Behavior and Design of Cast-in-Place Anchors under Simulated Seismic Loading

Phase I– Cyclic Tests of Cast-in Place Anchors in Plain Concrete

Material Properties

Anchor bolts

The 0.75-inch diameter anchors consisted of F1554 Grade 55 threaded rod and a heavy hex nut tack welded to the base. The F1554 Grade 55 threaded rods had a yield strength of 63 ksi and an ultimate strength of 76 ksi as shown in Figure 1.

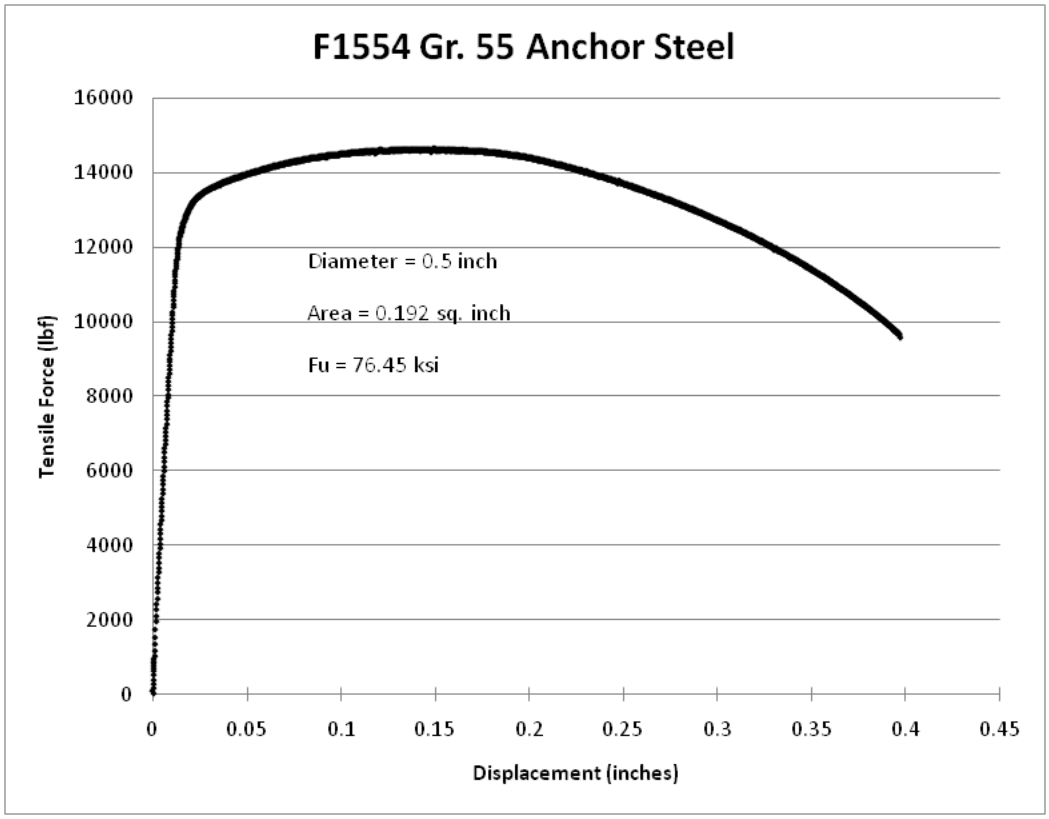

Figure 1: Stress-strain behavior of F1554 Grade 50 anchor steel

Concrete

All concrete specimens used for unreinforced anchor testing were poured at the same time with ready-mixed concrete. Concrete was non-air entrained with a measured air content of 2.3% on the day of pouring and a slump of 3.25 inches. Eighteen 4x8 inch cylinders were cast for testing concrete strengths at various ages throughout testing. All cylinders were kept in their sealed containers for the full 28 days of curing, after which the cylinders were removed and stored at ambient conditions similar to the test specimens. The first strength tests were conducted 56 days after the pour when the first specimen was tested. Subsequent testing resulted in an average concrete strength of 5650 psi for the majority of the specimens.

Construction of Anchor Specimens

Test blocks shown in Figure 2 were cast with anchors protruding from the bottom of the formwork. This inverted orientation produced perfect surface finish on the top of the test blocks where the loading plate was placed. The smooth surface around the anchor bolts helped the loading plate rest evenly on the test block. The inverted casting also eliminated any surface obstructions from the open side of the forms while pouring. Vertical orientation of the anchors were fixed in the bottom of the formwork through appropriately sized holes drilled into 4x4 blocks that were screwed to the outside of the formwork. This provided two inches of fixity to the anchors protruding out of the concrete test blocks. The heavy hex nuts used were then tack welded to the anchor rods to prevent any movement while concrete was being poured and compacted. PVC pipes used for the vertical tie down rod were secured in position by a plywood puck cut to the inside diameter of the pipe and bolted to the bottom of the formwork.

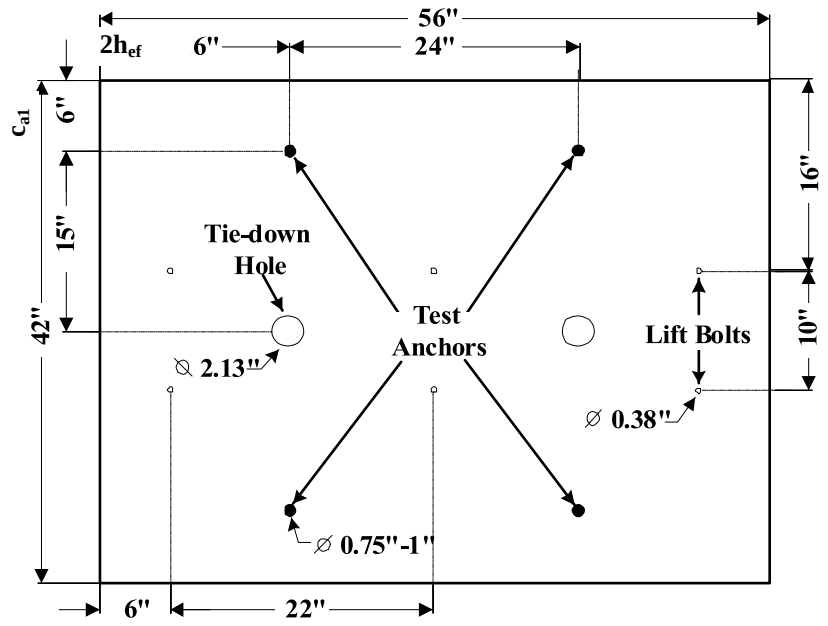

Figure 2: Plane view of test specimen containing 4 anchors

Lift bolts measuring 0.375 inches in diameter were secured to the formwork in the same fashion as the anchor bolts. The lift bolts located on the top of the test bocks as shown in Figure 2 served a dual purpose, being used to move the block via overhead crane as well as attaching instrumentation for testing as described later in this section. The lift bolts were placed outside a radius of $2.3h_{ef}$ from the anchors so as not to affect the behavior of the breakout cone formed in tension.

After formwork was removed from the test blocks, a thin layer of plaster of paris was applied to assist in identifying concrete cracks during and after testing. The plaster was mixed to a paint-like consistency and applied using a paint brush for even coverage. The thickness of the plaster layer and its contributions to the anchor connection capacity was assumed to be negligible. Chalk lines were also added in a one inch by one inch grid on all surfaces of the test blocks. The chalk lines created a simple measurement system that could easily be seen in pictures for current and future researchers.