EXPERIMENTAL STUDY ON SHEAR STRENGTH FOR ULTRA-HIGH PERFORMANCE CONCRETE BEAM

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1 Introduction

When it comes to the present, high-rise and larger buildings were increasing, as the research and the use of Ultra-High Performance Concrete (UHPC) are increasing. We should be solved the weakness thing, about a brittle fracture to use UHPC at the field. Especially it is immediate problem that is brittle fracture due to shear strength.

To prevent shear failures, beams are traditionally reinforced with stirrups. The use of stirrups is expensive because labor cost due to rise. And in terms of structure poor attachment of concrete and reinforced bar has become a problem. An alternative solution to stirrup reinforcement is the use of steel fiber. It can be shown to increase shear resistance.

This study aims to effect on shear strength, about steel fiber in UHPC through experiment. Also steel fiber is how to effects at the strength and ductility of Ultra-High Performance Concrete.

Investigate shear equation of UHPC through comparing previous proposal. How to effects steel fiber on shear strength equation of UHPC.

2 Background Research

Review previous study about shear strength estimation at High-strength concrete beams containing steel fiber. To know that concrete strength and steel fiber content how to effect on the beams.

2.1 Sharma (1986)

$$V_u = kf_t(d/a)^{0.25} \qquad (1)$$

Shear span ratio and tensile strength effect on shear strength. It can use this proposal simply, when we only have concrete tensile strength data. Coefficient k is affected by the test method.

But fiber factor does not appear directly.

2.2 Narayanan and Darwish (1987)

$$V_u = e[0.24f_{sp} + 80\rho d/a] + 0.41\tau F_1 \qquad (2)$$

Where $F_1 = (l_f/d_f) \times v_f \times \alpha$

l_f : length of fiber

d_f : diameter of fiber

v_f : volume of fiber

α : bond factor (straight=0.5)

It was composed with tensile strength of concrete, shear span ratio and fiber factor. It can be known through this proposal, how to effect on shear strength about fiber.

2.3 Ashour (1992)

$$V_u = (0.7\sqrt{f_{ck}} + 7F_1)d/a + 17.2\rho(d/a) \qquad (3)$$

This proposal is used high-strength (90MPa) concrete. So calculation of high strength of concrete shear strength is expected.

3 Experimental Programs

3.1 Material Properties

3.1.1 Concrete

Concrete made of steel fiber, instead of aggregate. According to the concrete compressive strength divided into two categories (v_c =100MPa or 200MPa) to determine the shear strength.

3.1.2 Steel fiber

Steel fiber that is used in this experiment has circular cross section and certain length. The diameter of fiber is d_f =0.15mm and length is l_f =6mm, straight fiber. Material tensile strength test results is f_u=2600MPa. According to the amount of fiber divided into two categories (v_f =0% or 2.0%) to determine the shear strength.

Steel fiber used 2% volume that was optimum ratio previous concrete cylinder test.

3.2 Testing Procedures

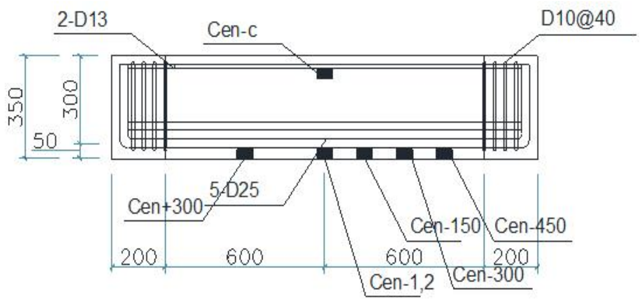

Fig.1. Shear-compression failure (BS-200-2.0)

To prepared the same shapes (200×350×1600mm) of three beams without stirrups. Shear span ratio (a/d=2.0) was constant. BS-100-2.0 and BS-200-2.0 are has different only concrete compressive strength. And Bs-200-0 and BS-200-2.0 are has different only steel fiber content. (See Table. 1)

Press at the center (1 Point) of beam using 200 ton actuator.

Specimen	b (mm)	d (mm)	f'_c (MPa)	f_y (MPa)	v_f (%)
BS-200-0			200		0
BS-100-2.0	200	300	100	400	2.0
BS-200-2.0			200		2.0

Table.1. Properties of Specimens

4 Test Results and Analysis

4.1 Modes of Failure

BS-200-0 and BS-100-2.0 have shown shear-tension failure. (See Fig. 2.) The first flexural crack occurred at the tension zone, enlarge from tension zone to compression zone.

BS-200-2.0 had shown shear-compression failure. (See Fig. 2.) That is similar to others but it has certainly crack spread to horizontally at the support.

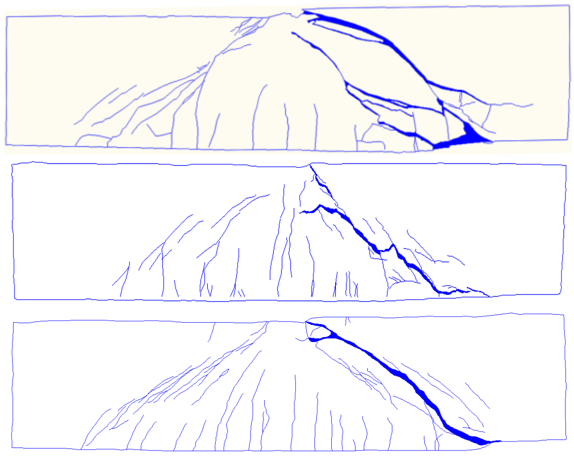

Fig.2. Failure mode BS-200-0, BS-100-2.0, BS-200-2.0

4.2 Deformed of reinforced bar

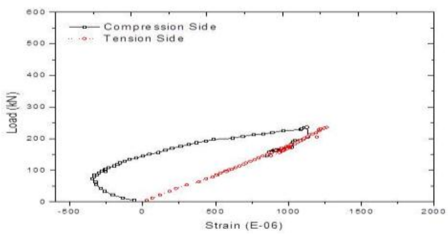

Fig.3-1, BS-200-0

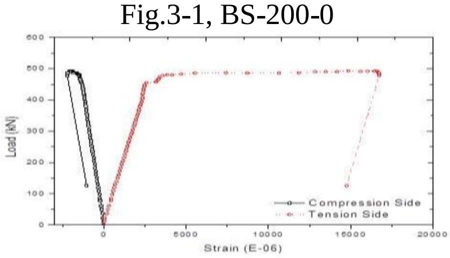

Fig.3-2, BS-100-2.0

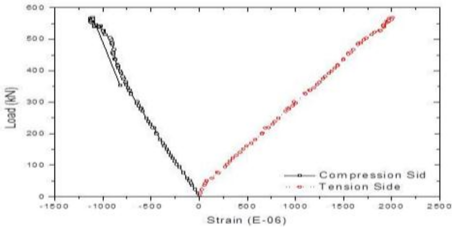

Fig.3-3, BS-200-2.0

Fig.3. Transformation reinforced bar

BS-200-0 specimen shows destroyed tension bar before it has yielding. (See. Fig. 3-1) It means rapidly destroyed beam in changing failure mode to bending fracture. High-strength concrete is weak in brittle fracture. Compare availability steel fiber (See. Fig. 3-1 and 3-3) the difference is clear.
Strain of compression and tension bars increase steadily until maximum strength.

4.3 Shear Strength

4.3.1 Cracking Shear Strength
The most effective thing is increasing initial shear crack when added fiber in concrete. Three times when compare BS-200-0 (22MPa) and BS-200-2.0 (58MPa) differ. The first crack occurred more slowly at the steel fiber containing concrete. (BS-200-2.0)

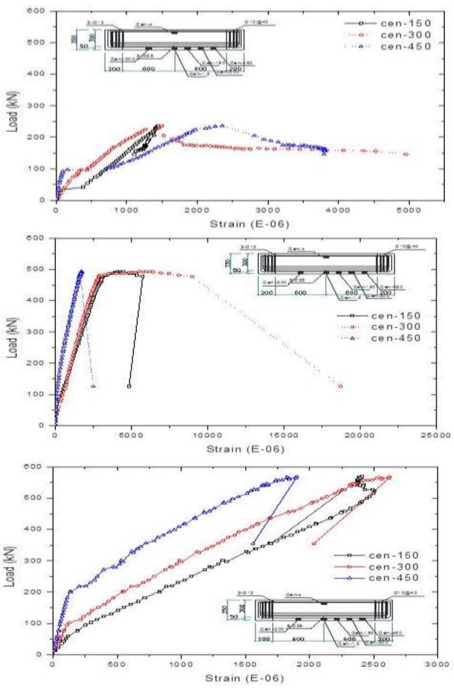

Fig.4. Deformation of tensile reinforcement

BS-200-0 specimen shown that diagonal tension crack is rapidly increased 300mm ~ 450mm range. Also, BS-200-2.0 specimen shows same pattern. But deformed occur in all area. It seems steel fiber is good at prevent brittle fracture. (See Fig.4)

4.3.2 Ultimate Shear Strength
If concrete compressive strength is increased, also increase that shear strength. And the specimen with steel fiber has higher shear strength than without steel fiber specimen. (See Fig.5)
Unlike the specimen without fiber (BS-200-0) shows rapid decrease at ultimate strength point, but steel fiber containing beams (BS-100-2.0 and BS-200-2.0) shown a more bit of a ductility effect.

Specimen	First Crack (kN)	Diagonal Crack (kN)	Ultimate strength (kN)
BS-200-0	22	63	235
BS-100-2.0	36	153	493
BS-200-2.0	58	287	568

Table.2. Time of Cracks

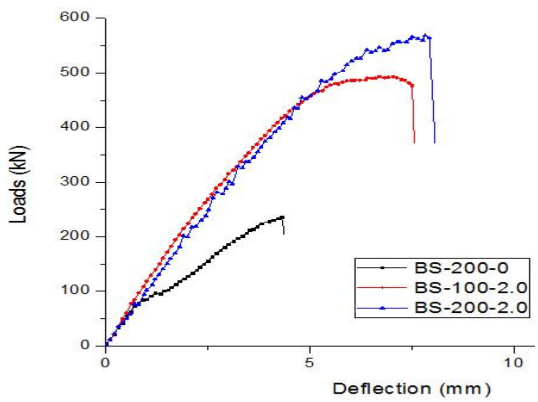

Fig.5. Load – Deflection Curves for Beams BS-200-0, BS-100-2.0, BS200-2.0

5 Test Results and Analysis

Sharma's proposal does not appropriate this experimental study. Steel fiber factor does not contained directly. So, BS-200-0 and BS-200-2.0 specimens were express same values.

Contrary to expectations, Ashour's proposed equation is inaccurate than Narayanan and Darwish. It said existing proposals can not be expressed high-strength concrete shear strength. (See. Table. 3)
Ashour used high strength (90MPa) of concrete. So expected fit the experiment result and Ashour's proposal. But the results are quite different.

Specimen	v_{exp} (kN)	$v_{prediced}$ (kN)		
		Sharma	Narayanan	Ashour
BS-200-0	235	158	352	318
BS-100-2.0	493	118	367	316
BS-200-2.0	568	158	475	403

Table.3. Comparison of shear strength

Thus, new approaches are needed in UHPC.

6 Conclusions

In this study, steel fiber effect on the shear strength in UHPC. It is difficult estimation of shear strength, common approach in the area of high strength. So, study the impact of each factor what configure UHPC will.
From this investigation, the conclusions can be followed.

(1) Initial shear strength 3 times increase to the effect of steel fiber.
(2) 200MPa specimen (BS-200-2.0) is 15% increase shear strength than compressive strength 100MPa (BS-100-2.0).
(3) Steel fiber contained specimen (BS-200-2.0) is 140% increase shear strength than without fiber specimen (BS-200-0).
(4) Flexural failure induction is more effective when steel fiber contain. Steel fiber contained concrete was increase the ductility at ultimate strength.
(5) Effect of steel fibers to prevent brittleness is excellent. (Comparing Fig.4 BS-200-0 and BS-200-2.0)
(6) It is difficult to express UHPC shear strength using previously proposal equations. More research is needed for factors that are influencing the shear. (Steel fiber, strength of concrete, shear span ratio)

7 Acknowledgements

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