FUNDAMENTAL STUDY ON ZERO-SPAN TENSILE TESTS FOR ECC

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1. INTRODUCTION

The basic assumptions of the ordinary tensile test are that the loading is purely uni-axial and that the deformation takes place uniformly, both along the length of the specimen and throughout every cross-section. However, in the zero-span tensile test (ZS test), the span length is typically less than the thickness of the specimen. Usually, the performance of the ECC or other ductile materials is confirmed though tensile or bending tests with no restraint along the length of the test specimen. But to test the localized fracture of the ECC material, zero-span tensile test is used [1,2]. This paper proposes the zero-span tensile test using steel plates for the ECC, and the effect of the steel plate thickness on the zero-span tensile test results was discussed.

2. EXPERIMENTAL PROCEDURES

2.1 Material

The ECC with W/C ratio of 30% was used. The compressive strength and Young's modulus measured by cylindrical specimens of Ø 100x200mm 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 [2]. The mix proportions of the ECC are shown in Table 1 [3].

2.2 Specimens and Test Setup

The specimen size is 100x100 mm with thickness of 15mm. Two steel plates were fixed on one side of the specimen using epoxy adhesive. Three different steel plate thicknesses were examined: 5mm, 3mm, and 1mm. Four specimens are tested for each thickness. 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.1. The used gauge was with gauge length of 50mm. The capacity of the gauge is ±2 mm and its sensitivity for tension is about 1/2000 mm.

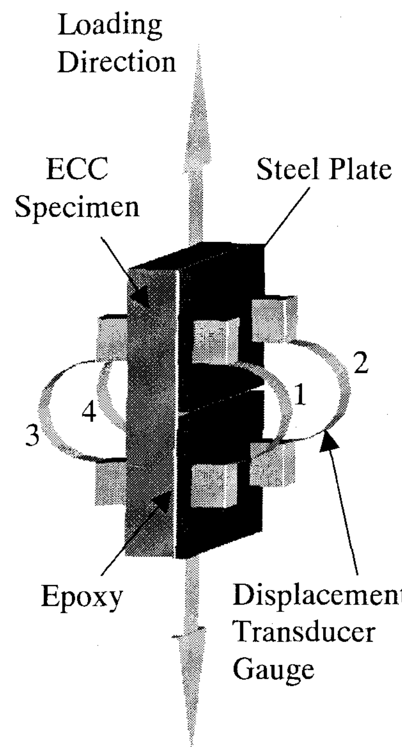

Fig.1 The Specimen and Test Setup

3. EXPERIMENTAL RESULTS

3.1 Effect of Steel Plate Thickness

By using steel plate with 1mm thickness, the opening displacement on the steel plate side is larger than the opening displacement on the specimen side. So the displacement transducers lead compression on the specimen side and tension on the steel plate side, as shown in Fig. 2. (a). It means that there is a bending moment in the specimen thickness direction. So the specimen in this case is not under pure axial tension.
By using steel plate with 3mm thickness, the behavior of the four displacement transducers tends to be the same. It means that both sides of the specimen are under tension force. So the specimen in this case is under almost pure axial load as illustrated, Fig. 2. (b).

Table 1 Mix Proportions of ECC [3]

Cement	Water	Fine aggregate	Superplasticizer	Methyl cellulose	Fiber Volume
1.0	0.30	0.31	0.030	0.00071	0.051

By using steel plate with 5mm thickness, the opening displacement on the specimen side is larger than the opening displacement on the steel plate side. So the displacement transducers lead compression on the steel plate side and tension on the specimen side, as shown in Fig. 2. (c). It means that there is also a bending moment in the specimen thickness direction (as in case of 1mm). So the specimen in this case is not under pure axial tension.

3.2 Global Response of the Tests

Fig. 3 shows the averaged P-Δ Curves for the three cases, which are obtained from the four gauges shown in Fig. 2.

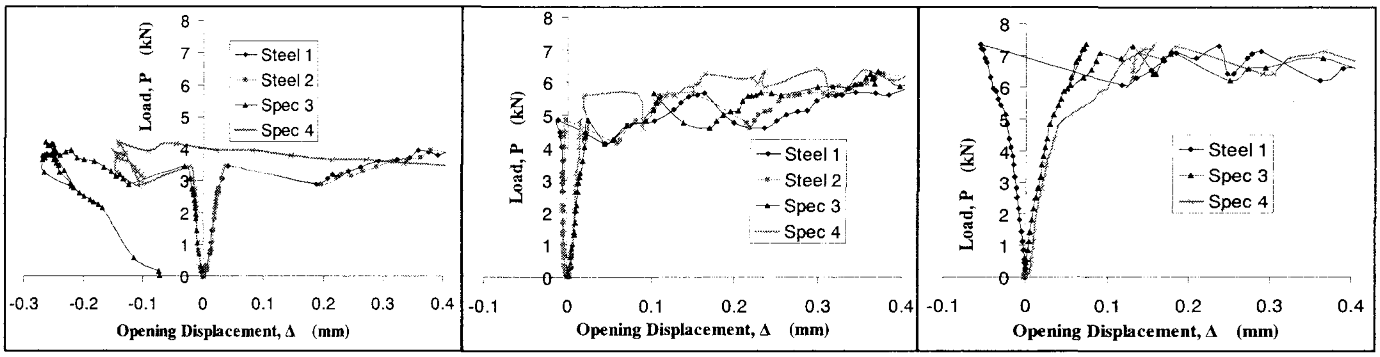

Fig.2 The P-Δ Curves for the Four Displacement Transducers Used in The ZS Test in Case of: (a) 1mm Steel Plate Thickness, (b) 3mm Steel Plate Thickness, (c) 5mm Steel Plate Thickness.

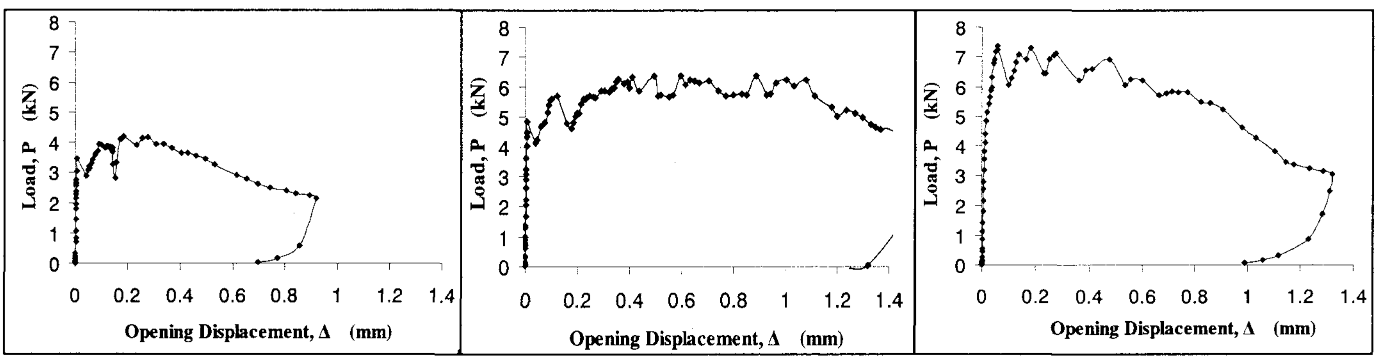

Fig.3 The Averaged P-Δ Curves for the Three Cases: (a) 1mm Steel Plate Thickness, (b) 3mm Steel Plate Thickness, (c) 5mm Steel Plate Thickness.

4. CONCLUSIONS

Using steel plates with thickness 1mm and 5mm, the zero-span tensile test leads to appear bending moment in the specimen thickness direction. But in case of using 3mm steel plate thickness, slight bending moment occurs and the specimen is subjected to almost pure tension. In this study, it seems that the 3mm steel plate is the best thickness to be used in zero-span tensile test. Other materials with different properties should be tested to investigate the applicability for using the same zero-span tensile test setup.

5. REFERENCES:

[1] K. Rokugo, M. Kunieda, and S. C. Lim. “Patching Repair With ECC on Cracked Concrete Surface,” Proceedings of ConMat'05, Vancouver, Canada, August 22-24, 2005.

[2] M. Kunieda, T. Kamada, K. Rokugo and J. E. Bolander, "Localized Fracture of Repair Material in Patch Repair Systems," Proceedings of FRAMCOS-5,Vail, Colorado, USA, April 2004, pp.765-772.

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