DEVELOPMENT OF ZERO-SPAN TENSILE TESTS ON HPFRCC

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1. INTRODUCTION

The most important characteristic of HPFRCC (High Performance Fiber Reinforced Cement Composites) is the formation of multiple fine cracks in tension. For this reason, HPFRCC can be widely used in retrofitting and repairing of concrete structures. For this application, elongation performance on an existing crack is required [1].

This research proposes the zero-span tensile test using steel plates for HPFRCC, and examines the effects of test conditions (i.e. steel plate thickness, specimen thickness, and artificial crack width) on the zero-span tensile test results.

2. EXPERIMENTAL PROCEDURES

2.1 Material

The tested material was ECC (Engineered Cementitious Composites) with fiber volume of 1.5 %, which is one of HPFRCC. The fiber was high strength polyethylene (PE). The mix proportions of the ECC are shown in Table 1 [2]. The compressive strength and Young's modulus measured by cylindrical specimens of ø100x200 mm were 69.5 MPa and 23.3 GPa, respectively. By conducting uniaxial tensile tests on dumbbell-shaped specimens, the tensile strength of the ECC was 5.2 MPa and the maximum strain was approximately 2.5% over the gauge length of 50mm [3].

2.2 Zero-Span Tensile Tests

Test setup for the crack elongation tests should represent existing conditions, such as properties of substrate concrete, crack width and thickness of ECC (as repair material). In this research, however, test setup using steel plate and epoxy adhesive was adopted in order to obtain the results in clarified boundary conditions, as shown in **Fig.1**. This type of loading is called "*ZERO-SPAN TENSILE TESTS*". The

Table 1 Mix Proportions of ECC [2]

C	W	S	Ad.1*1	Ad.2*2	F*3
1.0	0.30	0.310	0.030	0.00071	0.015

*1: Superplasticizer
*2: Methyl Cellulose
*3: Volume Fraction of Fiber

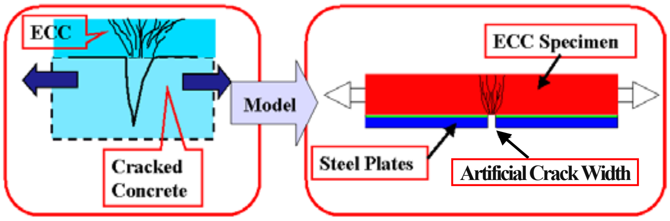

Fig.1 Zero Span Tensile Test Modeling

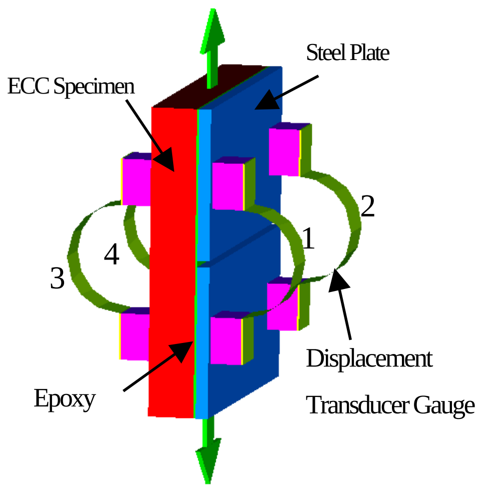

Fig.2 Specimen and Test Setup

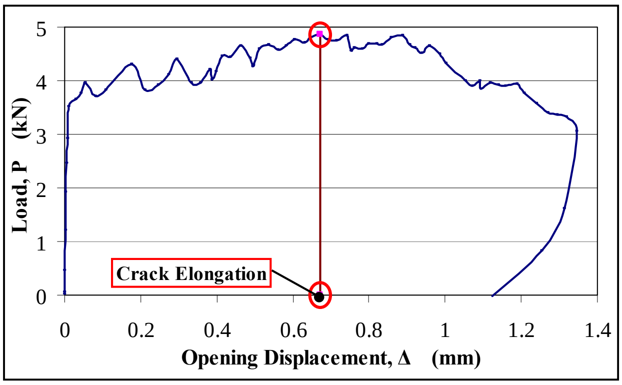

Fig. 3 Definition of Crack Elongation

specimen size is 100x100 mm. Several combinations between the steel plate thickness, specimen thickness, and artificial crack width, as shown in **Table 2**, were examined to evaluate their effects on the zero-span tensile test results. Three specimens are tested for each case. In each test, the opening displacement was measured at 4 points. Two Pi-type displacement transducer gauges were fixed on each side of the specimen, as shown in **Fig.2**. The used gauge was with gauge

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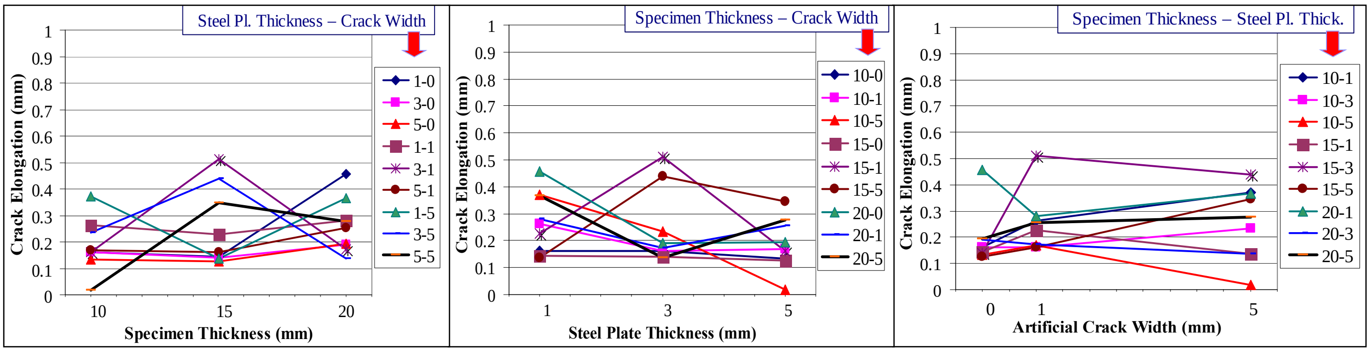
Table 2 Tested Specimens and Its Variables

Specimen Thickness (mm)	10									15									20								
Steel Plate Thickness(mm)	1			3			5			1			3			5			1			3			5		
Artificial Crack Width (mm)	0	1	5	0	1	5	0	1	5	0	1	5	0	1	5	0	1	5	0	1	5	0	1	5	0	1	5



(a) Specimen Thickness (b) Steel Plate Thickness (c) Artificial Crack Width

Fig. 4 Effect of Variables on the Crack Elongation Performance through Zero Span Tensile Tests

length of 50mm. The capacity of the gauge is ±2 mm and its sensitivity for tension is about 1/2000 mm.

3. EXPERIMENTAL RESULTS

3.1 Definition of Crack Elongation

Fig. 3 shows the example of measured load-displacement curves, which is the averaged curve of the four displacement transducers (Case: the specimen thickness of 15mm, steel plate thickness of 3mm and artificial crack width of 0mm). In this research, the crack elongation is defined as displacement value at the peak load.

3.2 Effects of Specimen Thickness, Steel Plate Thickness, and Artificial Crack Width

By plotting the crack elongation obtained from the tests versus the specimen thickness and steel plate thickness, there is not pure relation appeared between the results by changing the thickness of the specimen and the thickness of the steel plate, as shown in **Figs. 4 (a)** and **(b)**. But in case of changing the artificial crack width, in most cases, it is found that the crack elongation increases by increasing the artificial crack width, as shown in **Fig. 4 (c)**. That is due to the number of allowed cracks increases around the artificial crack region.

In addition, an important point is that obtained crack elongation, which shows the values ranging from 0.4% to 0.8 % in strain, is much smaller than that of deformation capacity (more than 1% strain level at peak load) in uniaxial tensile tests. Because a localized cracking can be observed around the artificial crack in this test, it was clarified that evaluating the crack elongation performance of HPFRCC through the zero-span tensile tests is quite important for repair applications.

4. CONCLUSIONS

(1) There is not pure relation appeared between the results by changing the thickness of the specimen and the thickness of the steel plate. However, in most cases, the crack elongation increases by increasing the artificial crack width.

(2) The evaluated crack elongation is much smaller than that of deformation capacity in ordinary uniaxial tensile tests. Because a localized cracking can be observed around the artificial crack in this test. These results show that evaluating the crack elongation performance of HPFRCC through the zero-span tensile tests is quite important for repair applications.

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