ABSTRACT

Twelve large-scale reinforced concrete (RC) specimens were tested at Purdue University's Bowen Laboratory to evaluate the deformability of structural walls with longitudinal lap splices at their bases. Eight specimens were tested under four-point bending and four specimens were tested as cantilevers under constant axial force and cyclic reversals of lateral displacement. All specimens failed abruptly by disintegration of the lap splice, irrespective of what loading method was used or what splice details were chosen. Previous work on lap splices has focused mainly on splice strength. But, in consideration of demands requiring structural toughness (e.g. blast, earthquake, differential settlement), deformability is arguably more important than strength.

Approximations of wall drift-strain relationships are presented in combination with estimates of splice strength and deformability to provide lower-bound drift capacity estimates for RC walls with lap splices at their bases. Deformations in slender structural walls (with aspect ratios larger than 3) are controlled by flexure. Shear deformations must be considered for walls with smaller aspect ratios. For slender walls with lap splices comparable to those tested, the observations collected suggest that drift capacities can be as low as 0.5%. That is: splices with minimum concrete cover, minimum transverse reinforcement[1] terminating in hooks, and lap splice lengths selected to reach yielding in the spliced bars[2] can fail as yield is reached or soon after. For splices of the same length, doubling the amount of hooked transverse reinforcement increases deformation capacity by nearly 50%. By maintaining the same transverse reinforcement ratio but confining splices with closed hoops (instead of hooks), deformation capacity nearly doubles. Increasing splice length increases the expected splice strength but also increases the strain required to reach the same drift ratio.

Evidence from this and similar experimental programs suggests that lap splices with minimum cover and confined only by minimum transverse reinforcement[1] terminating in hooks should not be used in critical sections of structural walls when toughness is required. To prevent abrupt failure during events that demand structural toughness, it is recommended that lap splices be shifted away from locations where yielding in structural walls is expected.

[1]selected to satisfy ACI 318-19 wall web reinforcement requirements; a minimum of 0.25%
[2]approximately 60 bar diameters (d_b) for splices of Grade-60 reinforcement