

ORINATION FORM

Proposed Revisions to the Specifications

(Please provide all information - incomplete forms will be returned)

Date: Specification Section:

Originator: Articles/Subarticles:

Telephone:

email:

Will the proposed revision involve Design Standard Index changes? Yes No

Roadway Design staff contacted (name):

Structures Design staff contacted (name):

Will the proposed revision involve PPM changes? Yes No

Roadway Design staff contacted (name):

Will the proposed revision involve CPAM changes? Yes No

Construction staff contacted (name):

Will the proposed revision involve Pay Item changes? Yes No

Estimates staff contacted (name):

Will the proposed revision involve SDG changes? Yes No

Structures staff contacted (name):

Will the proposed revision involve APL changes? Yes No

Product Evaluation staff contacted (name):

Will the proposed revision involve Material Manual changes? Yes No

State Materials Office staff contacted (name):

Will this revision necessitate any of the following:

Design Bulletin Construction Bulletin Estimates Bulletin Materials Bulletin

Are all references to external publications current? Yes No

If not, what references need to be updated? (Please include changes in the redline document.)

Why does the existing language need to be changed?

Summary of the changes:

Are these changes applicable to all Department jobs? Yes No

If not, what are the restrictions?

Contact the State Specifications Office for assistance in completing this form.

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M E M O R A N D U M

DATE: November 15, 2016

TO: Specification Review Distribution List

FROM: Dan Hurtado, P.E., State Specifications Engineer

SUBJECT: Proposed Specification: **4550100DB Structures Foundations.**

In accordance with Specification Development Procedures, we are sending you a copy of a proposed specification change.

This change was proposed by Juan Castellanos of the State Construction Office to update the language.

Please share this proposal with others within your responsibility. Review comments are due within four weeks and should be sent to Mail Station 75 or online at <http://www2.dot.state.fl.us/ProgramManagement/Development/IndustryReview.aspx> . Comments received after **December 13, 2016**, may not be considered. Your input is encouraged.

DH/dt
Attachment

STRUCTURES FOUNDATIONS (REV 10-21-16)

ARTICLE 455-1 is deleted and the following substituted

455-1 General Requirement.

The Contractor may examine available soil samples and/or rock cores obtained during the preliminary soil boring operations at the appropriate District Materials Office or designated storage location.

455-1.1 Monitor Existing Structures: Monitor existing structures in accordance with Section 108.

455-1.2 Excavation: Complete all excavation of the foundations prior to installing piles or shafts unless otherwise authorized by the Engineer. After completing pile/shaft installation, remove all loose and displaced materials from around the piles/shafts, leaving a clean, solid surface. Compact the soil surface on which concrete is to be placed or which will support the forming system for the concrete to support the load of the plastic concrete without settling or causing the concrete to crack, or as shown in the Contract Documents. ~~The Engineer will not require the Contractor to compact for excavations made below water for seals or when the footing or cap or forming system (including supports) does not rest on the ground surface.~~

455-1.2.1 Abutment (End Bent) Fill: Place and compact the fill before installing end-bent piling/shafts, except when:

~~1.~~ driving specified test piling in end bents or when

~~2.~~ the Plans show uncased piles through proprietary retaining wall fills.

When installing piles/shafts or casing prior to placing fill, take necessary precautions to prevent displacement of piles/shafts during placing and compacting fill materials within 15 feet of the piles/shafts or casing. Reference and check the position of the piles/shafts or casing at three approximately equal intervals during construction of the embankment.

Place embankment material in 6 inch loose lifts in the 15 foot area around the piles/shafts or casing. Compact embankment material within the 15 foot area adjacent to the piles/shafts or casing to the required density with compaction equipment weighing less than 1,000 pounds. When installing piles/shafts prior to the completion of the surrounding fills, do not cap them until placing the fills as near to final grade as possible, leaving only the necessary working room for construction of the caps.

When shown in the Plans, provide permanent casings installed prior to placement of the fill, for all drilled shafts through mechanically stabilized fills (for example, behind proprietary retaining walls) for shafts installed after fill placement. Install temporary casings through the completed conventional fill when permanent casings are not required.

Provide permanent casings, if required, before the fill is placed extending a sufficient distance into the existing ground to provide stability to the casings during construction of the abutment fill.

455-1.3 Cofferdams: Construct cofferdams as detailed in the Plans. When cofferdams are not detailed in the Plans, employ a qualified Specialty Engineer to design cofferdams, and to sign and seal the plans and specification requirements. Send the designs to the Engineer for his records before beginning construction.

Use when Geotechnical Services are required for the project.

Provide a qualified diver and a safety diver to inspect the conditions of the foundation enclosure or cofferdam when the Contract Documents require a seal for construction. Equip these divers with suitable voice communications, and have them inspect the foundation enclosure and cofferdam periphery including each sheeting indentation and around each piling or drilled shaft to ensure that no layers of mud or other undesirable materials were left above the bottom of seal elevation during the excavation process. Also have the divers check to make sure the surfaces of the piles or drilled shafts are sufficiently clean to allow bond of the concrete down to the minimum bottom of seal elevation. ~~When required, E~~Ensure that there are no mounds of stone, shell, or ~~other authorized~~unapproved backfill material left after placement and grading. Ensure that the seal is placed as specified and evaluate the adequacy of the foundation soils or rock. Correct any deficiencies found by the divers. Upon completion of inspection by the divers, the Department may also elect to inspect the work before authorizing the Contractor to proceed with subsequent construction operations. Submit a written report by the divers to the Engineer indicating the results of their underwater inspection before requesting authorization to place the seal concrete.

455-1.4 Vibrations on Freshly Placed Concrete (Drilled Shafts and Piers): Ensure that freshly placed concrete is not subjected to peak particle velocities ~~vibrations~~ greater than 1.5 inches per second from vibration sources ~~pile driving and/or drilled shaft casing installation sources~~ located within ~~the greater dimension of three shaft diameters (measured from the perimeter of the shaft closest to the vibration source)~~ or 30 feet (from the nearest outside edge of freshly placed concrete to the vibration source) until that concrete has attained its final set as defined by ASTM C403 except as required to remove temporary casings before the drilled shaft elapsed time has expired.

SUBARTICLES 455-2.1 through 455-2.4 are deleted and the following substituted:

455-2.1 General: Employ a professional testing laboratory, or Specialty Engineer with prior load test experience on at least three projects, to conduct the load test in compliance with these Specifications, to record all data, and to submit signed and sealed reports of the test results to the Engineer.

Perform the load test by applying a load up to the load required in the Contract Documents or to the failure load, whichever occurs first.

Do not apply test loads to piles sooner than 48 hours (or the time interval shown in the Plans) after driving of the test pile or reaction piles, whichever occurs last.

Do not begin static load testing of drilled shafts until the concrete has attained a compressive strength of 3,400 psi. The Contractor may use high early strength concrete to obtain this strength at an earlier time to prevent testing delays.

Provide all equipment, materials, labor, and personnel required to conduct the load tests, including determination of anchor reaction member depths. In this case, provide a loading apparatus designed to accommodate the maximum load plus an adequate safety factor.

While performing the load test, provide safety equipment, and employ safety procedures consistent with the latest approved practices for this work. Include with these safety procedures, adequate support for the load test plates and jack to prevent them from falling in the event of a release of load due to hydraulic failure, test pile/shaft failure, or any other cause.

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455-2.2 Loading Apparatus: Provide an apparatus for applying the vertical loads as described in one of the following:

1. As shown and described in the Contract Documents.
2. As supplied by the Contractor, one of the following devices designed to accommodate a load at least 20% higher than ~~that the test load~~ shown in the ~~Contract Documents~~ Plans or described herein for test loads:
 - a. Load Applied by Hydraulic Jack Acting Against Weighted Box or Platform: Construct a test box or test platform, resting on a suitable support, over the pile, and load it with ~~earth, sand, concrete, pig iron, or other suitable~~ material with a total weight greater than the anticipated maximum test load. Locate supports for the weighted box or platform at least 6 feet or three pile/shaft diameters, whichever is greater, measured from the edge of the pile or shaft to the edge of the supports. Insert a hydraulic jack with pressure gauge between the test pile or shaft and the underside of the reaction beam, and apply the load to the pile or shaft by operating the jack between the reaction beam and the top of the pile or shaft.

b. Load Applied to the Test Pile or Shaft by Hydraulic Jack Acting Against Anchored Reaction Member: Construct reaction member anchorages as far from the test piles/shafts as practical, but in no case closer than the greater of 3 pile/shaft diameters or 6 feet from the edge of the test pile/shaft. Attach a girder(s) of sufficient strength to act as a reaction beam to the upper ends of the anchor piles or shafts. Insert a hydraulic jack with pressure gauges between the head of the test pile/shaft and the underside of the reaction beam, and apply the test load to the pile/shaft by operating the jack between the reaction beam and the pile/shaft head.

If using drilled shafts with bells as reaction member anchorages, locate the top of the bell of any reaction shaft anchorage at least three shaft diameters below the bottom of the test shaft.

c. Combination Devices: The Contractor may use a combination of devices (a) and (b), as described above, to apply the test load to the pile or shaft.

d. Other systems proposed by the Contractor and accepted by the Engineer: When necessary, provide horizontal supports for loading the pile/shaft, and space them so that the ratio of the unsupported length to the minimum radius of gyration of the pile does not exceed 120 for steel piles, and the unsupported length to the least cross-section dimension does not exceed 20 for concrete piles or drilled shafts. Ensure that horizontal supports provide full support without restraining the vertical movement of the pile/shaft in any way.

When required by the Contract Documents, apply a horizontal load to the pile/shaft either separately or in conjunction with the vertical load. Apply the load to the test pile/shaft by hydraulic jacks, jacking against Contractor provided reaction devices. After receiving the Engineer's acceptance of the proposed method of load application, apply the horizontal load in increments, and relieve it in decrements as required by the Contract Documents.

455-2.2.1 Modified Quick Test:

1. Loading Procedure: Apply vertical loads concentric with the longitudinal axis of the tested pile/shaft to accurately determine and control the load acting on the pile/shaft at any time. Place the load on the pile/shaft continuously, in increments equal to approximately 5% of the maximum test load specified until approaching the failure load, as indicated by the measuring apparatus and/or instruments. Then, apply increments of approximately 2.5% until the pile/shaft "plunges" or attains the limiting load. The Specialty Engineer may elect to stop the loading increments when the pile/shaft has met the failure criteria or when a settlement equal to 10% of

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the pile/shaft width or diameter is reached. Apply each load increment immediately after taking and verifying the complete set of readings from all gauges and instruments. Apply each increment of load within the minimum length of time practical, and immediately take the readings. Complete the addition of a load increment and the completion of the readings within 5 to 15 minutes. Hold the maximum applied load for one hour.

Remove the load in decrements of about 10% of the maximum test load. Remove each decrement of load within the minimum length of time practical, and immediately take the readings. Complete the removal of a load decrement and the taking of the readings within 5 to 15 minutes. The Engineer may also require up to two reloading cycles with five loading increments and three unloading decrements. Record the final recovery of the pile/shaft until movement is essentially complete for a period of one hour after the last unload interval.

2. Failure Criteria and Nominal Resistance: Use the criteria described herein to establish the failure load. The failure load is defined as the load that causes a pile/shaft top deflection equal to the calculated elastic compression plus 0.15 inches plus 1/120 of the pile/shaft minimum width or the diameter in inches for piles/shafts 24 inches or less in width, and equal to the calculated elastic compression plus 1/30 of the pile/shaft minimum width or diameter for piles/shafts greater than 24 inches in width. Consider the nominal resistance of any pile/shaft so tested as either the maximum applied load or the failure load, whichever is smaller.

455-2.3 Measuring Apparatus: Provide an apparatus for measuring movement of the test piles/shafts that consists of all of the following devices:

1. Wire Line and Scale: Stretch a wire between two secure supports located at a distance at least:
 - a. 10 feet from the center of the test pile but not less than 3.5 times the pile diameter or width.
 - b. 12 feet from the centerline of the shaft to be tested but not less than three shaft diameters.

Locate the wire supports as far as practical from reaction beam anchorages. At over-water test sites, the Contractor may attach the wire line to the sides of the service platform. Mount the wire with a pulley on one support and a weight at the end of the wire to provide constant tension on the wire. Ensure that the wire passes across the face of a scale mounted on a mirror attached to the test pile/shaft so that readings can be made directly from the scale. Use the scale readings as a check on an average of the dial readings. When measuring both horizontal and vertical movement, mount separate wires to indicate each movement, horizontal or vertical. Measure horizontal movements from two reference wires set normal to each other in a horizontal.

2. Wooden Reference Beams and Dial Gauges: Attach wooden reference beams as detailed in the Plans and accepted by the Engineer to independent supports. For piles, install the independent supports at the greater of 3.5 times the pile diameter or width or 10 feet from the centerline of the test pile. For drilled shafts, install independent supports at the greater of three shaft diameters or 12 feet from the centerline of the shaft to be tested. Locate the reference beam supports as far as practical from reaction beam anchorages. For over-water test sites, the Contractor may attach the reference beams between two diagonal platform supports. Attach dial gauges, with their stems resting either on the top of the pile/shaft or on lugs or similar reference points on the pile/shaft, to the fixed beams to record the movement of the pile/shaft head. Ensure that the area on the pile/shaft or lug on which the stem bears is a smooth surface which will not cause irregularities in the dial readings.

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~~For piles, the minimum acceptable method for measuring vertical movement is two dial gauges, each with 0.001 inch divisions and with 2 inch minimum travel, placed at 180 degrees or at the diagonal corners of the pile.~~

~~For shafts, ensure that three dial gauges, each with 0.001 inch divisions and with 2 inch minimum travel, placed at 120 degree intervals around the shaft, are the minimum acceptable method for measuring vertical movement.~~ Provide Ensure that a minimum of four dial gauges, each with 0.001 inch divisions and with 2 inch minimum travel, placed at 90 degree intervals ~~are the minimum required~~ for measuring vertical or horizontal movement.

3. Survey Level: As a check on the dial gauges, determine the elevation of a point near the top of the test pile/shaft (on plan datum) by survey level at each load and unload interval during the load test. Unless accepted otherwise by the Engineer, level survey precision is 0.001 foot. Alternately, the surveyor may read an engineer's 50 scale attached near the pile/shaft head. Determine the first elevation before applying the first load increment; make intermediate readings immediately before a load increment or an unload decrement, and after the final unload decrement that completely removes the load. Make a final reading at the time of the last recovery reading.

For over-water test sites, when shown in the Plans or directed by the Engineer, the Contractor shall, drive an H pile through a 36 inch casing to provide a stable support for the level and to protect it against wave action interfering with level measurements. Provide a suitable movable jig for the surveyor to stand. Use a jig that has a minimum of three legs, has a work platform providing at least 4 feet width of work area around the casing, and is accepted by the Engineer before use. The described work platform may be supported by the protective casing when accepted by the Engineer.

455-2.4 Load Test Instrumentation:

1. General: The intent of the load test instrumentation is to measure the test load on top of the pile/shaft and its distribution between side friction and end bearing to provide evaluation of the preliminary design calculations and settlement estimates and to provide information for final pile/shaft length design. Ensure that the instrumentation is as described in the Contract Documents.

Supply 110 V, 60 Hz, 30 A of AC electric power in accordance with the National Electric Code (NEC) to each test pile/shaft site during the installation of the instrumentation, during the load testing, and during any instrumented set-checks/redrives.

Place all of the internal instrumentation on the rebar cage before installation in the test shaft. Construct the rebar cage at least two days before it is required for construction of the test shaft. Successfully demonstrate the lifting and handling procedures before installing the instrumentation. Place the instrumented rebar cage in one segment without causing damage to the instrumentation.

2. Hydraulic Jack and Load Cell: Provide hydraulic jack(s) of adequate size to deliver the required test load to the pile/shaft unless shown otherwise in the Plans. Before load testing begins, submit a certificate from a reputable testing laboratory showing a calibration of gauge readings for all stages of jack loading and unloading for jacks provided. Ensure that the jack has been calibrated within the preceding six months. Ensure that the accuracy of the gauge is within 5% of the true load.

Provide an adequate load cell accepted by the Engineer that has been calibrated within the preceding six months. Provide an approved electrical readout device for the load cell. ~~Before beginning load testing, s~~ Submit a certificate from an independent ~~reputable~~

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~~testing~~ laboratory showing a calibration of readings for all stages of loading and unloading for load cells furnished by the Contractor and obtain the approval of the Engineer before beginning load testing. Ensure that the accuracy of the load cell is within 1% of the true load.

3. Telltales: When shown in the Contract Documents, ~~provide~~ install telltales that consist of an unstressed steel rod ~~placed,~~ greased for reducing friction and corrosion, -with appropriate clearance ~~and greased for reducing friction and corrosion,~~ inside a constant-diameter pipe that rests on a flat plate attached to the end of the pipe at ~~a~~ the point of interest shown in the Plans. Construct telltales in accordance with ~~details shown in~~ the Contract Documents. Install dial gauges reading to 0.001 inch with 1 inch minimum travel as directed by the Specialty Engineer to measure the movement of the telltale with respect to the top of the pile/shaft.

4. Embedded Strain Gauges: Provide Install strain gauges ~~which shall be placed~~ in the test shaft to measure the distribution of the load. Ensure that the type, number, and location of the strain gauges are as shown in the Plans or as directed by the Geotechnical Foundation Design Engineer of Record (GFDEOR). Use strain gauges that are waterproof and have suitable shielded cable that is unspliced within the shaft. In drilled shafts provide sufficient instrumentation to determine side friction components in segments no longer than 5 feet and the end bearing component.

5. Caliper: Provide a caliper tool or system to measure accurately and continuously the shape of test shafts prior to placing concrete.

ARTICLES 455-5 and 455-6 are deleted and the following substituted:

455-5 General Requirements.

455-5.1 Site Preparation:

~~455-5.1.1~~ **455-5.1.1 Predrilling of Pile Holes:** Predrilled pile holes are either starter holes to the depth described in this ~~section~~ Subarticle or holes drilled through embankment/fill material down to the natural ground surface at no additional cost to the Department. When using low displacement steel piling such as structural shapes, drive them through the compacted fill without the necessity of drilling holes through the fill except when the requirements for predrilling are shown in the Plans. When using concrete or other high displacement piles, drill pile holes through fill, new or existing, to at least the elevation of the natural ground surface. Use the range of drill diameters listed below for square concrete piles.

12 inch square piles	15 to 17 inches
14 inch square piles	18 to 20 inches
18 inch square piles	22 to 26 inches
20 inch square piles	24 to 29 inches
24 inch square piles	30 to 34 inches
30 inch square piles	36 to 43 inches

~~455-5.1.1.1~~ For other pile sizes, use the diameter of the drills shown in the Plans or accepted by the Engineer. Accurately drill the pile holes with the hole centered over the Plan location of the piling. Maintain the location and vertical alignment within the tolerances allowed for the piling.

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———For predrilled holes required through rock or other hard (i.e. debris, obstructions, etc.) materials that may damage the pile during installation, predrill hole diameters approximately 2 inches larger than the largest dimension across the pile cross-section. Fill the annular space around the piles as described in 455-5.910.1 with clean A-3 sand or sand meeting the requirements of 902-3.3.

———In the setting of permanent and test piling, the Contractor may initially predrill holes to a depth up to 10 feet or 20% of the pile length whichever is greater, unless otherwise shown in the Plans. except that, When where installing piles in compacted fill, predrill the holes to the elevation of the natural ground surface. With prior written authorization from the Engineer, the Contractor may predrill holes to greater depths to minimize the effects of vibrations on existing structures adjacent to the work and/or for other reasons the Contractor proposes. Perform such work the Engineer allows but does not require at no expense to the Department.

455-5.1.2 Underwater Driving: Underwater driving is defined as any driving through water which is above the pile head at the time of driving.

———When conducting underwater driving, provide a diver equipped with voice communications to aid in placing the hammer back on the pile for required cushion changes or for subsequent re-driving, to attach or recover instrumentation, to inspect the condition of the pile, or for other assistance as required.

———Select one of the following methods for underwater driving:

———1. Accomplish underwater driving using conventional driving equipment and piling longer than authorized so that the piling will extend above the water surface during final driving. When choosing this option, furnish a pile hammer that satisfies the requirements of this Section for use with the longer pile.

———2. Accomplish underwater driving using an underwater hammer that meets the requirements of this Section and is accepted by the Engineer. When choosing this option, provide at least one pile longer than authorized at each pile group, extending above the water surface at final driving. At each group location, drive the longer pile first. Evaluate the adequacy of the underwater driving system. Use the pile tip elevation of the longer pile to evaluate the acceptability of the piles driven with the underwater hammer.

———3. Accomplish underwater driving using conventional driving equipment with a suitable pile follower. When choosing this option, provide at least one pile longer than required at each pile group, extending above the water surface at final driving. At each group location, drive the full length pile first without using the follower. Perform a dynamic load test on the first pile driven with the follower in each group. Use the pile tip elevation of the longer pile to evaluate the acceptability of the piles driven with the follower.

———Prior to use, submit details of the follower to the Engineer along with the information required in 455-10. Include the weight, cross-section details, stiffness, type of materials, and dimensions of the follower.

455-5.23 Pile Hammers: All equipment is subject to satisfactory field performance. Use a variable energy hammer to drive concrete piles. Hammers will be rated based on the theoretical energy of the ram at impact. Supply driving equipment which provides the required resistance at a blow count ranging from 3 blows per inch (36 blows per foot) to 10 blows per inch (120 blows per foot) at the end of initial drive, unless proven acceptable after satisfactory field trial. When the stroke height or bounce chamber pressure readings do not adequately determine the energy of the hammer, provide and maintain a device to measure the velocity of the ram at impact.

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Determine the actual hammer energy in the field so that it is consistent with the hammer energy used for each bearing capacity determination. When requested, submit to the Engineer all technical specifications and operating instructions related to hammer equipment.

455-5.32.1 Air/steam: Variable energy air/steam hammers shall be capable of providing at least two ram stroke lengths. The short ram stroke length shall be approximately half of the full stroke for hammers with strokes up to 4 feet and no more than 2 feet for hammers with maximum strokes lengths over 4 feet. Operate and maintain air/steam hammers within the manufacturer's specified ranges. Use a plant and equipment for steam and air hammers with sufficient capacity to maintain, under working conditions, the hammer, volume and pressure specified by the manufacturer. Equip the plant and equipment with accurate pressure gauges which are easily accessible. Drive piles with air/steam hammers operating within 10% of the manufacturer's rated speed in blows per minute.

455-5.32.2 Diesel: Variable energy diesel hammers shall have at least three fuel settings that will produce reduced strokes. Operate and maintain diesel hammers within the manufacturer's specified ranges. Determine the rated energy of diesel hammers using measured ram stroke length multiplied by the weight of the ram for open end hammers and by methods recommended by the manufacturer for closed end hammers.

Provide and maintain in working order an approved device to automatically determine and display ram stroke for open-end diesel hammers.

Equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge, in good working order, mounted near ground level so it can be easily read. Also, submit to the Engineer a chart, calibrated to actual hammer performance within 30 days prior to initial use, equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used.

455-5.32.3 Hydraulic: Variable energy hydraulic hammers shall have at least three hydraulic control settings that provide for predictable energy or equivalent ram stroke. The shortest stroke shall be a maximum of 2 feet for the driving of concrete piles. The remaining strokes shall include full stroke and approximately halfway between minimum and maximum stroke.

Supply hammer instrumentation with electronic read out, and control unit that allows the operator to read and adjust the hammer energy or equivalent ram stroke. When pressure measuring equipment is required to determine hammer energy, calibrate the pressure measuring equipment before use.

455-5.32.4 Vibratory: Vibratory hammers of sufficient capacity (force and amplitude) may be used to drive steel sheet piles and, with acceptance of the Engineer, to drive steel bearing piles a sufficient distance to get the impact hammer on the pile (to stick the pile). The Geotechnical Foundation Design Engineer of Record will determine the allowable depth of driving using the vibratory hammer based on site conditions. However, in all cases, use a power impact hammer for the last 15 feet or more of the final driving of steel bearing piles for bearing determinations after all piles in the bent/pier have been driven with a vibratory hammer. Do not use vibratory hammers to install concrete piles, or to install support or reaction piles for a load test.

455-5.34 Cushions and Pile Helmet:

455-5.43.1 Capblock: Provide a capblock (also called the hammer cushion) as recommended by the hammer manufacturer. Use commercially manufactured capblocks constructed of durable manmade materials with uniform known properties. Do not use wood

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chips, wood blocks, rope, or other material which permit excessive loss of hammer energy. Do not use capblocks constructed of asbestos materials. Obtain the Engineer's acceptance for all proposed capblock materials and proposed thickness for use. Maintain capblocks in good condition, and ~~change~~ replace them when charred, melted, or otherwise significantly deteriorated. Inspect the capblock before driving begins and weekly or at appropriate intervals based on field trial. Replace or repair any ~~hammer-cushion~~ capblock which loses more than 25% of its original thickness, in accordance with the manufacturer's instructions, before permitting further driving.

455-5.43.2 Pile Cushion: Provide a pile cushion that is adequate to protect the pile from being overstressed in compression and tension during driving. Use a pile cushion sized so that it will fully fill the lateral dimensions of the pile helmet minus one inch but does not cover any void or hole extending through the top of the pile. Determine the thickness based upon the hammer-pile-soil system. For driving concrete piles, use a pile cushion made from pine plywood or oak lumber. Do not use materials previously soaked, saturated or treated with oil. Maintain pile cushions in good condition and ~~change~~ replace them when charred, splintered, excessively compressed, or otherwise deteriorated to the point it will not protect the pile against overstressing in tension ~~and~~/or compression. Protect cushions from the weather, and keep them dry. Do not soak the cushions in any liquid. Replace the pile cushion, if during the driving of any pile, the cushion is either compressed more than one-half the original thickness or begins to burn. Provide a new cushion for each pile unless proven acceptable after satisfactory field trial.

Reuse pile cushions in good condition to perform all set-checks and redrives. Use the same cushion to perform the set-check or redrive as was used during the initial driving, unless this cushion is unacceptable due to deterioration, in which case use a similar cushion.

455-5.34.3 Pile Helmet: Provide a pile helmet suitable for the type and size of piling being driven. Use a pile helmet deep enough to adequately contain the required thickness of pile cushion and to assist in maintaining pile-hammer alignment. Use a pile helmet that fits loosely over the pile head and is at least 1 inch larger than the pile dimensions. Use a pile helmet designed so that it will not restrain the pile from rotating.

455-5.45 Leads: Provide pile leads constructed in a manner which offers freedom of movement to the hammer and that have the strength and rigidity to hold the hammer and pile in the correct position and alignment during driving. When using followers, use leads that are long enough and suitable to maintain position and alignment of the hammer, follower, and pile throughout driving.

455-5.56 Followers: ~~Use followers only for underwater driving.~~ Obtain the Engineer's acceptance for the type of follower, when used, and the method of connection to the leads and pile. Use followers constructed of steel with an adequate cross-section to withstand driving stresses. When driving concrete piles, ensure that the cross-sectional area of the follower is at least 18% of the cross-sectional area of the pile. When driving steel piles, ensure that the cross-sectional area of the follower is greater than or equal to the cross-sectional area of the pile. Provide a pile helmet at the lower end of the follower sized according to the requirements of 455-5.34.3. Use followers constructed that maintain the alignment of the pile, follower, and hammer and still allow the pile to be driven within the allowable tolerances. Use followers designed with guides adapted to the leads that maintain the hammer, follower, and the piles in alignment.

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Use information from ~~driving full length piles described in 455-5.1.2 compared to driving piles with the follower and/or~~ dynamic load tests described in 455-5.13-14 to evaluate the adequacy of the follower and to establish the blow count criteria when using the follower.

455-5.6-7 Templates and Ground Elevations: Provide a fixed template, adequate to maintain the pile in proper position and alignment during driving with swinging leads or with semi-fixed leads. Where practical, place the template so that the pile can be driven to cut-off elevation before removing the template. Ensure that templates do not restrict the vertical movement of the pile.

Supply a stable reference close to the pile, which is satisfactory in the opinion of the Engineer, for determination of the pile penetration. At the time of driving piles, obtain and record elevations of the original ground and template at each pile or pile group location. Note the highest and lowest elevation at each required location and the ground elevation at all piles.

455-5.8-7 Water Jets: Use jet pumps, supply lines, and jet pipes that provide adequate pressure and volume of water to freely erode the soil. Do not perform jetting without prior approval by the Engineer.

Do not perform jetting in the embankment or for end bents. Where conditions warrant, with approval by the GFDEOR, perform jetting on the holes first, place the pile therein, then drive the pile to secure the last few feet of penetration. Only use one jet for prejetting or jetting through piles constructed with a center jet-hole. Use two jets when using external jets. When jetting and driving, position the jets slightly behind the advancing pile tip (approximately 3 feet or as approved by the GFDEOR). When using water jets in the driving, determine the pile bearing only from the results of driving after withdrawing the jets, except where using jets to continuously eliminate soil resistance through the scour zone, ensure that they remain in place as directed by the GFDEOR and operating during pile bearing determination. Where practical, perform jetting on all piles in a pile group before driving begins. When large pile groups or pile spacing and batter make this impractical, or when the Plans specify a jet-drive sequence, set check a sufficient number of previously driven piles in a pile group to confirm their capacity after completing all jetting.

455-5.8-9 Penetration Requirements: Measure the penetration of piles from the elevation of natural ground, scour elevation shown in the Plans, or the bottom of excavation, whichever is lower. When the Contract Documents show a minimum pile tip elevation ~~or a minimum depth of penetration~~, drive the tip of the pile to this minimum elevation ~~or this minimum penetration depth~~. ~~In all such cases, t~~The Engineer will accept the bearing of a pile only if the Contractor achieves the required bearing when the tip of the pile is at or below the specified minimum tip elevation ~~or depth of penetration~~ and below the bottom of the preformed or predrilled pile hole.

When the ~~Contract Documents~~ Plans do not show a ~~minimum depth of penetration, scour elevation, or~~ minimum tip elevation, ensure that the ~~required~~ penetration is at least 10 feet into firm bearing material or at least 20 feet into soft material unless otherwise permitted by the Engineer. If a scour elevation is shown in the Plans, achieve ~~these~~ ~~this~~ penetrations below the scour elevation. The Engineer may accept a penetration between 15 feet and 20 feet when there is an accumulation of five consecutive feet or more of firm bearing material. Firm bearing material is any material offering a driving resistance greater than or equal to 30 tons per square foot of gross pile area as determined by the Dynamic Load Testing (455-5.11-12.4). Soft material is any material offering less than these resistances. The gross pile area is

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the actual pile tip cross-sectional area for solid concrete piles, the product of the width and depth for H piles, and the area within the outside perimeter for pipe piles and voided concrete piles.

Do not drive piles beyond practical refusal. To meet the requirements in this Subarticle, provide penetration aids, such as jetting or preformed pile holes, when piles cannot be driven to the required penetration without reaching practical refusal.

455-5.9-10 Preformed Pile Holes:

455-5.910.1 Description: Preformed pile holes serve as a penetration aid when all other pile installation methods fail to produce the desired penetration and when authorized by the GFDEOR to minimize the effects of vibrations on adjacent structures. Preformed pile holes are necessary when the presence of rock or strong strata of soils will not permit the installation of piles to the desired penetration by driving or a combination of jetting and driving, when determined necessary, and authorized by the GFDEOR to minimize the effects of vibrations on adjacent existing structures. Drive all piles installed in preformed pile holes to determine that the bearing requirements have been met.

For preformed holes which are required through material that caves during driving to the extent that the preformed hole does not serve its intended purpose, case the hole from the surface through caving material. After installing the pile to the bottom of the casing, remove the casings unless shown otherwise in the Plans. Determine bearing of the pile after removing the casing unless shown otherwise in the Plans. Fill all voids between the pile and soil remaining after driving through preformed holes with clean A-3 sand or sand meeting the requirements of 902-3.3, after the pile has achieved the required minimum tip elevation, unless grouting of preformed pile holes is shown in the Plans. If pile driving is interrupted during sand placement, drive the pile at least 20 additional blows after filling all of the voids between the pile and soil with sand at no additional ~~cost to the Department~~ compensation.

455-5.109.2 Provisions for Use of Preformed Pile Holes: Preformed pile holes may be used when the Contractor establishes that the required results cannot be obtained when driving the load bearing piles with specified driving equipment, or if jetting is allowed, while jetting the piles and then driving or while jetting the piles during driving.

455-5.109.3 Reasons for Preformed Pile Holes: The Department considers, but does not limit to, the following conditions as reasons for preformed pile holes:

1. Inability to drive piles to the required penetration with driving and jetting equipment.
2. To penetrate a hard layer or layers of rock or strong stratum that the Engineer considers not sufficiently thick to support the structure.
3. To obtain greater penetration into dense (strong) material and into dense material containing holes, cavities or unstable soft layers.
4. To obtain penetration into a stratum in which it is desired to found the structure.
5. To minimize the effects of vibrations or heave on adjacent existing structures.
6. To minimize the effects of ground heave on adjacent piles.

455-5.9-5.10.4 Construction Methods: Construct preformed pile holes by drilling, or driving and withdrawing a suitable punch or chisel at the locations of the piles. Construct a hole that is equal to or slightly greater than the largest pile dimension for the entire length of the hole and of sufficient depth to obtain the required penetration. Carefully form the preformed hole by using a drill or punch guided by a template or other suitable device, and do

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not exceed the minimum dimensions necessary to achieve the required penetration of the pile. When the Plans call for grouting the preformed pile holes, provide ~~the~~ a minimum pile hole dimension ~~of the pile hole that is~~ 2 inches larger than the largest pile dimension. Construct the holes at the Plan position of the pile and the tolerances in location, and ensure the hole is straight and that the batter is the same as specified for the pile. Loose material may remain in the preformed pile hole if the conditions in 455-5.910.3-1 are satisfied.

455-5.910.5 Grouting of Pile Holes: Clean and grout ~~Grout~~ preformed pile holes for bearing piles, when the Plans require grouting after driving. ~~Clean the preformed pile holes, and fill them with cement grout as shown in the Plans.~~ Use grout that meets the requirements of 455-40 to 455-42 and has a minimum compressive strength of 3,000 psi at 28 days or as specified in the Plans. Prepare cylinders and perform QC testing in accordance with 455-43. LOT size and verification will be in accordance with 455-43. Pump the grout through three or more grout pipes initially placed at the bottom of the preformed hole. The Contractor may raise the grout pipes when necessary to prevent clogging and to complete the grouting operations. Maintain the grout pipes below the surface of the previously placed grout. Continue grouting until the grout reaches the ground surface all around the pile. Provide divers to monitor grouting operations when the water depth is such that it is impractical to monitor from the ground surface.

455-5.10-11 Bearing Requirements:

455-5.110.1 General: Drive piles to provide the bearing required for carrying the loads shown in the Plans. For all types of bearing piles, consider the driving resistance as determined by the methods described herein sufficient for carrying the specified loads as the minimum bearing which is accepted for any type of piles. Determine pile bearing using the method described herein or as shown in the Plans.

For foundations requiring 100% dynamic testing of production piles, ensure each pile has achieved minimum penetration and the minimum required bearing obtained for 6 inches of consecutive driving, or the minimum penetration is achieved, driving has reached practical refusal in firm material and the bearing capacity obtained in all the refusal blows.

For foundations not requiring 100% dynamic testing of production piles, ensure each pile has achieved minimum penetration, the blow count is generally the same or increasing and the minimum required bearing capacity obtained for 24 inches of consecutive driving with less than 1/4 inches rebound per blow, or the minimum penetration is achieved and driving has reached practical refusal in firm material.

455-5.110.2 Bearing Criteria: For foundations requiring 100% dynamic testing, determine the bearing of all piles using the data received from dynamic load testing equipment utilizing internally or externally mounted sensors according to the methods described in 455-5.112.1.

For foundations not requiring 100% dynamic testing, drive all piles to the blow count criteria established by the GFDEOR and the Dynamic Testing Engineer (DTE) using the methods described herein and presented in the production pile length and driving criteria letter (see 455-5.1415.2).

455-5.110.3 Practical Refusal: Practical refusal is defined as 20 blows per inch or less than one inch penetration, with the hammer operating at the highest setting or setting determined by the DTE for driving piles without damage and less than 1/4 inches rebound per blow. Stop driving as soon as the pile has reached practical refusal.

455-5.110.4 Set-checks and Pile Redrive:

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1. **Set-checks:** Set-checks consist of redriving the pile after certain period of time, typically up to 24 hours. Perform set-checks as required and at the waiting periods shown in the Contract Documents. Provide an engineer's level or other suitable equipment for elevation determinations to determine accurate pile penetration during the set-checks. A pile may be accepted when a set-check shows that it has achieved the minimum required pile bearing and has met all other requirements of this Section.

2. **Pile Redrive:** Pile redrive consists of redriving the pile after the following working day from initial driving to determine time effects, to reestablish pile capacity due to pile heave, or for other reasons.

3. **Uninstrumented Set-Checks and Uninstrumented Pile Redrive:** A pile may be considered to have sufficient bearing resistance when the specified set-check criteria is met through the last 10 to 20 blows of the hammer at the specified minimum stroke and the total penetration is less than six inches with less than 1/4 inches rebound per blow. When the total penetration ~~during a set-check or redrive~~ is greater than six inches or pile rebound exceeds 1/4 inches per blow, the pile may be considered to have sufficient bearing resistance when the specified blow count criteria is achieved in accordance with 455-5.11.1. Set-check criteria shall be based on dynamic testing specifically performed at similar penetrations and driving interruption time as the set-check criteria is applied. If dynamic test data under these conditions are not available, an instrumented set-check or redrive must be performed.

4. **Instrumented Set-Checks and Instrumented Pile Redrive:** Dynamic load tests using at least 6 hammer blows may be used to determine whether the pile bearing is sufficient. The pile may be considered to have sufficient bearing resistance when dynamic measurements demonstrate the static pile resistance ~~exceeds when at least one hammer blow exceeds~~ the required pile resistance for at least one hammer blow and the average static pile resistance during the next five hammer blows exceeds 95% of the required pile resistance. If the pile is advanced farther, the static pile resistance during all subsequent blows must exceed 90% of the required pile resistance.

455-5.11.5 Pile Heave: Pile heave is the upward movement of a pile from its originally driven elevation. Drive the piles in an appropriate sequence to minimize the effects of heave and lateral displacement of the ground. Monitor piles previously driven in a pile group for possible heave during the driving of the remaining piles. Take elevation measurements to determine the magnitude of the movement of piles and the ground surface resulting from the driving process. Redrive all piles that have heaved 1/4 inches or more.

455-5.11.6 Piles with Insufficient Bearing: When the bearing capacity of any pile is less than the required bearing capacity, the Contractor may splice the pile and continue driving or may extract the pile and drive a pile of greater length, or drive additional piles. ~~until reducing the required bearing per pile to the determined bearing capacity of the piles already driven.~~

455-5.11.7 Optional Soil Set-up approach: If the Contractor so desires, it may consider soil set-up. Production piles that are driven to less than the Nominal Bearing Resistance (NBR) may be accepted based on the anticipated soil setup without set checks on all piles, only if the following criteria are met:

(a) Pile tip penetration satisfies the minimum penetration requirement following 455-5.8.9.

(b) End of Initial Drive (EOID) resistance exceeds 1.10 times the Factored Design Load for the pile bent/pier, as determined by the dynamic testing or blow count criteria.

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(c) The Resistance Factor for computing NBR is taken from the following

table:

Resistance Factors for Pile Installation Using Soil Setup (all structures)				
Loading	Design Method	Construction QC Method	Resistance Factor, ϕ	
			Blow Count Criteria ³	100% Dynamic Testing ⁴
Compression	Davisson Capacity	EDC using UF method, or PDA and CAPWAP ¹	0.55	0.60
		Static Load Testing ²	0.65	0.70
		Statnamic Load Testing ²	0.60	0.65
Uplift	Skin Friction	EDC using UF method, or PDA and CAPWAP ¹	0.45	0.50
		Static Load Testing ²	0.55	0.55

1 Dynamic Load Testing and Signal Matching Analysis
2 Used to confirm the results of Dynamic Load Testing and Signal Matching Analysis
3 Initial drive of production piles using Blow Count Criteria
4 Initial drive of all piles accepted by results of Dynamic Testing of all blows.

(d) At least one test pile is driven at each bent/pier with a successful set check at the anticipated production pile tip elevations and one of the following sets of dynamic load testing conditions are met at each bent/pier.

1. The bearing of at least 10% of piles in the bent/pier (round up to the next whole number) is confirmed by instrumented set-check, and all test piles and instrumented set-checks demonstrate the pile resistance exceeds the NBR within seven days after EOID

2. The bearing of at least 20% of piles in the bent/pier (round up to the next whole number) is confirmed by instrumented set-check, and all test piles and instrumented set-checks demonstrate the pile resistance exceeds the NBR within 21 days after EOID.

(e) All uninstrumented piles are driven deeper and to a greater EOID resistance than the EOID resistance of all instrumented production piles in the same bent/pier.

455-5.121 Methods to Determine Pile Capacity:

455-5.1112.1 General: Dynamic load tests using ~~internal gauges, or~~ an externally mounted instrument system and signal matching analyses ~~or internal gauges will be used to~~ determine pile capacity for all structures or projects unless otherwise shown on the Plans. Notify the Engineer two working days prior to placement of piles within the template and at least one working day prior to driving piles.

455-5.1112.2 Wave Equation:

1. ~~General:~~ Use Wave Equation Analysis for Piles (WEAP) programs to evaluate the suitability of the proposed driving system (including the hammer, follower, capblock and pile cushions) as well as to estimate the driving resistance, in blows per 12 inches or blows per inch, to achieve the pile bearing requirements and to evaluate pile driving stresses.

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Use Wave Equation Analyses to show the hammer meets the requirements described in 455-5.245.3.

2. Required Equipment For Driving: Hammer acceptance is solely based on satisfactory field trial including dynamic load test results and Wave Equation Analysis. Supply a hammer system that meets the requirements described in the specifications based on satisfactory field performance.

In the event piles require different hammer sizes, the Contractor may elect to drive with more than one size hammer or with a variable energy hammer, provided the hammer is properly sized and cushioned, will not damage the pile, and will develop the required resistance.

3. Maximum Allowed Pile Stresses:

a. General: The maximum allowed driving stresses for concrete, steel, and timber piles are given below. In the event ~~dynamic load tests~~ ~~Wave Equation analyses~~ show that the hammer will overstress the pile, modify the driving system or method of operation as required to prevent overstressing the pile. In such cases provide additional cushioning, ~~reduce the stroke~~, or make other appropriate agreed upon changes. ~~For penetration of weak soils by concrete piles, use thick cushions and/or reduced stroke to control tension stresses during driving.~~

b. ~~Prestressed~~ Concrete Piles: ~~Use the wave equation to evaluate the proposed pile cushioning.~~ Use the following equations to determine the maximum allowed pile stresses ~~as predicted by the wave equation, and measured during driving when driving prestressed concrete piling:~~

$$s_{apc} = 0.7 f'_c - 0.75 f_{pe} \quad (1)$$

$$s_{apt} = 6.5 (f'_c)^{0.5} + 1.05 f_{pe} \quad (2a) \text{ for piles less than 50 feet long}$$

$$s_{apt} = 3.25 (f'_c)^{0.5} + 1.05 f_{pe} \quad (2b) \text{ for piles 50 feet long and greater}$$

$$s_{apt} = 500 \quad (2c) \text{ within 20 feet of a mechanical splice}$$

where:

s_{apc} = maximum allowed pile compressive stress, psi

s_{apt} = maximum allowed pile tensile stress, psi

f'_c = specified minimum compressive strength of concrete, psi

f_{pe} = effective prestress (after all losses) at the time of driving, psi, taken as 0.8 times the initial prestress force ($f_{pe} = 0$ for dowel spliced piles).

c. Steel Piles: Ensure the maximum pile compression and tensile stresses ~~as predicted by the Wave Equation, and/or~~ measured during driving are no greater than 0.9 times the yield strength ($0.9 f_y$) of the steel.

d. Timber Piles: Ensure the maximum pile compression and tensile stresses ~~as predicted by the wave equation, and/or~~ measured during driving are no greater than 3.6 ksi for Southern Pine and Pacific Coast Douglas Fir and 0.9 of the ultimate parallel to the grain strength for piles of other wood.

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455-5.121.3 Temporary Piles: Submit for the Engineers review, an analysis signed and sealed by the GFDEOR which establishes the pile lengths for temporary piles, ~~and submit~~ **Submit** for the Engineer's acceptance, a Wave Equation analysis signed and sealed by the GFDEOR which establishes the driving criteria for temporary piles at least five working days prior to driving temporary production piles. The required driving resistance is equal to the sum of the factored design load plus the scour and down drag resistances shown in the Plans, divided by the appropriate resistance factor or the nominal bearing resistance shown in the Plans, whichever is higher:

The maximum resistance factor is 0.45 when only wave equation analysis is performed. However, a larger resistance factor may be applicable when additional testing is provided by the GFDEOR in accordance with Section 3.5.6 of Volume 1 of the FDOT Structures Manual.

455-5.121.4 Dynamic Load Tests: Dynamic load testing consists of estimating pile capacity by the analysis of electronic data collected from blows of the hammer during driving of an instrumented pile in accordance with 455-4.5.134.

455-5.121.5 Static Load Tests: Static load testing consists of applying a static load to the pile to determine its capacity. Use The Modified Quick Test Procedure in accordance with 455-2.2.1.

455-5.121.6 Fender Pile Installation: For piles used in fender systems, regardless of type or size of pile, either drive them full length or jet the piles to within 2 feet of cutoff and drive to cutoff elevation to seat the pile. The Engineer will not require a specific driving resistance unless noted in the Plans. Use methods and equipment for installation that do not damage the piles. If the method or equipment used causes damage to the pile, modify the methods or equipment.

455-5.121.7 Structures Without Test Piles: For structures without 100% dynamic testing or test piles ~~or 100% dynamic testing~~, dynamically test the first pile(s) in each bent or pier at locations shown in the Plans to determine the blow count criteria for the remaining piles. Dynamically test at least 5% of the piles at each bent or pier (rounded up to the next whole number).

455-5.132 Test Piles:

455-5.132.1 Description General: All test piles will have dynamic load tests.

Drive piles of the same cross-section and type as the permanent piles shown in the Plans, in order to determine any or all of the following:

1. ~~the~~ installation criteria for the piles.
2. ~~the~~ nature of the soil.
3. ~~the~~ lengths of permanent piles required for the work.
4. ~~the~~ driving resistance characteristics of the various soil strata.
5. ~~the~~ amount of work necessary to obtain minimum required pile

penetration.

6. ~~the~~ ability of the driving system to do the work.
7. ~~the~~ need for point protection.

Because test piles are exploratory in nature, drive them harder (within the limits of practical refusal), deeper, and to a greater bearing resistance than required for the permanent piling. Except for test piles which are to be statically or Statnamically load tested, drive test piles their full length or to practical refusal. Splice test piles which have been driven

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their full length and have developed only minimal required bearing, and proceed with further driving.

As a minimum, unless otherwise accepted by the Engineer, do not cease driving of test piles until obtaining the required bearing capacity continuously, where the blow count is increasing, for 10 feet unless reaching practical refusal first. For test piles which are to be statically or Statnamically load tested, ignore this minimum and drive these piles as anticipated for the production piles.

When test piles attain practical refusal prior to attaining minimum penetration, perform all work necessary to attain minimum penetration and the required bearing. Where practical, use water jets to break the pile loose for further driving. Where jetting is impractical, extract the pile and install a preformed pile hole through which driving will continue. Install instruments on all test piles.

455-5.13~~2~~.2 Location of Test Piles: Drive all test piles in the position of permanent piles at the designated locations. Ensure that all test piles designated to be statically load tested are plumb. In the event that all the piles are battered at a static load test site, an out-of-position location for driving a plumb pile for the static load test may be selected.

455-5.13~~2~~.3 Equipment for Driving: Use the same hammer and equipment for driving test piles as for driving the permanent piles. Also use the same equipment to redrive piles.

455-5.13-14 Dynamic Load Tests: Take dynamic measurements during the driving of piles designated in the Plans. Provide all personnel, materials and equipment for dynamic testing. For concrete piles, install~~Install~~ instruments prior to driving and monitor all blows delivered to the pile. For steel production piles, the Engineer may accept instrumented set-checks or redrives. ~~All test piles will have dynamic load tests.~~ Perform dynamic load tests to evaluate the following:

1. ~~Evaluate-s~~Suitability of the driving equipment, including hammer, capblock, pile cushion, and any proposed follower.
2. ~~Determine-P~~Pile capacity.
3. ~~Determine-p~~Pile stresses.
4. ~~Determine-e~~Energy transfer to pile.
5. ~~Determine-d~~Distribution of soil resistance.
6. ~~Evaluate-s~~Soil variables including quake and damping.
7. ~~Evaluate-h~~Hammer-pile-soil system for Wave Equation analyses.
8. ~~Evaluate-p~~Pile installation problems.
9. Verify the bearing stratum is of sufficient thickness to prevent punching shear failure.

Either install internal gauges in the piles in accordance with Design Standards, Index No. 20602 or attach instruments (strain transducers to measure force and accelerometers to measure acceleration) with bolts to the pile for dynamic load testing.

Monitor the stresses in the piles with the dynamic test equipment during driving to ensure the maximum allowed stresses are not exceeded. If necessary, add additional cushioning, replace the cushions, or reduce the hammer stroke to maintain stresses below the maximum allowable. If dynamic test equipment measurements indicate non-axial driving, immediately realign the driving system. If the cushion is compressed to the point that a change in alignment of the hammer will not correct the problem, add cushioning or change the cushion.

Drive the pile to the required penetration and resistance.

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Do not use a cold diesel hammer for a set-check. Generally, warm up the hammer by driving another pile or applying at least 20 blows to a previously driven pile or to timber mats placed on the ground.

~~For steel production piles, the Engineer may accept instrumented set checks or redrives as dynamic testing for the purpose of meeting the requirements for 100% Dynamic Testing.~~

455-5.154 Pile Lengths:

455-5.154.1 Test Pile Length: Provide the length of test piles shown in the Plans or as directed by the GFDEOR.

455-5.154.2 Production Pile Length

The production pile lengths shall be the lengths determined by the DTE and the GFDEOR based on all information available before the driving of the permanent piles, including, but not limited to, information gained from the driving of test piles, dynamic load testing, static load testing, supplemental soil testing, etc. When authorized by the Department, soil freeze information obtained during set checks and pile redrives may be used to determine authorized pile lengths for sites with extreme soil conditions.

After completion of the test pile program, production pile lengths and driving criteria shall be established in a letter signed and sealed jointly by the DTE and the GFDEOR. The letter will contain an itemized list of authorized pile lengths as well as the blow count criteria for acceptance of the pile, minimum penetrations, maximum strokes, criteria to replace cushions and any other conditions and limitations deemed appropriate for the safe installation of the piles. Use these lengths for furnishing the permanent piling for the structure. At least two working days, excluding weekends and Department observed holidays, prior to beginning of production pile driving, submit the letter and load test reports to the Engineer including the following electronic files (Windows compatible): dynamic testing data, signal matching data and results, and Wave Equation data and results.

If there are no test piles, provide the Production Pile Order Lengths in the Pile Data Table on the Structure Plans.

455-5.15-16 Allowable Driving Tolerances:

455-5.165.1 General: Meet the tolerances described in this Subarticle ~~to~~ for the piles that are free standing without lateral restraint (after the template is removed). After the piles are driven, do not move the piles laterally to force them to be within the specified tolerances, except to. ~~The Contractor may~~ move battered piles laterally to overcome the dead load deflections caused by the pile's weight. When this is necessary, submit calculations signed and sealed by a Specialty Engineer to the Engineer that verify the amount of dead load deflection prior to moving any piles.

455-5.165.2 Position: Ensure that the final position of the pile head at cut-off elevation is no more than 3 inches laterally in the X or Y coordinate from the Plan position indicated in the Plans.

455-5.165.3 Axial Alignment: Ensure that the axial alignment of the driven piles does not deviate by more than 1/4 inches per foot from the vertical or batter line indicated in the Plans.

455-5.165.4 Elevation: Ensure that the final elevation of the pile head is no more than 1-1/2 inches above, or more than 4 inches below, the elevation shown in the Plans, however in no case shall the pile be embedded less than 8 inches into the cap or footing.

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For fender piles, cut off piles at the elevation shown in the Plans to a tolerance of plus 0.0 inches to minus 2.0 inches using sawing or other means as accepted by the Engineer to provide a smooth level cut.

455-5.165.5 Deviation From Above Tolerances: Have the Contractor's Engineer of Record perform an evaluation of the as built foundation to determine whether a foundation redesign or an increase in the loading requirements of the piles is needed. Include the signed and sealed evaluation as part of the certification package submitted in accordance with 455-5.1819. If the evaluation indicates the foundation or the pile load requirements must be modified, propose a redesign to incorporate out of tolerance piles into pile caps or footings, at no expense to the Department. Submit signed and sealed redesign drawings and computations to the Engineer for review and acceptance. Do not begin any proposed construction until the redesign has been reviewed and accepted by the Engineer, excepted as noted in 455-5.1920.

455-5.176 Disposition of Pile Cut-offs, Test Piles, and Load Test Materials:

455-5.176.1 Pile Cut-offs:

Take ownership of any unused cut-off lengths remaining, and remove them from the right-of-way. Provide areas for their disposal.

455-5.176.2 Test Piles: Cut off, or build-up as necessary, test piles, and leave them in place as permanent piles. Extract and replace test piles driven in permanent position and found not suitable for use. Pull, or cut off at an elevation 2 feet below the ground surface or bottom of proposed excavation, test piles driven out of permanent position, and dispose of the removed portion of the test pile.

When test piles are required to be driven in permanent pile positions, the Contractor may elect to drive the test pile out of position provided that a replacement pile is furnished and driven in the position that was to be occupied by the test pile. Unless otherwise directed in the Plans or by the Engineer, retain ownership of test piles that are pulled or cut off and provide areas for their disposal.

455-5.187 Recording: Inspect and record all the pile installation activities, including but not limited to handling, jetting, predrilling, preforming and driving on the Department's Pile Driving Record form. Steel piles and dynamically tested concrete piles in accordance with 455-5.1314 will not require inspection during handling. Keep a pile driving log for each pile installed whether it is, or is not, instrumented. Within one working day after completing the installation of a pile, submit the Pile Driving Record to the Engineer.

455-5.1819 Foundation Certification Packages: Submit certification packages of pile foundations to the Engineer prior to Pile Verification Testing. A separate Foundation Certification Package must be submitted for each foundation unit. A foundation unit is defined as all the piles within one bent or pier for a specific bridge for each phase of construction. Each Foundation Certification Package shall contain an original certification letter signed and sealed by the GFDEOR certifying the piles have the required axial capacity including compression and uplift, lateral stability, pile integrity, and settlement will not affect the functionality of the structure. The package shall also include all pile driving logs, EDC records, all supplemental dynamic testing raw data and analyses for the foundation unit, and the signed and sealed evaluation performed to address out of tolerance piles in accordance with 455-5.1516.5. The certification shall not be contingent on any future testing or approval by Engineer.

455-5.1920 Verification: One working day, excluding weekends and Department observed holidays, after receipt of the Foundation Certification Package, the Engineer will determine whether a pile in that foundation unit will be selected for verification testing. Based on

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its review of the certification package, the Engineer may or may not choose a pile for verification testing in any or all foundation units. For the pile selected by the Engineer for verification testing, the Engineer will provide the dynamic load test equipment and personnel for the Pile Verification Testing. Provide the driving equipment and pile driving crew for the Pile Verification Testing and provide support as needed to prepare the piles for testing. The Engineer will provide the results of the verification testing and identify additional needs for verification testing within one working day of testing.

If the capacity or integrity of any pile is found to be deficient, the Engineer will reject the entire certification package for the foundation unit, and the Contractor shall:

1. Correct the deficiency;
2. Correct the process that led to the deficiency;
3. Demonstrate to the Engineer that the remainder of the piles in the

foundation unit are acceptable, including additional dynamic load tests to verify pile capacity and integrity, and;

4. Recertify the foundation unit.

One working day, excluding weekends and Department observed holidays, after receipt of the recertification, the Engineer shall then determine whether additional verification testing is required in that foundation unit. If the capacity or integrity of a verification pile is found to be deficient, additional cycles of deficiency correction and verification testing shall be completed until no more pile capacity or integrity deficiencies are detected or the design is modified accordingly. Piles shall not be cut-off nor bent/pier caps placed prior to successful completion of the Pile Verification Testing Program for that foundation unit. In case of disagreement of dynamic testing results, the Engineer's results will be final and will be used for acceptance.

On land foundation units or water foundation units when the pile cutoff is at least six feet above mean high water, the Contractor may cut-off piles prior to a complete submittal of the Certification Package or to a successful completion of the Pile Verification Testing Program at its own risk. If any piles in a foundation unit are cut-off prior to the submittal of a certification package or completion of the Pile Verification Testing Program and the Engineer determines that verification testing is required, the Contractor shall perform, at no expense to the Department, any work and labor required to expose any pile selected for verification to allow the installation of the instruments in dry conditions and to provide references and access to the Engineer for such testing. Piles experiencing damage during the verification testing or requiring build-up after the verification shall be repaired by the Contractor at no expense to the Department. No pile bent/cap shall be poured prior to successful completion of the Pile Verification Testing Program for that foundation unit or notification by the Engineer that no verification will be required.

455-6 Timber Piling.

455-6.1 Description: Drive timber piles ~~constructed of round timber~~ of the kind and dimensions specified in the Plans at the locations and to the elevations shown in the Plans.

455-6.2 Materials: Meet the timber piling requirements of Section 953. Treat the piles according to the applicable provisions of Section 955. Treat all cuts and drilled holes in accordance with 470-3.

455-6.3 Preparation for Driving:

Use when Geotechnical Services are required for the project.

455-6.3.1 Caps: Protect the heads of timber piles during driving, using a cap of approved type, that will distribute the hammer blow over the entire cross-section of the pile. When necessary, cut the head of the pile square before beginning pile driving.

455-6.3.2 Collars: Provide collars or bands to protect piles against splitting and brooming at no expense to the Department.

455-6.3.3 Shoes: Provide piles shod with metal shoes, of a design satisfactory to the Engineer, at no expense to the Department. Shape pile tips to receive the shoe and install according to the manufacturer's directions.

455-6.4 Storage and Handling: Store and handle piles in the manner necessary to avoid damage to the piling. Take special care to avoid breaking the surface of treated piles. Do not use cant dogs, hooks, or pike ~~p~~holes when handling and storing the piling.

455-6.5 Cutting Off: Saw off the tops of all timber piles at the elevation indicated in the Plans. Saw off piles which support timber caps to the exact plane of the superimposed structure so that they exactly fit ~~it~~. Withdraw and replace broken, split, or misplaced piles.

455-6.6 Build-ups: The Engineer will not permit splices or build-ups for timber piles. Extract piles driven below Plan elevation and drive a longer pile.

455-6.7 Pile Heads:

455-6.7.1 Piles with Timber Caps: On piles wider than the timber caps, dress off ~~to a slope of 45 degrees~~ the part of the pile head projecting beyond the sides of the cap to a slope of 45 degrees. Coat the cut surface with the required preservative ~~over which and then~~ place a sheet of copper, ~~of with~~ a weight of 10 ounces per square foot or greater, meeting the requirements of ASTM B370. Provide a cover measuring at least 4 inches more in each dimension greater than the diameter of the pile. Bend the cover down over the pile and fasten the edges with large head copper nails or three wraps of No. 12 copper wire.

455-6.7.2 Fender and Bulkhead Piles: ~~First p~~Paint the heads of fender piles and of bulkhead piles with preservative and then cover with copper as provided above for piles supporting timber caps.

SUBARTICLES 455-7.1 through 455-7.5 are deleted and the following substituted:

455-7.1 Description: Provide prestressed concrete piles that are manufactured, cured, and driven in accordance with ~~the requirements of~~ the Contract Documents. Provide piles full length without splices when transported by barge or the pile length is less than or equal to 120 feet. When piles are transported by truck and the pile length exceeds 120 feet but is less than the maximum length for a three point pick-up according to Design Standards Index No. 20600, and splicing is desired, provide minimal splices. Include the cost of the splices in the cost of the pile.

455-7.2 Manufacture: Fabricate piles in accordance with Section 450. When internal gauges will be used for dynamic load testing, supply and install in square prestressed concrete piles in accordance with Design Standards, Index No 20602. Ensure the internal gauges are installed by personnel approved by the manufacturer.

455-7.3 Storage and Handling:

455-7.3.1 Time of Driving Piles: Drive prestressed concrete piles at any time after the concrete has been cured in accordance with Section 450, and the concrete compressive strength is equal to or greater than the specified 28 day compressive strength.

Use when Geotechnical Services are required for the project.

455-7.3.2 Storage: Support piles on adequate dunnage both in the prestress yard and at the job site in accordance with the locations shown in the [Design Standards Indexes](#) to minimize undue bending stresses or creating a sweep or camber in the pile.

455-7.3.3 Handling: Handle and store piles in the manner necessary to eliminate the danger of fracture by impact or of undue bending stresses in handling or transporting the piles from the forms and into the leads. In general, lift concrete piles by means of a suitable bridge or slings attached to the pile at the locations shown in the [Design Standards Indexes](#). Construct slings used to handle piles of a fabric material or braided wire rope constructed of six or more wire ropes which will not mar the corners or the surface finish of the piles. Do not use chains to handle piles. During transport, support concrete piles at the lifting locations shown in the [Design Standards Indexes](#) or fully support them throughout 80% or more of their length. In handling piles for use in salty or brackish water, exercise special care to avoid damaging the surface and corners of the pile. If an alternate transportation support arrangement is desired, submit calculations, signed and sealed by the Specialty Engineer, for acceptance by the Engineer prior to transporting the pile. Calculations must show that the pile can be transported without exceeding the bending moments calculated using the support locations shown in the Plans.

455-7.4 Cracked Piles: The Engineer will reject any pile that becomes cracked in handling to the point that a transverse or longitudinal crack extends through the pile, shows failure of the concrete as indicated by spalling of concrete on the main body of the pile adjacent to the crack, or which in the opinion of the Engineer will not withstand driving stresses. The Engineer will not reject any pile for the occasional minor surface hairline cracking caused by shrinkage. ~~or tensile stress in the concrete from handling.~~

Do not drive piling with irreparable damage, which is defined as any cracks that extend through the pile cross-sectional area that are, or will be, below ground or water level at the end of driving. ~~Such cracks are normally evidenced by emitting concrete dust during their opening and closing with each hammer blow.~~ Remove and replace broken piles or piles cracked to the extent described above at no expense to the Department. The Engineer will accept cracks less than 0.005 inches which do not extend through the pile. Using approved methods, cut off and splice or build-up to cut-off elevation piles with cracks greater than 0.005 inches at the pile head or above ground or water level, and piles with cracks above ground or water level which extend through the cross-sectional area of the pile. The Engineer, at his discretion, may require correction of pile damage or pile cracks by cutting down the concrete to the plane of sound concrete below the crack and rebuilding it to cut-off elevation, or the Engineer may reject the pile. Extract and replace rejected piles that cannot be repaired, at no expense to the Department.

Take appropriate steps to prevent the occurrence of cracking, whether due to handling ~~or driving,~~ [transporting or driving.](#) ~~When cracking occurs during driving, take immediate steps to prevent additional cracking by using thicker cushions or reducing the ram stroke length. Revise handling and transporting equipment and procedures as necessary to prevent cracking during handling and transportation.~~

455-7.5 Preparation for Transportation: Cut ~~any strands protruding beyond the ends of the pile~~ flush with the surface of the concrete using an abrasive cutting blade before transporting the piles from the casting yard.

Cut and patch the metal lifting devices in accordance with 450-9.2.1.

Use when Geotechnical Services
are required for the project.

SUBARTICLE 455-10.2 is deleted and the following substituted

455-10.2 Acceptance of the Pile Installation Plan: The Engineer will evaluate the PIP for conformance with the Contract Documents. Within five working days, excluding weekends and Department observed holidays, after receipt of the plan, the Engineer will notify the Contractor of any comments and additional information required and/or changes that may be necessary to satisfy the Contract Documents. Submit changes and respond to the Engineer's comments and allow at least two working days, excluding weekends and Department observed holidays, for the Engineer to review the revised PIP.

All equipment and procedures are subject to satisfactory field performance. Make any required changes that may result from unsatisfactory field performance. The Engineer will give final acceptance after the Contractor makes necessary modifications. Do not make any changes in the driving system after acceptance without a revised PIP with concurrence of the GFDEOR and acceptance by the Engineer. A hammer repaired on site or removed from the site and returned is considered to have its performance altered (efficiency increased or decreased), which is considered a change in the driving system. Perform a dynamic load test in accordance with 455-5.13-14 on the first pile driven with this hammer to confirm the driving criteria is still appropriate at no additional compensation.

Acceptance of the PIP by the Engineer does not relieve the Contractor of the responsibility to perform the work in accordance with the Contract Documents. The Engineer's acceptance is not a guarantee that the chosen methods and equipment are capable of obtaining the required results; this responsibility lies with the Contractor.

SUBARTICLE 455-11.2.2 is deleted and the following substituted

455-11.2.2 Furnished Length: The furnished length of precast concrete piles will be considered as the overall length from head to tip. Final pay length will be based on the casting length as authorized in accordance with 455-5.14-15.3-2 subject to provisions of 455-11.2.3 through 455-11.2.8, 455-11.8, 455-11.9 and 455-11.12.

SUBARTICLE 455-11.2.7 is deleted and the following substituted

455-11.2.7 Replacing Piles: In the event a pile is broken or otherwise damaged by the Contractor to the extent that the damage is irreparable, in the opinion of the Engineer, the Contractor shall extract and replace the pile at no additional expense to the Department. In the event that a pile is mislocated by the Contractor, the Contractor shall extract and replace the pile at no expense to the Department except when a design change proposed by the Contractor is approved by the Department as provided in 455-5.15-16.5.

In the event that a pile is driven below cut-off without obtaining the required bearing, and the Engineer elects to have the pile pulled and a longer pile substituted, it will be paid for as Unforeseeable Work. In the event a pile is damaged or mislocated, and the damage or mislocation is determined to be the Department's responsibility, the Engineer may elect to have the pile extracted, and it will be paid for as Unforeseeable Work. If the extracted pile is undamaged and driven elsewhere the pile will be paid for at 30% of the Contract unit price

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for Piling. When the Department determines that it is responsible for damaged or mislocated pile, and a replacement pile is required, compensation will be made under the item for piling, for both the original pile and replacement pile.

The Contractor may substitute a longer pile in lieu of splicing and building-up a pile. In this event, the Contractor will be paid for the original authorized length of the pile, plus any additional length furnished by the Contractor up to the authorized length of the build-up, as piling. The Contractor will be paid 30 feet of piling as full compensation for extracting the original pile.

SUBARTICLE 455-11.5 is deleted and the following substituted

455-11.5 Dynamic Load Tests: Payment will be based on the number of dynamic load tests shown in the Plans, authorized by the Engineer, or required in 455-5.12+7, completed and accepted in accordance with the Contract Documents. No separate payment will be made for dynamic load tests used to evaluate the Contractor's driving equipment. This will generally be done on the first test pile or production pile driven on a project with each combination of proposed hammer and pile size and/or a separate pile to evaluate any proposed followers, or piles driven to evaluate proposed changes in the driving system. No payment will be made for dynamic load tests used to evaluate the integrity of a pre-planned epoxy-bonded dowel splice. Include all costs associated with dynamically testing production piles with epoxy-bonded dowel splices under Pay Item No. 455-34. No payment will be made for dynamic load tests on test piles.

For structures with 100% dynamic testing, the cost of supplying and installing internal gauges or attaching external gauges to each pile for dynamic load tests is included in the cost of the pile, no separate payment will be made.

For structures without 100% dynamic testing, the cost of supplying and installing internal gauges or attaching external gauges to each production pile for dynamic load testing prior to initial driving, authorized by the Engineer, will be 20 feet of additional pile. No payment will be made for attaching dynamic testing equipment for set-checks or redrives.

SUBARTICLE 455-11.12 is deleted and the following substituted

455-11.12 Preformed Pile Holes: The quantity added to the payment for piling will be 30% of the length of completed preformed pile holes from existing ground or the bottom of any required excavation, whichever is lower, to the bottom of preformed hole acceptably provided, complete for the installation of the bearing piles, regardless of the type of pile (test pile or production pile) installed therein. Only those holes authorized to be paid for, as provided in 455-5.910.3, will be included in the measurement for payment. The Engineer will authorize payment for preformed pile holes only when the pile has been placed in proper position and has achieved the required penetration.

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are required for the project.

SUBARTICLE 455-12.3 is deleted and the following substituted

455-12.3 Steel Piling: Price and payment will be full compensation for all labor, equipment, and materials required for furnishing and installing steel piling, including welding and painting as specified and the cost of predrilling pile holes described in 455-5.1.+. The cost of any sand or concrete fill and reinforcing steel in pipe piles will be included in the price for steel piling.

Bracing and other metal parts attached to or forming a part of piling or bracing and not otherwise classified, will be measured and paid for as provided in Section 460.

ARTICLE 455-20 is deleted and the following substituted:

455-20 Construction Tolerances.

Meet the following construction tolerances for drilled shafts:

1. Ensure that the top of the drilled shaft is no more than 3 inches laterally in the X or Y coordinate from the position indicated in the Plans.
2. Ensure that the vertical alignment of the shaft excavation does not vary from the alignment shown in the Plans by more than 1/4 inches per foot of depth.
3. After placing all the concrete, ensure that the top of the reinforcing steel cage is no more than 6 inches above and no more than 3 inches below plan position.
4. Ensure that the reinforcing cage is concentric with the shaft within a tolerance of 1-1/2 inches. Ensure that concrete cover is a minimum of 4-1/2 inches unless shown otherwise in the Plans.
5. All casing diameters shown in the Plans refer to I.D. (inside diameter) dimensions. However, the Contractor may use casing with an outside diameter equal to the specified shaft diameter if the extra length described in 455-15.7 is provided. In this case, ensure that the I.D. of the casing is not less than the specified shaft diameter less 1 inch. The Contractor may elect to provide a casing larger in diameter than shown in the Plans to facilitate meeting this requirement. ~~When casing is not used,~~ E-ensure that the minimum diameter of the drilled shaft is 1 inch less than the specified shaft diameter. When conditions are such that a series of telescoping casings are used, provide the casing sized to maintain the minimum shaft diameters listed above.
6. Ensure that the top elevation of the drilled shaft concrete has a tolerance of plus 1 inch and minus 3 inches from the top of shaft elevation shown in the Plans.
7. The dimensions of casings are subject to American Petroleum Institute tolerances applicable to regular steel pipe.
8. Use excavation equipment and methods designed so that the completed shaft excavation will have a flat bottom. Ensure that the cutting edges of excavation equipment are normal to the vertical axis of the equipment within a tolerance of plus or minus 3/8 inches per foot of diameter.