Wood Sole Plate Anchorage to Concrete under Monotonic and Cyclic Loading

Lateral force resisting systems for wood-framed buildings typically consist of wood structural panel shear walls with anchor bolts located at the edge of foundations. The resisting system is relied upon to defend against wind and seismic loading conditions. For wood construction, anchor bolt connections often have an edge distance of 1-3/4 in. from the bolt center line to the face of the concrete slab or footing. Engineers have historically anticipated the controlling failure of this connection to occur between the anchor bolt and the wood sill plate, but current design provisions predict concrete break-out failures. With little information, engineers and code officials are forced to specify lower anchor bolt capacities than what has historically been accepted.

Background

During the 1990s, American Concrete Institute (ACI) reviewed past research to develop the current Concrete Capacity Design (CCD) method for the anchor design provisions. This methodology is calibrated to test results to predict failures at the 5th percentile capacity and resides in Appendix D of ACI 318 Building Code Requirements for Structural Concrete. The test results were pulled from an international database of research on anchorage systems for commercial and industrial construction. In 2006, International Building Code referenced the new ACI 318–05 Appendix D provision for determination of anchor bolt capacity for wood sill plates to concrete foundations.

Engineers have historically anticipated the controlling failure of this anchor bolt connection to occur between the anchor bolt and the wood sill plate. However, design capacities for concrete break-out strength of the anchor bolt in shear, determined in accordance with ACI 318–05 Appendix D, are greatly reduced and typically less than the design capacity applicable to the wood-to-concrete connection with small edge distances. ACI 318–05 provides an increase to break-out design capacity where connections are ductile, but how to apply these ductile provisions to a wood–concrete anchorage is not clearly defined within ACI 318–05. Currently, there is a lack of test data to substantiate the reduced design capacities for anchors in concrete in a typical wood-to-concrete connection loaded parallel to the edge.

Objective

The objective of this project is to improve the accuracy of design methods for residential anchors by capturing representative failure modes, response variability, and applicable safety margins.
Approach

Three methods will be used to develop an understanding of concrete-to-wood sill anchorage systems:

1. Test full-scale shear walls to evaluate the response of anchors as part of the wall assembly with a loading mechanism more representative of in situ conditions, including friction considerations.

2. Measure the variability in shear anchor performance through testing of an increased number of specimens of the same configuration.

3. Evaluate the performance of multiple-bolt connections, including load distribution between bolts in cracked and uncracked concrete.

Expected Outcomes

Expected outcomes of this project include the following:

• Clarification of the meaning of “ductile” connection for application of ACI 318–05 Appendix D

• Improved design methods for residential anchors

• Understanding of the effect of cracked concrete on residential anchor capacity

Timeline

Fabrication and testing will occur in the last quarter of 2009. Interpretation of tests results and modification of the anchorage design method will commence in the spring 2010 and be concluded by winter 2010.

Cooperators

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