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Anchorage Strength of Headed Round Bar within Exterior Beam-Column Joint

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ABSTRACT

To investigate the anchorage strength and failure mechanisms of precast concrete (PC) exterior beam-column joints, lateral cyclic loading tests were conducted on four PC specimens (S1, S2, S3 and S4) connected by headed anchors within the panel zone. As shown in Fig. 1, two distinct final failure mechanisms were observed. During the loading step where maximum tensile forces were applied, S1 and S3 experienced concrete cover spalling on the column surface after substantial steel yielding, while S2 and S4 underwent ductile steel rod (round bar) yielding followed by abrupt fractures of the screw between the anchor rod and socket. No yielding was observed outside the beam-column joint for all specimens. The reason for the difference in mechanism was analyzed based on the calculated anchorage strength and steel (yield) and tensile strength. The steel tensile strength was approximately 2,975 kN, calculated based on the tensile forces corresponding to the maximum beam moment induced by the lateral load. The concrete breakout strength was calculated by substituting the design strength of stirrups (transverse reinforcement) around the anchors, in accordance with ACI 318-19 (ACI 2019). Based on strain gauge data attached on the transverse reinforcement, the maximum tensile forces of adjacent transverse reinforcement during the first cycle of a drift ratio of 4.0% were found to be 1,608 kN for S1, 1,755 kN for S2, 1,739 kN for S3, and 1,745 kN for S4. This indicates that for S1 and S3, the contribution of the supplementary reinforcement was insufficient, leading to gradual reduction of the confining effect on the concrete and causing the cover spalling under cyclic loading, whereas for S2 and S4 the greater contribution would allow for resisting larger tensile forces; thus, restraining concrete failure led to steel rod yielding brittle followed by fracture of the screw at the anchor at a drift ratio of 4.0% (which could have been prevented by proper manufacturing). As reported by Ferreira et al. (2021), the concrete breakout strength is significantly enhanced by surface reinforcement (longitudinal reinforcement of columns) and supplementary reinforcement (transverse reinforcement within the joint), increasing by average of 1.4 times that without (95% confidence interval:

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1.19–1.66 times), and average of 1.97 times (95% confidence interval: 1.63–2.31 times), respectively.

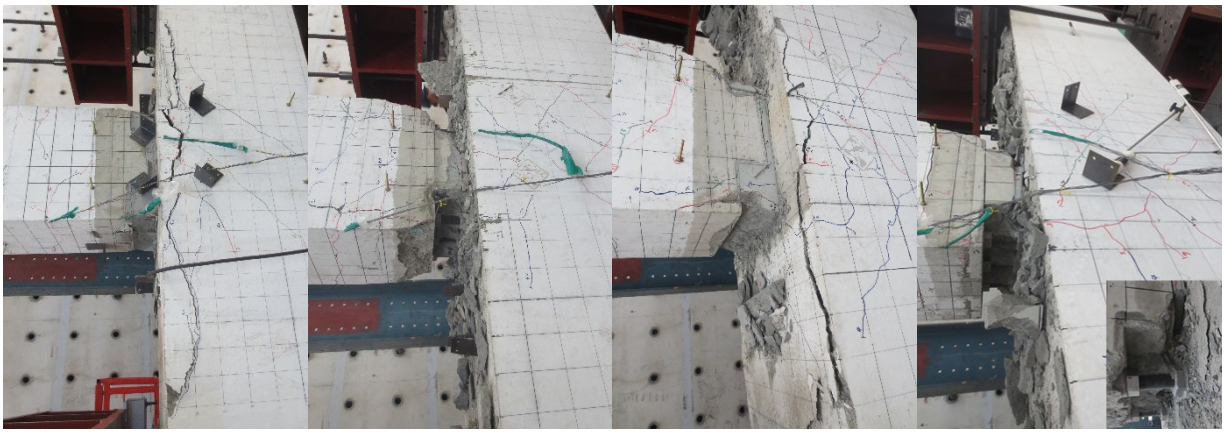

Fig. 1 Crack pattern of specimens at end of testing

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