength is 1.75% while percentage increase is 28.71%. Satisfactory workability was maintained with increasing volume fraction of fibres by using super plasticizer. The width of cracks is found to be less in SFRSCC than that in plain SCC beam.

The pullout force is increased with increase in fibre content.

With increasing fibres content, mode of failure was changed from brittle to ductile failure when subjected to compression and bending.

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