

**SPECIAL PROVISIONS
MODIFYING
SECTION 504: LOAD TESTING OF BEARING PILES**

The 2014 Edition of the New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction shall apply in addition to the following:

Delete SECTION 504: LOAD TESTING OF BEARING PILES in its entirety and substitute the following:

504.1 DESCRIPTION

This Work consists of static axial compressive load tests (pile load test), static axial tensile load tests (pile pullout tests), and high strain dynamic measurements (dynamic measurements) of piles for the purpose of determining ultimate bearing capacity and pile pullout capacity.

For driven piles, dynamic measurements determine driving stresses, pile integrity, and hammer efficiency. For cast-in-place concrete piles (drilled shafts), dynamic measurements verify pile integrity.

504.1.1 Contractor's Responsibilities

504.1.1.1 Dynamic Measurements

Provide labor, Equipment, and Materials necessary to drill the dynamic test piles holes and for mounting transducers. Provide the analysis Equipment power supply.

Where dynamic measurements are to be made on cast-in-place piles, provide a gravity drop hammer and pile cushioning. Excavate around the pile, cut the permanent casing, drill holes in the test pile(s) and provide impacts on cast-in-place dynamic test piles as required.

If a Pile Dynamic Test Consultant Testing is required, as designated on the plans, the consultant's qualifications and equipment must meet the requirements of this Section and Section 504.3 "Equipment." Pile Dynamic Consultant Equipment must meet the requirements of Section 504.3.1.5 "Pile Driving Analyzer." Perform field Pile Dynamic Testing with an experienced technician or engineer having at least two (2) years of experience with Pile Dynamic Testing methods. Use a licensed Professional Engineer having at least three (3) years of experience in Pile Dynamic Testing performed to interpret the recorded measurements and generate reports.

At the option of the State Geotechnical Engineer, Department personnel may perform the Pile Dynamic Testing.

504.1.1.2 Pile Load and Pile Pullout Tests

Provide everything necessary to perform pile load or pile pullout tests. Record load measurement and pile movement readings, and produce a report(s) showing the load displacement curve(s).

504.1.2 Department's Responsibilities

504.1.2.1 Dynamic Measurements

If Pile Dynamic Testing performed by the Department is required, as designated on the plans, the Department will provide the Equipment to perform dynamic measurements and the Department will provide personnel to take the dynamic measurements.

504.1.2.2 Pile Load and Pile Pullout Tests

The Contract will specify the anchor pile requirements. The Department will provide personnel to observe and monitor the Contractor's test apparatus, test methods, and data collection.

504.1.3 Pile Testing Mobilization

Mobilize testing Equipment as needed and as designated by the Contract or authorized by the State Geotechnical Engineer. Mobilize testing Equipment only after receipt of written authorization.

504.2 SUBMITTALS

504.2.1 Load Test Frame

Submit the proposed load test frame and anchorage method, details, and design computations 30 Days before the start of pile load tests and pile pullout tests. Use a professional Engineer licensed in New Mexico to prepare and seal the proposed loading apparatus detail Plans.

504.2.2 Certificates of Calibration

Submit a calibration certificate and a calibration chart relating pressure to load for the load pressure gauge(s) from a certified Laboratory before use. Calibrate each jack and its gauge as a unit. Submit a calibration certificate for load cell(s). Calibrate gauges and cells within six (6) months before use.

504.2.3 Pile and Equipment Data Form

Submit a *Pile and Driving Equipment Data Form* as required in Section 501.2.3.1, "Pile Driving Equipment Submittals," when proposing a gravity drop hammer for dynamic measurements of cast-in-place piles.

504.3 EQUIPMENT

504.3.1 Equipment for Dynamic Testing

504.3.1.1 Power Supply

Provide dynamic test Equipment electric power that supplies 10 A, 115 V, 55 Hz to 60 Hz, A.C. only. If a field generator is used as the power source, provide functioning voltage and frequency level monitoring

meters.

504.3.1.2 Gauge Mounting Equipment

Provide a power drill, bits, taps, and expandable masonry anchor studs to drill holes in the dynamic test piles for bolting transducers to the piles. Provide a six (6) lb rubber mallet hammer when dynamic testing is specified on precast concrete piles.

504.3.1.3 Personnel Lift

To assist with the installation of instruments, provide a hydraulic, telescoping arm personnel lift. Provide a personnel lift with adequate length to reach the top of the pile while the pile is located in the leads.

The contractor may use an alternative to a personnel lift in accordance with Section 504.3.4.1.2 "Preparation for Testing."

504.3.1.4 Gravity Drop Hammer

Provide a gravity drop hammer and pile cushion when cast-in-place piles dynamic testing is specified. Provide the minimum hammer ram weight and free fall height and cushion thickness specified in the Contract. Equip gravity hammers with guides to ensure concentric drive head impact.

If approved by the State Geotechnical Engineer, the Contractor may use a diesel hammer with the minimum required ram weight and impact energy. Cut-off the fuel flow.

504.3.1.5 Pile Driving Analyzer

Perform the Pile Dynamic Testing using a Pile Driving Analyzer® (PDA) system (Model 8G or PAX) or equivalent. The Dynamic Testing Consultant shall furnish all equipment necessary for the Pile Dynamic Testing such as sensors, cables or wireless transmitters, etc.,. The equipment shall conform to the requirements of ASTM D-4945.

504.3.2 Equipment for Pile Load Test

Provide testing Equipment and measuring systems in accordance with ASTM D 1143, except as modified within these Specifications.

504.3.2.1 Load System

Provide a load system capable of applying 250% of the required ultimate pile capacity. Provide a load test frame design compatible with the anchor pile requirements in accordance with Section 504.3.4.2.1, "Test Pile and Anchor Pile Requirements."

Construct the apparatus so that it is possible to place load increments gradually without causing test pile or load test frame vibration.

504.3.2.2 Load Application System

Use hydraulic jacks to apply the load. When using multiple jacks, fit each jack with a pressure gauge in addition to the master hydraulic pressure gauge. Use jacks from the same manufacturer with the same rated capacity. Connect jacks to a common manifold with pressure supplied by one (1) hydraulic pump.

504.3.2.3 Load Measuring System

Provide a dual load measuring system (gauge and load cell) to verify the test pile load. Calibrate the load cell and mount it between the load frame and the pile head to confirm the load recorded from the pressure gauge.

504.3.2.4 Settlement Measuring System

Use a dual settlement measuring system. Provide two (2) dial gauges bearing on the reference beams at opposite sides of the pile, below the test plate. Support the reference beams outside of pile-soil movement influences. Provide two (2) linear variable differentiating transformers, with remote digital read-outs bearing on reference beams on opposite sides of the pile.

504.3.3 Equipment for Pile Pullout Test

Use testing Equipment and measuring systems in accordance with Section 504.3.2, "Equipment for Pile Load Test," except as modified within these Specifications.

504.3.3.1 Load System

Provide a load system capable of applying 200% of the required ultimate pile pullout capacity.

504.3.3.2 Reaction System

It is permissible to use suitable cribbing or other bearing plates for reaction points instead of anchor piles. Use cribbing or bearing plates of sufficient size and stiffness to limit undesirable reaction frame movement.

504.3.4 Testing Requirements

504.3.4.1 Preconstruction Wave Equation Analysis

The State Geotechnical Engineer or Dynamic Testing Consultant shall use the submitted information required in Section 501.2.3.1 "Pile Driving Submittals" to perform wave equation analyses and shall prepare a summary report of the wave equation results. The wave equation analysis (using GRLWEAP™ software by Pile Dynamics, Inc. or equivalent) shall be used to assess the ability of the proposed driving system to install the pile to the required capacity and desired penetration depth within the allowable driving stresses.

Approval of the proposed driving system by the Engineer shall be based upon the wave equation analyses indicating that the proposed driving system meeting the requirements of Section 501.3.1.4 "Approval of Driving System."

A Preliminary Wave Equation Analysis Acceptance Chart shall be developed and submitted to the Project Manager a minimum of seven (7) days before commencing pile driving. Submit the Preliminary Wave Equation Analysis Acceptance Chart meeting the template requirements as provided by the NMDOT Geotechnical Section.

504.3.4.2 Dynamic Pile Testing Requirements

Perform dynamic testing during the pile driving as described in the Contract as "Dynamic Test Piles." The State Geotechnical Engineer may decide to designate additional piles shown in the Contract as dynamic test piles.

504.3.4.2.1 Driven Pile Preconstruction Meeting

Attend and respond to comments provided by NMDOT at the required Driven Pile Preconstruction Meeting held after all submittals have been approved. The Driven Pile Preconstruction Meeting will take place no less than one (1) week before the start of pile driving.

504.3.4.2.2 Notification to Proceed

Notify the Project Manager at least 21 Days before commencing dynamic test pile testing. Confirm the testing schedule with the Project Manager 3 Days before the testing date. Notify the Project Manager promptly of any changes in the schedule. Test dynamic test piles before any other piles are driven or installed, unless the Project Manager approves otherwise.

504.3.4.2.3 Preparation for Testing

Prepare dynamic test piles as follows:

1. **Drilling for Mounting Transducers.** Drill holes for mounting the transducers. Bolt the instruments near the head of the pile at the location and using a bolt pattern designated by the State Geotechnical Engineer.

Drilling requirements for each test pile include the following:

- 1.1. Steel pipe piles: Seven (7) holes drilled with a 7/32 inch diameter bit, tapped to accommodate ¼ in bolts;
- 1.2. Steel HP piles: Five (5) holes drilled with a 5/16 inch diameter bit through the web;
- 1.3. Precast concrete or cast-in-place concrete piles: Seven (7) ¼ inch x 1 ½ inch holes with ¼ inch expandable anchor studs set in the holes to accommodate ¼ inch bolts;

2. **Wave Speed Measurements.** When precast concrete piles are specified as dynamic test piles, place the pile horizontally on wooden sleepers so that it is not in contact with the ground or with other piling. The State Geotechnical Engineer will take wave speed measurements for the Pile Driving Analyzer (PDA) by hitting the pile with a six (6) lb rubber mallet hammer. The Department will not require wave speed measurements for steel piles;
1. **Transducer Installation.** Install the instruments while the pile is in the leads using a man-lift raised to the top of the pile. As an alternative to the man-lift requirement, the State Geotechnical Engineer may install the instruments after the pile is driven to a tip elevation of ten (10) ft above the Plan tip elevation.

504.3.4.2.4 Procedure for Testing Driven Piles

The following are the procedures for testing driven piles for either Department or Consultant Pile Dynamic Testing:

1. Drive the test pile in accordance with Section 501.3.5, "Pile Driving Operations," while monitoring the dynamic measurements;
2. Monitor the test pile stresses that result from the driving to ensure that the compressive or tensile stresses do not exceed the allowable driving stresses as defined in Table 501.3.1.4:1, "Wave Equation Analysis Allowable Driving Stress." If the monitored pile stresses exceed these criteria, stop driving. Perform necessary modifications to the driving operation to ensure that pile damage does not occur;
3. Monitor the test pile stresses on individual gauges to determine if non-axial driving is indicated. If the pile bends beyond acceptable allowances, stop driving and realign the driving system;
4. If the Contract specifies an estimated penetration elevation, drive the first dynamic test pile until the required ultimate capacity or the estimated penetration elevation is achieved;

If the Contract specifies a minimum penetration elevation, drive the first dynamic test pile to that elevation;

If the test pile does not achieve the required ultimate capacity at the estimated or minimum penetration elevation, splice the test pile with additional length of pile. Remove and relocate the instruments to the spliced section. Proceed with driving until the ultimate driving capacity is achieved;

5. Forty-eight hours after the initial drive, restrike each test pile previously driven with the dynamic measuring Equipment installed. The State Geotechnical Engineer may allow shorter wait periods depending on soil and test conditions. Alternatively, the Contract may require longer wait periods, multiple restrike intervals, or both on a given test pile. Use a "warm" hammer that has previously driven at least one (1) pile other than the test pile(s), to restrike the test pile(s). The maximum total number of hammer blows for the restrike is 40.

504.3.4.2.5 Procedure for Testing Cast-in-Place Piles

The following are the procedures for testing cast-in-place piles:

1. When the Contractor casts the dynamic test pile(s), the Inspector will make three (3) test cylinders of concrete or grout for each test pile in accordance with AASHTO T 23M.
Provide concrete that will achieve a compressive strength at seven (7) Days of 3,000 psi;
2. After seven (7) Days, weigh the three (3) concrete test cylinders and report the average unit weight to the State Geotechnical Engineer.

Test one (1) concrete cylinder at seven (7) Days. If the compressive strength is at least 3,000 psi, test the other two (2) cylinders. Report the average of the three (3) breaks to the State Geotechnical Engineer.

Perform the dynamic test on the test pile the same Day that the cylinders are broken;

3. If the first test cylinder breaks at less than 3,000 psi, report the result to the State Geotechnical Engineer. The State Geotechnical Engineer may decide either to have the last two (2) cylinders tested the same Day or to wait up to a maximum of 14 additional Days before breaking the last two (2) cylinders. The Day the last two (2) cylinders are tested, re-weigh the cylinders and determine the average unit weight of the concrete.

Perform the dynamic test on the test pile the same Day the last two (2) cylinders are broken;
There will be no added compensation to the Contractor and no time extension to the Contract if Delays occur because the concrete does not achieve the required strength at seven (7) Days.

4. Use the average compressive strength and the average unit weight of the concrete to estimate the modulus of elasticity and the wave speed of the concrete for input into the PDA;
5. Perform excavation around the test pile as needed to mount the gauges. Typically, the required depth of excavation will be twice the diameter of the pile;
6. Attach the instruments to the pile head and impact the pile with the ram at the free fall height directed by the State Geotechnical Engineer. Each test pile will not require more than 40 blows. Monitor the pile stresses that result from the ram impact to ensure that the compressive or tensile stresses do not exceed the allowable pile driving stresses defined in Table 501.3.1.4:1, "Wave Equation Analysis Allowable Driving Stress." If the monitored pile stresses exceed these criteria, the Department will direct the Contractor to reduce the ram free fall height or add pile cushioning.

504.3.4.2.6 Case Pile Wave Analysis

NMDOT Geotechnical Section personnel or approved Pile Dynamic Testing Consultant will perform the Case Pile Wave Analysis as designated on the plans or determined by the NMDOT State Geotechnical Engineer.

Signal matching analysis (by CAPWAP® software, available from Pile Dynamics, Inc. or equivalent) of the dynamic pile testing data shall be performed on data obtained from the end of initial driving and the beginning of restrike of specified Pile Dynamic Test piles. CAPWAP analysis should be performed by an

engineer who meets the minimum requirements outlined in Section 504.1.1.1 "Dynamic Measurements", and is capable of returning analysis within one (1) working day from time of transmission. The State Geotechnical Engineer or Dynamic Testing Consultant may request additional analyses at selected pile penetration depths.

504.3.4.3 Pile Load and Pile Pullout Testing Requirements

504.3.4.3.1 Test Pile and Anchor Pile Requirements

1. Driven Piles. Apply the load to a production pile driven in the final Plan location, unless otherwise specified in the Contract, and apply the test frame against anchor (tension) piles;

Use production piles driven in final Plan locations for the anchor piles unless the layout of the test frame reaction points is fixed and inconsistent with the production pile layout or unless an alternative pile type is required to develop adequate pullout resistance. The Project Manager will decide if anchor piles that are not final production piles may be cut-off below final grade or pulled after the testing is completed;

2. Cast-in-Place Piles. Apply the load to a production pile located in the final Plan location, unless otherwise shown in the Contract. Use either driven piles or cast-in-place piles as anchor piles. Do not use anchor piles as final production piles. Provide cast-in-place anchor piles with reinforcement capable of carrying the pile tension force.

504.3.4.3.2 Commencement of Load Test

Unless otherwise specified in the Contract, wait a minimum of 24 h between driving or installing anchor piles or the test pile and commencing with the pile load or pile pullout test.

When testing pipe piles filled with concrete or cast-in-place concrete piles, begin load tests after the concrete has attained a compressive strength of 2,500 psi.

504.3.4.3.3 Load Testing Procedures

Conduct pile load tests and pile pullout tests in accordance with the following requirements:

1. Perform the *Quick Load Test Method for Individual Piles* in accordance with ASTM D 1143, but take the load test to the first of either failure of the test pile or capacity of the load system;
2. Test pile failure is defined as total vertical pile movement equal to the greater of either five percent (5%) of the pile diameter or two (2) inches;
3. If failure occurs, remove the test load in four (4) approximately equal amounts with a five minute interval between removals;
4. For pile load tests where piles are 24 inch or less in diameter or width, the ultimate capacity is the load that produces a settlement of the pile head in accordance with the following equation:

$$sf = S + (0.15 + 0.008D) \quad (1)$$

Where,

- sf is the settlement at the ultimate pile capacity in inches
- D is the pile diameter or width in inches
- S is the elastic deformation of pile length in inches

Use the following equation for piles with diameters or widths greater than 24 inches:

$$sf = S + \frac{D}{30} \quad (2)$$

Where,

- sf is the settlement at the ultimate pile capacity in inches
- D is the pile diameter or width in inches
- S is the elastic deformation of pile length in inches

5. For pile pullout tests, the State Geotechnical Engineer will determine when the ultimate pile capacity is attained.

504.3.4.4 Completion of Dynamic Testing of Driven Piles

After completing the dynamic test pile(s) at a Substructure element, prepare the pile(s) for any specified pile load or pile pullout test(s).

If no load testing is required as determined in Section 501.3.6, "Pile Acceptance", the Final Wave Equation Analysis Acceptance Charts, based on results of the Pile Dynamic Testing, should be submitted to the Project Manager within thirty six (36) hours after completion of PDA testing and CAPWAP analyses at the applicable bridge or structure element.

The Dynamic Testing Consultant shall prepare a written report of the of the Pile Dynamic Testing results within seven (7) days of completion of all dynamic test piles specified. This report shall include the results of static load test(s) (if performed) and shall contain a discussion of the pile capacity obtained from the dynamic and static testing. The report shall also discuss hammer and driving system performance, driving stress levels, and pile integrity.

Drive production piles no deeper than the estimated or minimum penetration elevation before receiving the field Acceptance criteria. Record the average hammer stroke and pile set after driving of each pile to determine pile Acceptance once the driving criteria is established. After receiving the field Acceptance criteria, drive piles until attaining the required ultimate capacity.

504.3.4.5 Completion of Dynamic Testing of Cast-in-Place Piles

Base the required production pile tip elevation on the dynamic testing and load testing results if specified. The State Geotechnical Engineer will require up to 36 h after completion of the last test pile to provide the pile tip elevation.

Unless the State Geotechnical Engineer directs otherwise, place no other piles until receiving the production pile tip elevation.

504.3.4.6 Completion of Load Testing

After completing the specified load test(s) to the Project Manager's satisfaction, dismantle the test apparatus and Equipment and remove from the site. Use the load test results to determine the ultimate pile capacity Acceptance criteria of driven piles as established under Section 501.3.6, "Pile Acceptance," and to confirm ultimate pile capacities determined by dynamic pile tests.

Pulled anchor piles of the same type as the production piles may be reused as production piles if not rejected by the Project Manager due to damage as covered in Section 501.3.6.3, "Damaged Pile Limitations."

For cast-in-place piles, use the load test results to determine the pile penetration requirements, if no subsequent dynamic testing is specified.

The State Geotechnical Engineer will require up to 36 h after completion of the last test pile to provide the pile tip elevation.

Re-drive production piles used as anchor piles in accordance with Section 501.3.6, "Pile Acceptance."

504.4 METHOD OF MEASUREMENT—Reserved

504.5 BASIS OF PAYMENT

Pay Item	Pay Unit
<i>Pile Testing Mobilization</i>	Lump Sum
<i>Pile Load Test</i>	Each
<i>Pile Pullout Test</i>	Each
<i>Pile Dynamic Test</i>	Each
<i>Pile Dynamic Test Consultant Testing</i>	Each
<i>Case Pile Wave Analysis Test</i>	Each
<i>Case Pile Wave Analysis Test Consultant Testing</i>	Each

504.4.1 Work Included in Payment

The following Work will be considered as included in the payment for the mail item(s) and will not be measured or paid for separately: Non-production anchor and test piles which will not remain in use as part of the permanent structure.