

## SEAOC Blue Book – Seismic Design Recommendations Anchor Bolts in Light-Frame Construction at Small Edge Distances

changes to the anchor bolt design methodology. Since issues with the old values were not apparent, the need for substantial change was puzzling.

### Testing

The primary goals of the SEAOC Anchor Bolt Test program were to:

- 1) Determine whether the wood connection yielding controls the connection capacity when loaded parallel to an edge and if the equations found in each material standard are good predictors of behavior.
- 2) Determine whether the connection exhibits ductile behavior.
- 3) Propose rational design capacities for the connection.

It was decided to test the 5/8-inch diameter bolts since they are representative of most medium and heavy duty shear wall applications. While much residential concrete construction is specified at  $f'_c=2500$  psi, in-service concrete is expected to experience some strength gain over time. For this reason, a range of 2500 to 3000 psi was specified for the test concrete compressive test. In actuality, the highest compressive test cylinder result was 2710 psi. As also detailed in the SEAOC “Report on Laboratory Testing of Anchor Bolts Connecting Wood Sill Plates to Concrete with Minimum Edge Distances,” the tests included two unique features. First, the effect of friction was isolated on half of the tests by providing a lubricated polyethylene membrane at the wood-concrete interface. This allowed the contribution of friction to be better understood from the test data. Second, impact-echo testing was conducted during the test to continuously monitor the status of delamination that developed in the concrete that may not have been visibly apparent. Aside from these unique features, every effort was made to test materials representative of the most common shear wall connections.

The independent variables tested were:

Item	Configuration Tested
Sill plate size	2x4, 3x4, 2x6 and 3x6
Anchor bolt edge distance	1.75 inches or 2.75 inches, dependent upon sill plate
Testing protocol	monotonic versus pseudo-cyclic
Wood-concrete interface condition	friction versus “frictionless” membrane

To properly generate test data for the purpose of assessing behavior, a new displacement based loading protocol was developed. Using data from an initial set of monotonic pull tests, cyclic tests were calibrated so that damage produced by the test would best represent actual in-service failure modes. For the new protocol, the SEAOC Seismology Committee used a hybrid approach essentially taking the CUREE protocol with additional cycles added at low load levels. Independently, the SEAOSC sequential phased displacement (SPD) loading was used on several tests to compare results.

### Findings

The first result to note was that the monotonic tests were an accurate predictor of the elastic performance characteristics exhibited in the cyclic tests. Once the anchors were loaded to approximately 5000 pounds, the anchors slowly started to exhibit some plastic behavior as further displacement occurred. The frictionless membrane applied under the length of sill plate had a minor effect at small displacements within the elastic range. For loads in the range of design values, which were well within the elastic range, there was little difference between the pseudo-cyclic, monotonic, and sequential phased displacement test results.

Second, the test showed that fastener fatigue was not a limit state influenced by any of the various loading protocols. This is an important observation since it limits the area of concern to the strength of wood and concrete elements tested.