Shear Behavior of Ultra-High Performance Fiber Reinforced Concrete under Monotonic and Cyclic Loading

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1. INTRODUCTION

There are promising research reports on the shear performance of Ultra-High Performance Fiber Reinforced Concrete (UHPFRC). For instance, Wang et al. conducted an experiment to investigate the shear behavior of 14 reinforced UHPFRC beams for different parametric studies[1]. Another report by Tokutake et al. also presented the shear transfer mechanism on cracked UHPFRC specimen [2]. However, the effect of confinement and its stability on shear performance behavior were not yet paid attention. Thus, the main aim of this paper is to present the effect of confinement on shear performance of UHPFRC specimen.

2. EXPERIMENTAL SETUP

Two holes were provided to install polyethylene sheath and prestressing bar. The average compressive, f_c , and tensile strength, f_t, of the specimen are 180.90 MPa and 8.76 MPa, respectively.

The schematic view is shown in Figure 1, monotonic and cyclic loads were applied through Load cell-02. The confinement pressure shown as σ_c (MPa) in Table 1 was applied through Load cell-01 using hydraulic jacks from both sides. For cyc-02 to 08, the splitting force by using wedge jigs on and under the notch was applied until the horizontal strain across notched cross section reached 500 μ before the shear loading as pre-crack process. The vertical movement of the specimen was measure by displacement transducers labeled from 01 to 04 in Figure 1.

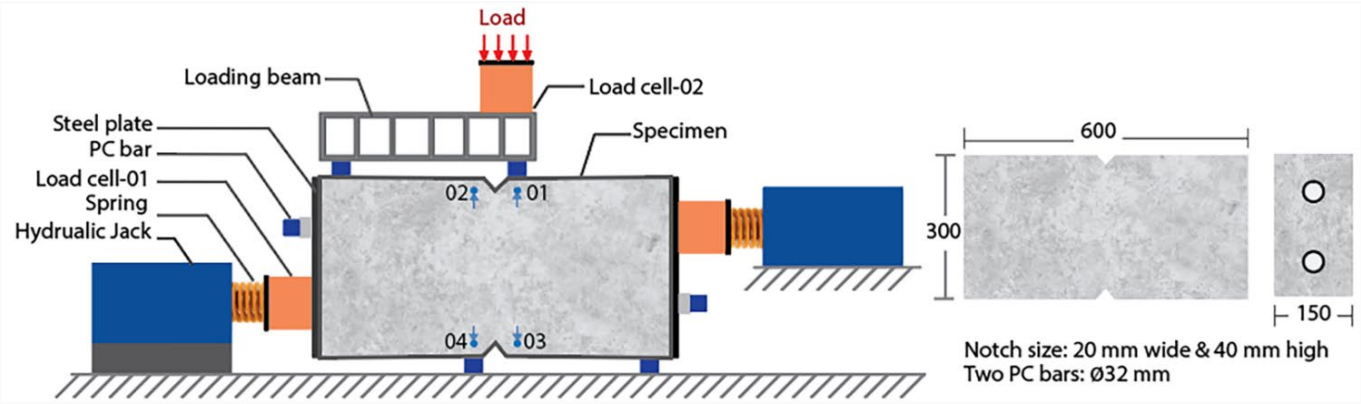

Figure 1:Experimental setup and specimen detail

Table 2:Test conditions and results

Specimen ID	σ_c (MPa)	θ $(deg.)$	A (m^2)	P_{max} (kN)	τ_{exp} (MPa)	τ_{mohr} (MPa)	$\frac{\tau_{exp}}{\tau_{mohr}}$	Spring	Remark
mon-01	0.00	-	0.0390	1301.10	33.36	-	-	No	No pre-crack
cyc-02	0.00	71.00	0.0476	1223.60	25.71	19.90	1.29	No	No pre-crack
cyc-03	2.50	74.00	0.0468	1476.90	31.16	25.10	1.24	Yes	pre-crack
cyc-04	5.00	77.00	0.0462	1636.40	35.35	30.44	1.16	Yes	pre-crack
cyc-05	7.50	77.50	0.0461	1735.50	37.99	35.74	1.06	Yes	pre-crack
cyc-06	10.00	78.00	0.0460	1918.70	42.36	41.05	1.03	Yes	pre-crack
cyc-07	5.00	-	-	1540.89	-			No	pre-crack
cyc-08	10.00	-	-	1643.44	-			No	pre-crack

Keywords: UHPFRC, shear behavior, monotonic load, cyclic load, confinement effect, shear plane
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3. RESULT AND DISCUSSIONS

Two main fracture planes were observed during experimental test as shown in Figure 3. The first one was fracture plane through the notches that was observed for monotonic loading. The other one was the inclined fracture plane, despite the pre-crack process, within the hatched region.

The resultant shear stress, τ_t, can be calculated from load and confinement components, which are " $P_s = (P/A)\cos(\theta)$" and "$\tau_c = \sigma_c \cos(\theta)$" by using shear plane inclination angle "θ" and shear area "A". The shear area, A, for monotonic and cyclic loading equal to $150x260\ mm^2$ and $150x(300/\sin(\theta))\ mm^2$, respectively. The value of angle θ ranges from 71° to 78 °. However, the actual shear fracture pattern doesn't exactly yield straight line. Hence, an engineering estimation was considered, and it can be calculated within $\pm 5°$ deviation.

A comparative study was conducted with Mohr's criterion and the fitting line from experiments (Figure 3). The shear strengths obtained in the experiment were lower especially if the confinement stress higher. The possible reason is the pre-crack process even though it didn't form the fracture planes.

The load versus vertical displacement (relative slip) shown in Figure 5. There were not significant differences in shear stiffnesses, however, the slip development in early state of the loading were different due to not only confinement stress but also the installation of spring system. The less slip development on the case cyc-05 was an exception because the slip restricted by upper PC bar was observed at the beginning.

4. CONCLUSIONS

Based on the experimental result, the confinement pressure proportionally improves the shear capacity of UHPRFC specimen. On the other hand, the shear stiffnesses were not clearly influenced by the confinement pressures rather than the initial slip development.

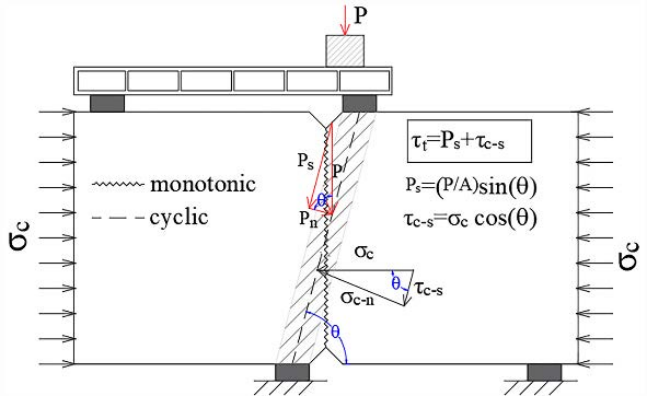

Figure 3 Shear planes and load components

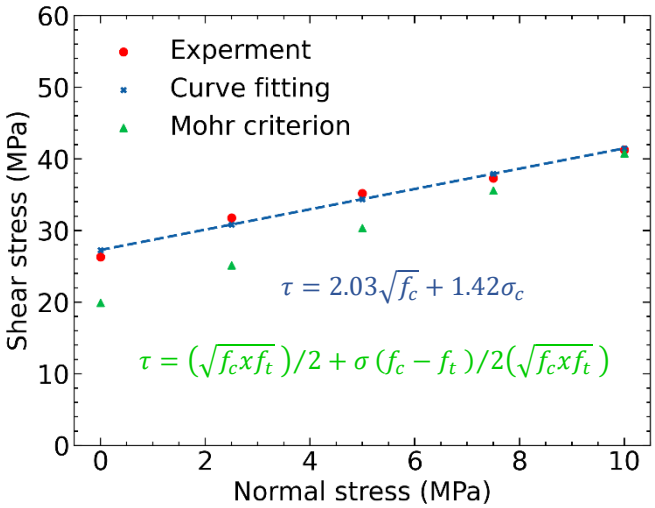

Figure 4:Experimental result and Mohr's criteria comparison

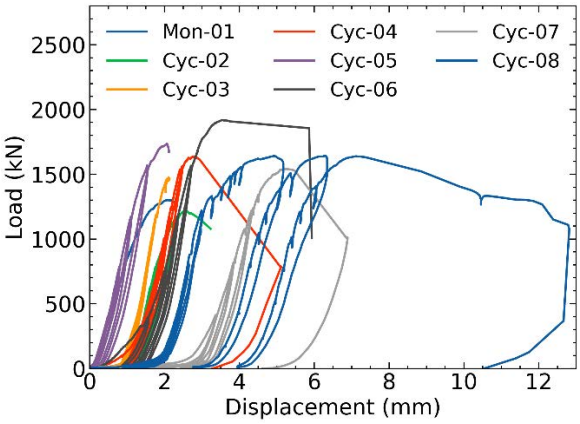

Figure 5:Load - vertical displacement (relative slip) relation

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