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Seismic Performance of Short Coupling Beams with Various Reinforcement Layouts

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ABSTRACT

In general, the use of diagonal bars is necessary in reinforced concrete short coupling beams that requires large deformation capacity, but the details are complicated and costly. In this study, for better constructability and cost-effectiveness, various reinforcement details were investigated. Six specimens were tested to evaluate the cyclic behavior of short coupling beams with the length-to-height ratio of 2. The test parameters were the ratio and details of longitudinal bars, transverse reinforcement ratio, and diagonal reinforcement. The test results showed that the proposed details exhibited better structural performance than conventional rebar details.

1. INTRODUCTION

Most of the tall buildings have load-bearing walls, and it has become increasingly important to provide methods of construction that both improve seismic performance and constructability (Naish 2013). A coupling beam is a structural member that connects two shear walls, and the performance of the coupling beam is an important factor in evaluating the structural performance of the shear walls. In particular, in the case of slender coupling beams, since they are vulnerable to shear failure, the reinforcement details follow the standard of the special moment frames with diagonal reinforcement. Several coupling beam details have been developed, but the constructability was not sufficiently considered because the focus was on the diagonal reinforcement method. In this study, the details of coupling beams that can satisfy the required deformation performance of the intermediate-ductility seismic wall system while improving the constructability were proposed.

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2. TEST PROGRAM

2.1 Beam design

Six Specimens were tested with various ratio and details of reinforcement. The test beam was based on a coupling beam with the same thickness as the shear walls, and the length-to-height ratio of $2(l/h = 2.0)$. The cross-section dimension is 200 x 600 mm. The configuration of the longitudinal bars and transverse reinforcement was the primary parameter of the test program. For longitudinal bars, D16, D22, and D25 bars were used. The longitudinal bar ratio was $\rho = 0.72$ (Detail1 and Detail2), 0.82 (Detail3 and Detail4), 1.45 (Detail5), and 0.61 (Detail6). For transverse reinforcement, the spacing of hoops was 100 mm (Detail1 and Detail2) according to the special moment frames, and 125 mm (others) according to the intermediate moment frames. The reinforcement details are summarized in Table1.

Specimens	l/h	Rebar Type	Concrete Strength f_c' [Mpa]	Reinforcement				Details
				Longitudinal		Transverse		
				f_y [Mpa]	ρ [%]	f_y [Mpa]	ρ [%]	
Specimen1				646	0.72 (2-D22)		0.71 (D10@100)	Conventional bars Total: 4-D22
Specimen2			33.3	649	0.82 (4-D16)			Distributed bars Total: 12-D16
Specimen3				649	0.82 (4-D16)			Distributed bars Total: 12-D16
Specimen4	2.0	SD600S		646	0.72 (2-D22)	629		Distributed bars Total: 6-D22
Specimen5			28	615	1.45 (2-D25, 2-D16)		0.57 (D10@125)	Distributed bars Total: 4-D25, 8-D16
Specimen6				649	0.61 (2-D16, 2-Ø15.2)			Reinforced with 2-Ø15.2 cable Total: 4-D16, 4-Ø15.2

Table. 1 Reinforcement figurations

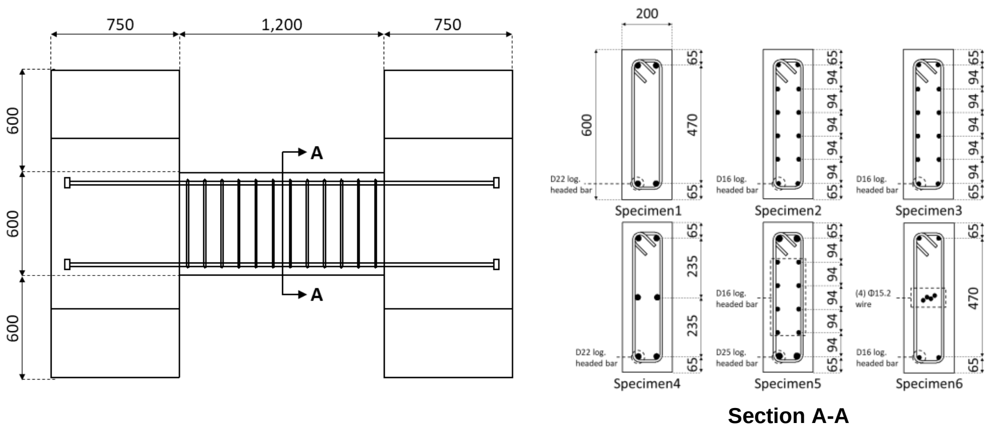

Fig. 1 Test beam geometries

2.2 Test setup

The specimen with the end blocks simulating the wall boundary condition was installed vertically, as shown in Fig. 2. The lateral load was applied by a horizontal actuator. Three load cycles were applied to the specimen at the drift-ratio of 0.25, 0.375, 0.5, 0.75, 1, 1.5, 2, 3, and 4%.

Fig. 2 Test set-up for coupling beam

2.3 Test results

Fig. 3(a) shows the load-drift relationship of Specimen1 with conventional reinforcement. Diagonal cracks occurred at a drift-ratio less than 1%, and the load-carrying capacity decreased due to cover concrete spalling. At drift-ratio of 2%, concrete crushing occurred at the beam end. As the drift ratio increased, the contribution of shear deformation to the drift ratio increased.

The cyclic behavior of Specimen2 and Specimen3 with distributed reinforcement was similar. The peak load was 1.3 times the nominal flexural strength. After the peak load, shear failure occurred, and most of the damage and deformation were concentrated at the coupling beam-wall joint interface.

In Specimen4 and Specimen5, diagonal shear cracks occurred at drift-ratio less than 1%. After drift ratio of 1%, crack width exceeded 1 mm, which significantly decreased the load-carrying capacity. In particular, Specimen5 exhibited premature shear failure before beam yielding.

Specimen6 reinforced with ∅15.2 cables exhibited ductile behavior (Fig. 3(f)). However, because the coupling beam failed before the cable reached the yield strength, the deformation capacity was not significantly improved.

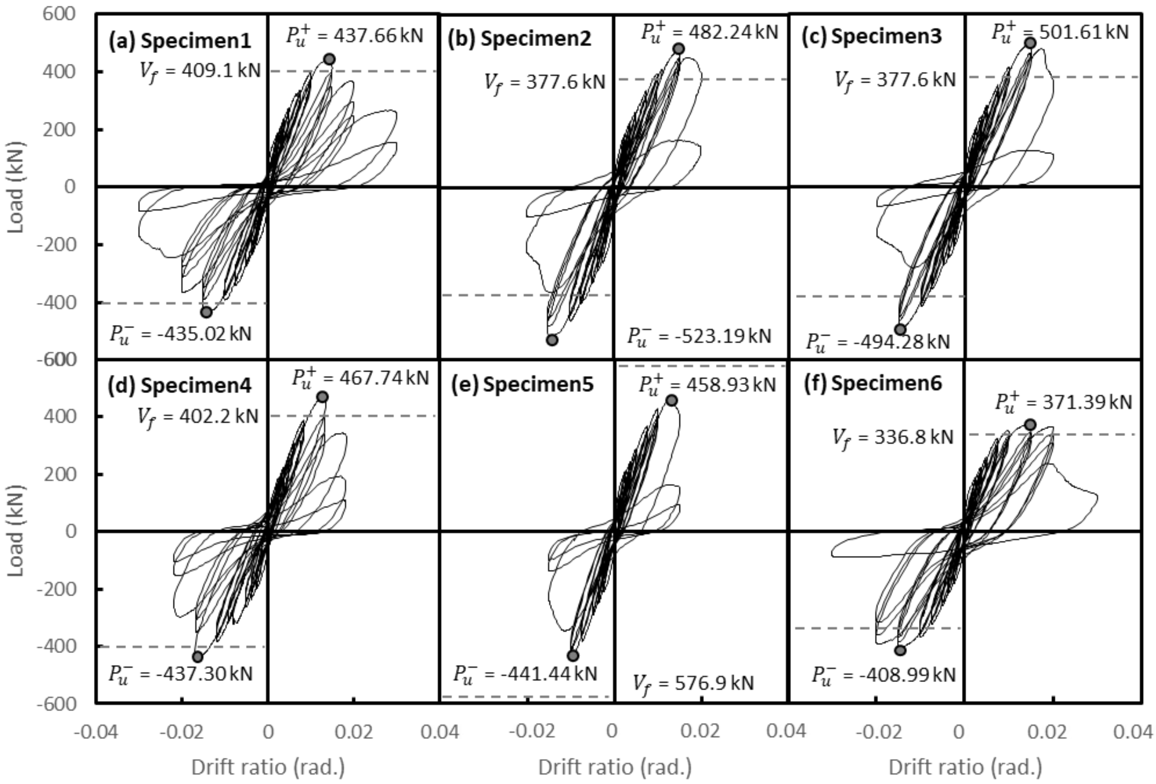

Fig. 3 Load-Drift ratio

3. CONCLUSIONS

To develop the details of coupling beams with intermediate-ductility, cyclic loading test was performed on six coupling beams with various details. According to the test results, the deformation capacity of specimen 2-4 was about 2% drift ratio, and the specimen6 reinforced with cables failed at about 3% drift-ratio.

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