WJE

Static and Dynamic Testing of Post Tech Manufacturing Post-Tensioning Monostrand Anchors and Two-Piece Wedges

ICC-ES AC303 Testing of Post Tech Manufacturing 0.5-in. Two-Piece Wedge and LPT5I Monostrand Anchor

FINAL REPORT

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WJE No. 2024.7275

PREPARED FOR:

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INTRODUCTION

At the request of Post Tech Manufacturing (PTM), the firm of Wiss, Janney, Elstner Associates, Inc. (WJE) conducted testing services following the procedures outlined in the International Code Council-Evaluation Services (ICC-ES) Acceptance Criteria AC303, *Acceptance Criteria for Post-Tensioning Anchorages and Couplers of Prestressed Concrete*. Testing summarized in this report was performed using an anchorage configuration of a LPT, LLC 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge.

Scope of Work

The scope of work consisted of performing tests by WJE in accordance with AC303 for the 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge. All testing utilized 0.5-in. Grade 270 low relaxation 7-wire strand. The following tasks were performed as part of the scope of work:

- Random sampling of the strand anchorages to be tested from the manufacturer's supply (*AC303 Section 2.4*)
- Performing static tensile tests to determine the breaking strength of the strand (*AC303 Section 3.1*)
- Performing static load tests of strand with the use of anchors (*AC303 Sections 3.2 and 4.1*)
- Performing fatigue load tests of strand with the use of anchors (*AC303 Sections 3.3 and 4.2*)

BASIC PRODUCT DESCRIPTION

Product Description

The 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge and 0.5-in. diameter strand consists of a cast steel anchor and two-piece wedge that grip the strand (Figure 1). The monostrand anchor with the use of a two-piece wedge can be used for monostrand post-tensioning end anchorages. Appendix A contains production drawings and certificates of compliance for the anchors and wedges used for testing.

Product Sampling

All of the products for the testing program were sampled by WJE from a production sampling sent to WJE by PTM. The test sample dimensions were measured and compared to available production drawings. The measured dimensions agreed with the production drawings.

TEST METHODS AND REQUIREMENTS

All static and fatigue testing of the strand and anchorages were conducted by WJE personnel at our structural laboratory in Northbrook, Illinois. Test machine calibration records are included in Appendix B. All testing protocols followed WJE's Quality Manual. All anchorages tested were assembled from components shipped to WJE. WJE personnel assembled each anchorage from production components prior to testing.

Strand Control Tests

Representative strands were chosen from the samples provided to determine the actual breaking strength of the strand used for the tests. These tests were conducted in accordance with ASTM A1061, *Standard*

Test Methods for Testing Multi-Wire Steel Strand and results were compared to ASTM A416 *Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete* requirements. Yield load, ultimate load, and elongation data were recorded and are included in Appendix C along with mill reports for the strand used for testing. A total of three samples were tested and the results were averaged to determine the actual breaking strength to be used for comparison of the anchorage static tests. A short section of strand, measuring approximately 12-in, was used to determine the cross-sectional area of the strand.

Static Load Tests

Static load tests were performed using a 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge. The static load tests were performed in accordance with AC303 Section 4.1. The static tests using a monostrand anchor with a two-piece wedge consisted of the anchor bearing on loading heads (Figure 2) of the test machine on one end of the strand and the test machine gripping the strand on the other end. Test machine grips utilized did not cause stress risers in the strand.

The strands used for the tests had a free length of at least 42 in. between the anchor and gripped end. The actual distance between the anchorages was measured prior to loading the samples. A baseline gage length, a minimum of 3 in. from anchorage and test machine grip, was measured and recorded prior to loading. At the conclusion of each test, the gage length was re-measured and recorded to determine the total elongation at strand failure. Load and elongation data were recorded for each test.

In accordance with AC303, Section 3.2.2, each test assembly is considered to pass when the failure load of the strand exceeds 95 percent of the actual breaking strength of the strand as determined from the strand control tests and the strand elongation at failure is at least 2 percent. It is noted that ACI 423.7-14 *Specification for Unbonded Single-Strand Tendon Materials* and Post-Tensioning Institute (PTI) M10.2-17 *Specification for Unbonded Single Strand Tendons* have similar static and fatigue testing criteria. The static test requirements for ACI 423.7 and PTI M10.2 are the anchor shall develop at least 95 percent of the specified minimum tensile strength of the strand and a the strand total elongation shall be at least 2 percent.

It is noted that PTI M10.2-17 has a requirement for testing wedge seating methods for fixed anchors that include the pull method, strand push method, and wedge push method. The wedges for the anchors tested were seated by applying a load to the strand using the test machine grips. The method of wedge seating for testing is like the pull method as described in PTI M10.2-2017 – *Specification for Unbonded Single Strand Tendons*, Section 3.7.7.2 – *Wedge seating methods for fixed anchorages* for attaching fixed anchors to strands, except it does not leave permanent gripping wedge teeth marks on the strand which are known to cause stress risers in the strand. Wedge seating for fixed anchors by the pull method performed in post-tensioning plants typically utilize strand grips that do leave permanent gripping wedge teeth marks in the strand, which is known to change the performance of the tendon. The static testing described in this report does not represent the performance of the anchors, wedge, and strand system assembled using the wedge seating pull method typically performed by post-tensioning plants (where the wedge seating process leaves permanent wedge teeth marks in the strand).

Fatigue Load Tests

Fatigue load tests were performed using a 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge. Tests were performed in general accordance with AC303 Section 4.2. A test tendon consisted of an anchor with a two-piece wedge on both ends of a length of strand approximately 80-in long. One end of the test tendon was connected to a fixture consisting of steel plates separated by threaded rods bolted to a hydraulic actuator (Figure 3). The strand passed through the structural floor opening with the anchor on the other end of the test tendon bearing on the underside of the floor (Figure 4).

It is noted that PTI M10.2-17 has a requirement for testing wedge seating methods for fixed anchors that include the pull method, strand push method, and wedge push method. The wedges for the anchors tested were seated by applying a load to the anchors through the strand using the hydraulic actuator. The method of wedge seating for testing is like the pull method as described in PTI M10.2-2017 Section 3.7.7.2 for attaching fixed anchors to strands, except it does not leave permanent gripping wedge teeth marks in the strand which are known to cause stress risers in the strand. Wedge seating for fixed anchors by the pull method performed in post-tensioning plants typically utilize strand grips that do leave permanent gripping wedge teeth marks in the strand, which is known to change the performance of the tendon. The fatigue testing described in this report does not represent the performance of the anchor, wedge and strand system assembled using the wedge seating pull method typically performed by post-tensioning plants (where the wedge seating process leaves permanent wedge teeth marks in the strand).

The first fatigue load test consisted of 500,000 cycles with a cycle frequency of 6 Hz. The load range of cycling was at least between 60 and 66 percent of the strand's minimum specified breaking strength of 41,300 lbf (24,780 lbf to 27,260 lbf). The hydraulic actuator load limits were set between 24,700 lbf and 27,400 lbf to ensure the specified load range was achieved. Data for the 500,000-cycle fatigue test were recorded on a per cycle basis. Recorded data included maximum force and minimum force per cycle.

At the completion of the 500,000 cycles, 50 cycles with a cycle frequency of 1 Hz were performed with a load range of cycling between 40 and 85 percent of the strand's minimum specified breaking strength of 41,300 lbf (16,520 lbf to 35,105 lbf). The hydraulic actuator load limits were set between 16,400 lbf and 35,200 lbf to ensure the specified load range was achieved. Recorded data included applied maximum and minimum force for each cycle.

It is noted that ACI 423.7-14 and PTI M10.2-17 have the same fatigue testing criteria.

At the conclusion of the testing, the anchorage configuration was deemed to pass if neither the strand nor anchorage failed during any part of the fatigue tests.

TEST DATA AND RESULTS

The test results of the strand used for testing the anchors and wedges show the strand meets the minimum ultimate tensile capacity requirements listed in ASTM A416. Table 1 summarizes the strand control test results.

The results from the static load tests for the 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge are listed in Table 2.

The results from the fatigue load tests for the 0.5-in. LPT5I monostrand anchor with a 0.5-in PTM two-piece wedge are listed in Table 3.

Included in each table is the testing summary for each test. The load-elongation plots for static testing and the load-cycle plots for the fatigue testing are included in Appendix D and Appendix E, respectively.

The anchorage assemblies' static test results exceeded 95 percent of the actual strand tensile strength and strand elongation exceeded the minimum 2 percent elongation requirement. The anchorage assemblies survived the fatigue test without failure, therefore satisfying the fatigue performance criteria. The anchorage configuration listed in Table 2 and Table 3 passed the requirements outlined in AC303 Sections 3.2.2 and 3.3.2. The anchorage assemblies also satisfied the requirements of ACI 423.7-14 and PTI M10.2-17.

Table 1. Summary of 7-Wire Strand Control Tests

Test Number	Weight (g)	Length (in.)	Area (in^2)[1]	Load at 1% Elongation (lbf)	Ultimate Load (lbf)	Elongation at Maximum Load (%)
05-1	233.1	12.119	0.149	38,730	42,800	6.27
05-2	233.1	12.119	0.149	38,710	42,880	6.20
05-3	233.1	12.119	0.149	38,690	42,840	6.09
			Average	38,710	42,840	6.14

Note 1: Strand weight and length used to determine strand area.

Table 2. Summary of ICC-ES AC 303 Static Testing

Test Number	Anchorage Material	Total Elongation (%)	Ultimate Load (lbf)	95% of Control Strand Ultimate Load (lbf)	Pass/Fail
Static #1	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	4.26	42,180	40,700	Pass
Static #2	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	4.53	42,350	40,700	Pass
Static #3	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	4.42	42,440	40,700	Pass

Table 3. Summary of ICC-ES AC303 Fatigue Testing

Test Number	Anchorage Material	Load Test Cycles	Start Length (in.)	Final Length (in.)	Load Range		Pass/Fail
					Min Load (lbf)	Max Load (lbf)	
Fatigue #1	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	500,000	80	80	24,700	27,400	Pass
Fatigue #1	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	50	80	80	16,400	35,200	Pass
Fatigue #2	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	500,000	80	80	24,700	27,400	Pass
Fatigue #2	0.5-in. LPT5I Monostrand Anchor with PTM Two-Piece Wedge	50	80	80	16,400	35,200	Pass

FIGURES

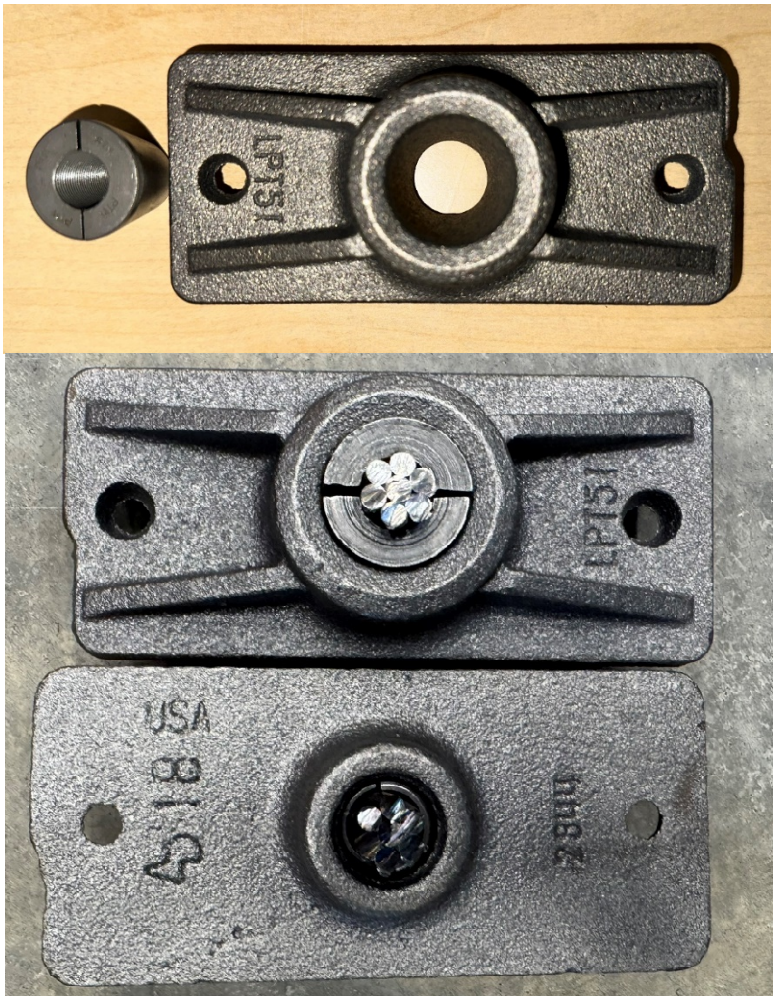


Figure 1. 0.5-in. LPT5I monostrand anchor with two-piece wedge



Figure 2. 0.5-in. LPT5I monostrand anchor with two-piece wedge during ICC-ES AC303 static testing

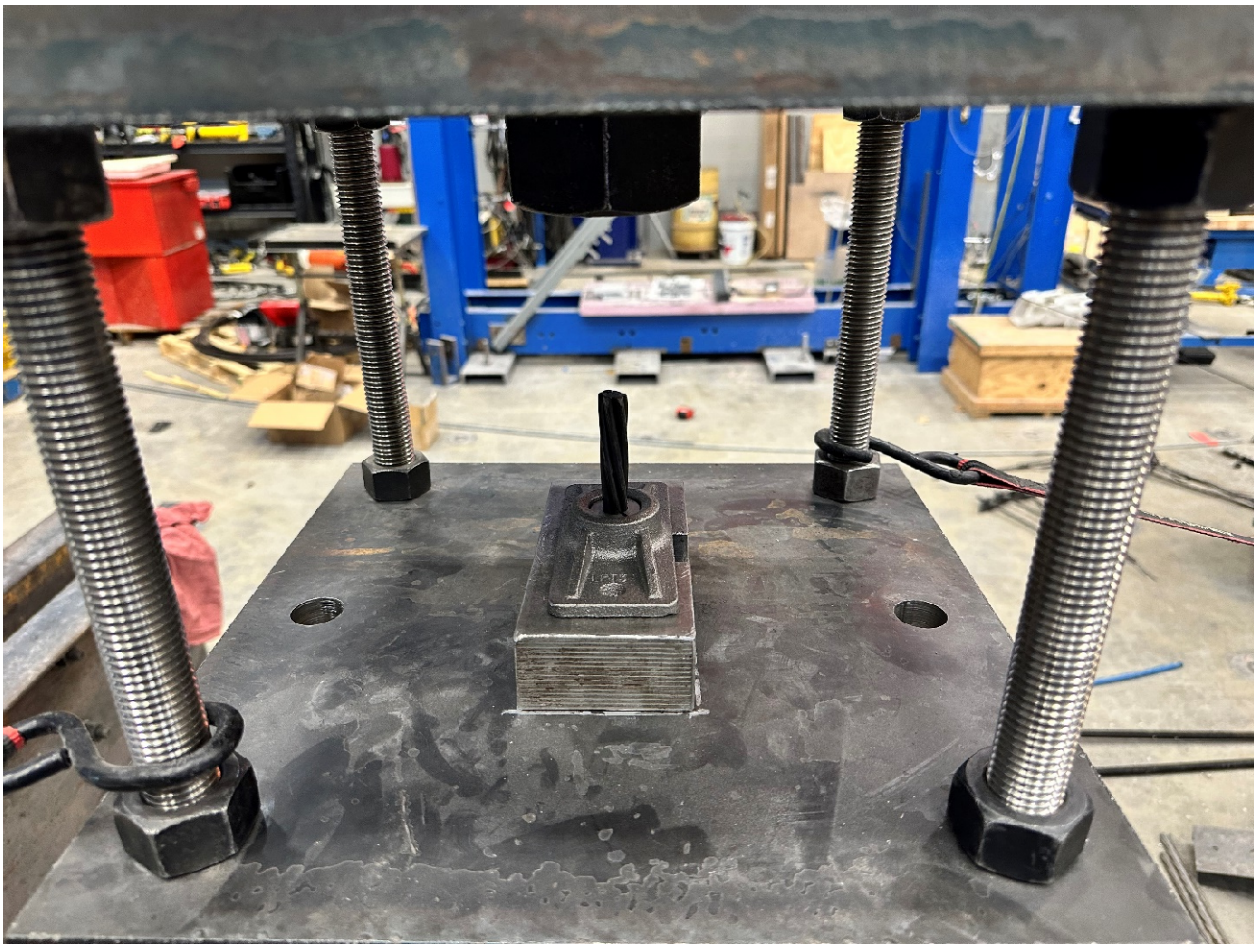


Figure 3. 0.5-in. LPT5I monostrand anchor with two-piece wedge during ICC-ES AC303 fatigue testing



Figure 4. 0.5-in. LPT5I monostrand anchor with two-piece wedge during ICC-ES AC303 fatigue testing