Cyclic seismic in-plane performance of precast lightweight aggregate concrete insulation panels with splice-sleeve-based bolting technique

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Introduction

- PC insulated panels are increasingly used as exterior claddings to meet both thermal insulation and fire resistance requirements, and meta-based panels, in particular, embed internal structures or metamaterials to enhance performance.
- To securely attach these panels to building exteriors, a robust panel-to-base connection technique capable of withstanding external loads such as wind and earthquakes is essential.
- Existing research has largely focused on out-of-plane strength and static loading conditions, while in-plane behavior under cyclic (repeated) loading has not been adequately addressed.
- The aim of this study is to apply the newly developed splice-sleeve-based bolting technique to HMI-panels to evaluate their in-plane behavior under cyclic loading and verify structural safety, and to examine how parameters such as ρ_v (vertical reinforcement ratio) and the panel-to-base connection type influence their behavior.

Experimental details

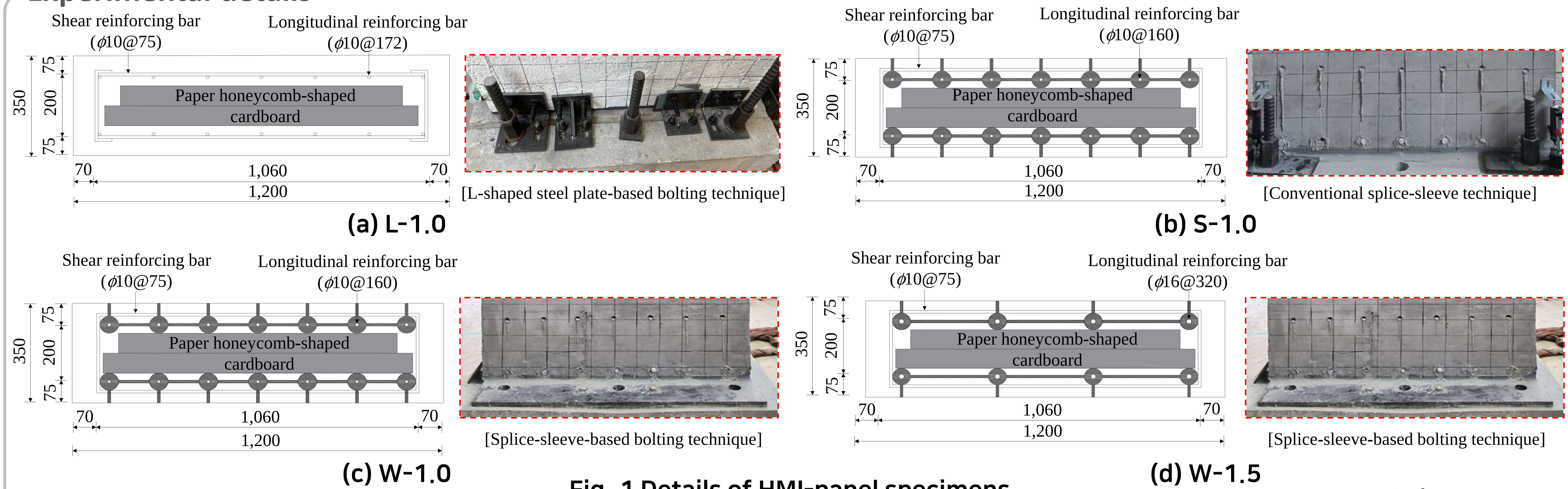

Fig. 1 Details of HMI-panel specimens

- Fig. 1 shows the details of the HMI-panel specimens. The main parameters for the HMI-panel were the type of base-to panel connection and the vertical reinforcement ratio (ρ_v).
- All the HMI-panel specimens were manufactured with thicknesses (t_w), widths (b_w), and lengths (L) of 350, 1200, and 2775 mm, respectively. The shear reinforcement consisted of deformed bars with a diameter of 10 mm placed at 75 mm intervals.
- The compressive strength of concrete was 25.4 MPa.
- Loading was applied in both the positive and negative directions within the in-plane using a 2000 kN capacity actuator connected to the top of the panel (Fig. 2).
- The drift ratios at each cycle were determined following the procedure specified FEMA 356.

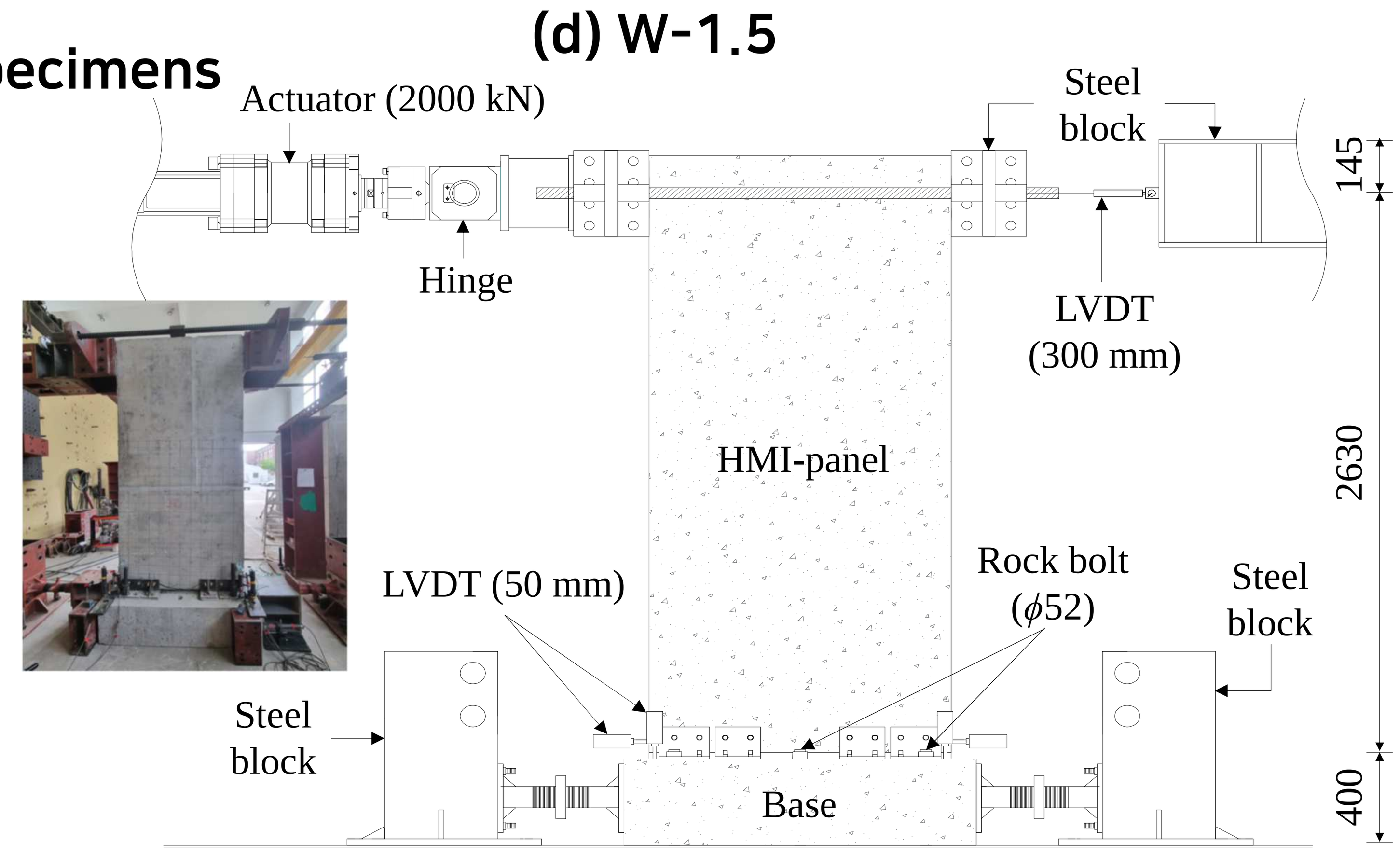

Fig. 2 Test setup

Test results and conclusions

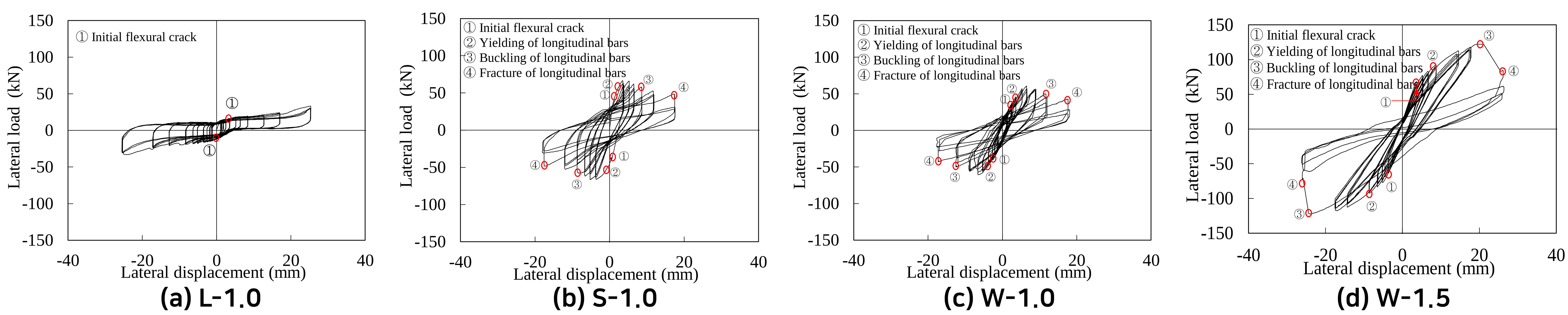

Fig. 3 Lateral load-displacement relationship of HMI-panel specimens under cyclic in-plane loading

Table 1 Summary of experimental results for HMI-panel specimens

Specimens	P_{cr} (kN)	P_y (kN)	P_n (kN)	Δ_y (mm)	Δ_n (mm)	μ_Δ	E_{80} (kN·m)	β_r		
								Experimental values	Predicted values (ACI ITG-5.1)	≥0.125
L-1.0	15.5	25.5	37.1	17.1	25.4	1.5	-	-	0.125	NG
S-1.0	48.3	51.1	66.6	1.2	3.5	2.9	2266	0.115	0.125	NG
W-1.0	49.1	50.8	62.4	2.2	6.7	3.0	9908	0.165	0.125	OK
W-1.5	68.1	83.8	122.2	6.5	17.8	2.7	15373	0.175	0.125	OK

- The L-shaped steel-plate-based bolting technique showed insufficient lateral load transfer due to slip at the base-to-panel joint, with P_{cr}, P_n, and μ_Δ significantly reduced, whereas the splice-sleeve-based bolting technique demonstrated adequate lateral-load transfer and ductility, comparable to or better than the conventional splice-sleeve technique, and no slip was observed at the joints.
- Furthermore, when the vertical reinforcement ratio ρ_v was increased by 1.5 times, the panels designed with the splice-sleeve-based bolting technique maintained E80 post-peak energy absorption and achieved approximately 6.78 times higher lateral load resistance, indicating improved safety and performance.