Performance of High Strength Concrete Beam Under Flexure and Shear Failure

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Abstract:

This paper represents an experimental exploration on performance of High Strength Concrete (HSC) beam under flexure and shear. For this study M75 grade of concrete was adopted, the cube compressive strength of concrete at 28 days will be 79.5N/mm^2. The HSC was achieved by addition of silica fume as a supplementary cementitious material along with steel fibre, to improve the ductility of the concrete. The failure of beam element depends on different parameters. In this study the on flexural behaviour of HSC simply supported beam of size (150 x 180 x 1500)mm and also another specimen of same size was investigated for shear failure. The two number of beam specimen was cast with the main reinforcement of 2 numbers of 10mm diameter bars and 2 numbers of 8mm diameter as a hanger reinforcement along with stirrups of 6mm diameter bars at spacing of 150mm center to centerfor one member. Similarly the another member was cast with 2 numbers of 10mm diabars as main reinforcement and 2 numbers of 8mm dia bars as hanger reinforcement along with 6mm stirrups of spacing 250mm c/c.The experimental reports representthe mode of failure, crack load, yield load and ultimate load of these beam elements.

Keywords: *High strength concrete, shear failure, flexure failure.*

I. INTRODUCTION:

To protect the environment from being polluted by Co_2 released by cement industries and to improve the mechanical and durabilitycharacteristics of concrete, mineral admixtures are usedas supplementary cementitious materials, suchas GGBS, fly ash, silica fume andmetakaolineetc.Fortunely, most of these admixtures are industrial by-products. To reduce the cement content and improve the strength of concrete, silica fume was used as a supplementary cementitious material in this work. A definition of high strength concrete in quantitative term, as per ACI code, HSC is usually considered to be a concrete with a 28-day compressive strength of at least 42 MPa (6000Psi) and also as per IS 456- 2000, the concrete grade varies from M60 – M80 can be consider as a High strength concrete. In this study M75 grade of Concrete is preferred. Production of HSC may or may not require special materials, but it definitely requires materials of highest quality and their optimum proportion.The HSC can be beneficially used in compression members like columns and piles. HSC results reduction in column size and increases available floor space. The RCC beam element is universally used structural element for construction work. The mode of failure of beam element is depends on span to depth ratio, longitudinal and shear reinforcement,strength ofconcrete, Type of loading and support condition etc.

In this present work the behaviour of HSC beam has investigated with two different spacing of shear reinforcement. Otherwise the longitudinal reinforcement, span to depth ratio, grade of concrete, type of loading and support condition was same.

II. EXPERIMENTAL INVESTIGATION:

A. Materials Used:

Table 1: Properties of Cement

Grade of Cement	OPC 53
Specific gravity	3.15
Setting time	60 mins(Initial) and 300 minsFinal)

Table 2: properties of Fine Aggregate:

Type of sand	River sand
Specific gravity	2.6
Water absorption	1.4%
Dry rodded unit weight	1760 kg/m^3
Void content	34.2%
Fineness modulus	3.12

Aggregate passing through 10mm sieve was used as coarse aggregate in the concrete mixture.

Table 3: Properties of Coarse Aggregates:

Specific gravity	2.92
Water absorption	0.9%
Dry rodded unit weight	1679 kg/m^3

Plasticizer:

A commonly available super-plasticizer SIKA – Viscocrete HE 20 was used throughout this project to obtain the workableconcrete mix.

Steel Fibre:

The stainless steel fibre of aspect ratio 50 was used throughout this project.

III. POZZZOLONS:

As per ACI, the pozzolons are a broad class of siliceous or siliceous and aluminous materials which, in themselves, possess little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to formcompounds possessing cementitious properties.

A. Silica Fume:

It is much more reactive than any other natural pozzolans. Most research workers agree that the C-S-H gel formed by the reaction between the micro silica and $Ca(OH)_2$ appears dense and amorphous compared to the other pozzolons. It consistslarge amount of silica, approximately (90 – 99%).Because of its fine particles, large surface area and the high silica content, silica fume is a very reactive pozzolon when used in concrete.

Table 4:Chemical composition:

Constituents	*Cement (%)*	*Silica fume (%)*
Cao	60-67	0.5
Sio_2	17-25	90.26
Al_2O_3	3-8	5.84
Fe_2O_3	0.5-6	1.11
MgO	0.1-4	0.3
K_2O	0.5-1.3	0.7

*As per Astra chemicals

IV. CONCRETE MIX PROPORTIONS:

In the present work, a HSC grade to obtain a characteristic compressive strength of 75 MPa has been adopted. The mix design was done under the guidance of ACI 211.4R-93 “Guide for selecting Proportions for High Strength Concrete with Portland cement and Fly ash”.

Table 5: Mix Proportioning(Kg/m^3):

Cement	561
Silica Fume	99
Fine Aggregates	565
Coarse Aggregates	1138
Super Plasticizer	9.9
Water	165
Steel fibre	23.6

Table 6: Specification of Specimens

Specimen	***Beam 1***	***Beam 2***
Main Reinforcement	2 No's of 10 mm dia bars	2 No's of 10 mm dia bars
Hanger Reinforcement	2 No's of 8mm dia bars	2 No's of 8 mm dia bars
Shear Reinforcement	6mm dia bars	6mm dia bars
Effective Cover	25mm	25mm
Spacing of stirrups	150mm	250mm

V. SPECIMEN CASTING:

The specimens are cast with proper mix proportion and optimum usage of material. Due to low water – binder ratio, the super plasticizer was used. The concrete mixture was prepared by machine to get a better mixing as well as to get a better compaction, the vibration table has been used. After 24 hrs of casting the specimens were shifted to curing process. After 28 days of casting the cubes and cylinders are tested to obtain the characteristic compressive strength of concrete. A 2000 KN capacity uniaxial digital compression testing machine was used to test the specimens and the beam elements are tested by using 100Tons capacity Loading Frame at Structural Technology Center, Kumaraguru College of Technology.

VI. TEST RESULTS:

The specimens were tested and the test results have been tabulated.

Table 7: Compressive Strength of Concrete:

Specimens	***Compressive Strength (N/mm^2)***	***Avg Compressive Strength (N/mm^2)***
1	79.0	79.5
2	75.4	
3	84.12	

Table 8: Split Tensile Strength of Concrete:

Specimens	***Split Tensile Strength (N/mm^2)***	***AvgTensile Strength (N/mm^2)***
1	5.66	6.23
2	6.8	
3	6.24	

VII.PERFORMANCE OF BEAM ELEMENT:

The beams are tested and the test results such as mode of failure, first crack load and ultimate load can be observed. The displacement corresponding to the load can be observed by using dial gauge at the L/2 and L/4 region of the beam element. From the load and corresponding displacement, the load – deflection curve has been plotted and the yield load was computed.

A. ***Beam 1:***The first beam element is failed in the mode of flexure under ultimate load of 80kN. The flexure cracks are developed at the region of L/2 to L/3 distance of both sides.

B. ***Beam 2:***The second beam element is failed in the mode of shear under ultimate load of 75.1kN. The shear cracks are developed at the support.

Figure 1: Performance of beam (1) under flexure mode

Figure 2: Performance of beam (2) under shear mode

Figure 3: Comparison of beams under flexure and shear mode of failure

Table 9: Results Comparison

Specimen	*First Crack Load (KN)*	*First Yield Load (KN)*	*Second Yield Load (KN)*	*Ultimate Load (KN)*	*Mode of Failure*
Beam 1	23	38	52	80	Flexure
Beam 2	26	40	64	75.1	Shear

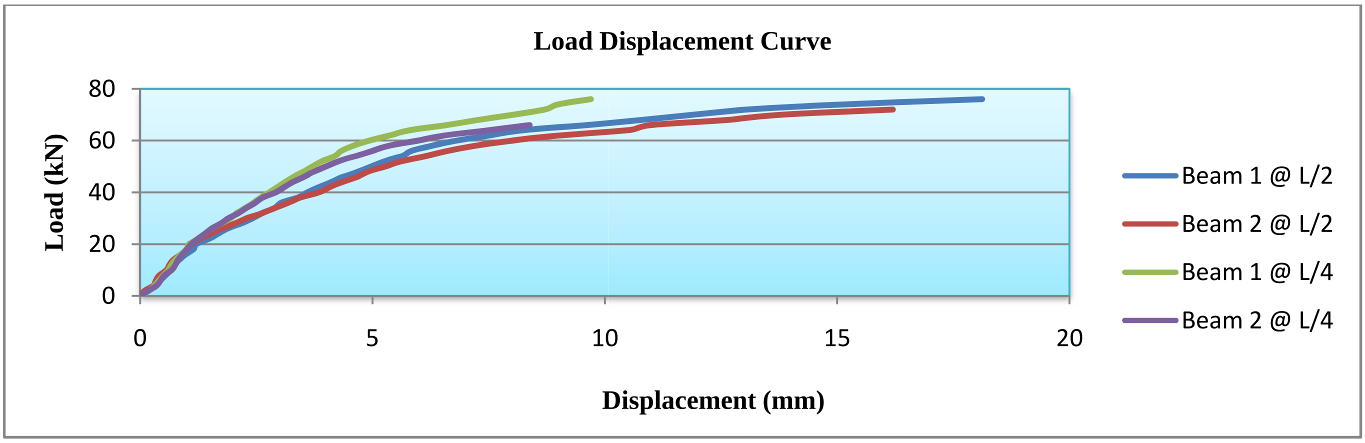

Figure 4: Load Displacement curve

From the plot the yield load can be obtained. The plot shows that the displacement is maximum (or) higher at L/2 of span (mid span) and the displacement is relatively low at the L/4 of span (quarter span). The displacement at quarter span is about 75% lesser than the mid span of the member.

VIII. CONCLUSION:

Based on the results of this study, it can be concluded that mix contains silica fumecan improve the mechanical properties of the concrete by 15% admixing level by weight of cement. The increase in strength can be attributed to the improved aggregate-matrix bond, higher rate of pozzolonic reaction resulting from the formation of a less porous transition zone in the silica fume concrete. The test results revealed that failure mode of the beam element depends on the spacing of the shear reinforcement. Under the nominal spacing, the element was failed in flexure mode. The increase of stirrups spacing will change the mode of failure and it will failed in shear modeThe test results shows that the ultimate load carrying capacity of flexure failure beam was 80KN and that of shear failure beam was 75KN. This shows relative increase in load carrying capacity of flexure beam. Thedeflection of shear failure beam shows less deflection upto ultimate.

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